Research on the Application of Time Series in Financial Markets

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Abstract. In the current situation, the application of time series is extended to more fields. Macroeconomics has always been an important topic of concern for a country. Time series analysis of these data can obtain the relationship between various financial data, the law and trend of changes over time, abnormal changes, similar groups or different individuals, etc. Analysis, special investment opportunity exploration, etc. all have important reference value. Therefore, this paper discusses the application of time series in macroeconomics in different countries, China and the United States by reviewing several studies done by experts in the field of time series. The results show that the application of time series in the macroeconomics of China and the United States has reached a state of popularization. The research in this paper lays a theoretical foundation for the application and expansion of future time series. At the same time, the progress of time series analysis technology in other fields can also be used for reference by financial time series data mining technology.

Keywords: Time Series; Macro-economy; China; United State.

1. Introduction

1.1 Research Background

From the past few decades to the present, time series are gradually being used in different fields, including economics, engineering, and many others. Different models and methods, like ARIMA model, simple exponential smoothing method, and MCMC, could be applied to forecast the future value, analyze the existed data of numerous datasets, and adjust seasonality, eliminating the noise it brings to the data and finding the trend. Since they are so effective and useful for coping with millions numbers of data, they became a paramount motivation for financial market, internet, and e-commerce to gain more data and use them into their works [1].

As time came to 2020, COVID-19 spread across the whole world. Every country had been affected negatively because everyone needed to be quarantined at home in order to avoid being infected, which lead to the halt of international trades, giving rise to the decline of many nations' economic situation: increased unemployment, rising debts, bankrupt business, brittle financial market, and whole world's economy became worse than the time before COVID-19 happened. China's and the United States' economy had been affected as well, but with different situation. For China, although its economy decreased sharply, the trend of the whole year maintained the positive growth, being the main power helping global economy to revive. However, Chinese government quickly made plan to solve problems that were caused by this sudden event. The result shows that the plan was effective to help the national economy to go back to the norm [2]. For the United States, it was also being influenced by this sudden pandemic, similar to the effects on China. After a period of time to recover, the United States also improved somehow, but did not back to the normal state because of its high inflation, high price level, high government debts, and huge difference of trade. This situation might be caused by three reasons: ineffective policy for COVID-19, reduced demand for goods and services, and decreased supply [3].

1.2 Research Significance

Combing the background information together, the macro economy is an extremely important area for every nation. It decides the success or failure of a country. Thus, it should be analyzed precisely and effectively, in order to avoid the chance for a country to fail. Time series is a useful tool for

analyzing macro economy because datasets of macro economy are recording in continuous time, which is suitable for the definition of time series. And, since it is useful, its penetration is gradually increased into the area of macro economy. Reviewing the existed research papers, the advantages and disadvantages of using time series into macro economy could be found out. Plus, these studies could be samples for future experts to apply time series into the newly discovered area of macro economy.

1.3 Research Framework

This paper would review several papers about the application of time series on macro economy in China and the United States. Then, this paper would conclude the points of researches and discuss about the answer for the research question: how is the application of time series on macro economy in both China and the United States?

2. Literature Review

Started from past several decades, the research and application of time series began. As time goes by, the importance and availability of time series receives more attention, and the range of the application of time series expand to more areas, including macro-economy. Through these years, there are increased number of studies and papers that present studying results about the application of time series in macro economy in different countries. Under this background, this paper would search and find 10 studies that are highly related to the application of time series in macro economy in two different countries, China and the United States. This paper would be classified and explained in details.

2.1 Research on China Macro Economy

The time series analysis is popular in investigating and forecasting China macro economy. In 1978, China experienced national reform and opening policy. Every part of the country change to a new state. The financial sector changed in the nation as the whole country reformed. Abdul Jalil and Ying Ma used ARDL Modeling approach, to analyze whether the reform of financial sector in China achieve that the economic growth could be led by the financial development, and Brown et al technique of CUSUM and CUSUMSQ to check the result. Abdul Jalil and Ying Ma mentioned that the banking system of China reform at 1978 was under the control of the national government. The banking system of China was mainly separated by four largest state owned banks, which limited other private banks and financial sector to contribute to the economic growth. With the result of the test, they showed that China had a positive, but insignificant, relationship with credit to private sector. It could be related to the explanation in the front part. Since the main profit and current was in the hand of those four banks, these small financial sector did not have power to contribute to the economic growth, so China had an insignificant relationship with credit to private sector with the reformed financial sector after 1978 [4].

Later, after the reform, the trade channels between nation and foreign nations expanded. According to Hualin Jin and Shenghua Li, they examined that the foreign investment towards China after the reform and opening increased dramatically. At the same time, the China's GDP and the exports increased at a high speed as well. Many scholars have related the China's GDP with exports and foreign investment. However, Hualin Jin and Shenghua Li claimed that the problem that relatively worth to be explored is not the theoretical causal relationship, but under a specific time period and a specific economic entity, whether the direct investment lead the economic growth or the economic growth attract the direct investment. Thus, Hualin Jin and Shenghua Li used Granger causality test to find out the causal relationship between direct investment and GDP and export. The specific data they chose was time series from 1983 to 2004 coming from the National Statistical Bureau, and they also use time series data from 1979 to 1982 to add the sample number. Through the specific four steps, which are root test, cointegration test, VECM, and causality test, Hualin Jin and Shenghua Li showed that FDI is the Granger cause of GDP, but the FDI would not lead the China's GDP growth, and it

would not increase the exports, which shows that the exports would not attract direct investment. Therefore, though from the macro perspective, experts could claim the direct investment affects the exports through the economic growth, but this phenomenon was not been observed directly through their experiment [5].

Except for the financial sector change and the foreign investment and imports' effect on China's GDP, the casual relationship between China's urbanization and income inequality also is a paramount aspect that should be carefully discussed since the start of the reform in 1978. Guo Chen, Amy K. Glasmeier, Min Zhang, and Yang Shao used the Gini index, the VAR model, Granger causality tests, ACF and PACF plots, and the Cochrane-or cut method to figure out the relationship between China's urbanization ad inequality incomes. The Gini index time series and the urbanization rate graphs shows that the Gini index would increase because of the change of the urbanization. When the urbanization speed increase, the income inequality would increase. Conversely, when the urbanization speed decrease, the income inequality would decrease. Based on VR model, it increased dramatically after 1995, so Guo Chen and others together built a dummy exogenous variable, which assigned years after 1985 as 1 and other years as 0. They also created second dummy exogenous variable for year 1989. The result shows that the urbanization leads to reduced income inequality in year 0, but positive hikes in year 1. This pattern is also consistent with the result of the Granger casualty tests. The AR estimation shows that Gini index is dependent on previous year value as well as the urbanization rates. Based on the Gini Index and different models and methods, the urbanization would increase the income inequality. The positive reaction of Gini index lag reflect that the difference of productivity between urban and city department became larger and larger [6].

Except time series application in China macro economy for the purpose to investigate the economic situation around 1978, it also was used to analyze the present time macro economy as well. Wen Li, Yonghui Liu, and Jiao Yang used China macro economy as the research object to investigate the stability of time series through the combination of ADF, PP, DF-GLS, KPSS and NP tests. Through their test, it shows that the time series could be used to analyze and forecast the China macro economy of the recent decades as well because they used the data of important indices in China macro economy from 1982-2016 [7]. The specific application of time series in China macro economy was examined by Jiwen Wu. She used national GDP from 1978 to 2016 as the data and builds the models after coping with the data. Finally, she used the models to forecast the GDP and compare with the real data to test whether the forecast model is accurate or not. Jiwen test the stability and difference the data, making it become more stable. Then, she selected ARIMA (0,2,3) to forecast. Finally, she used white noise to check the effect of ARIMA model towards the China GDP. All the test results show that the ARIMA (0,2,3) is effective to forecast China GDP. The forecast results state that the GDP in 2017-2021 would show increased trend [8].

2.2 Research on the United States macro economy

Time Series is also popular applied in the area of macro economy in the United States. Lanne, Markku, Nyberg Henri, and Saarinen Erkka used models to test whether the causal or non-causal AR model would performance better. The result is that the non-causal AR model could be used in more different time series than the causal AR model. That's probably because there are more dataset contain the non-causality [9]. Zhifang Wei also applied the time series analysis into the forecast of the Unite States economy. She used ISM American manufacturing index and pending home sales index from June in 2009 to June in 2010 as the basic data. At first, Zhifang used moving average to smooth both indices, testing several n values to determine the best value for forecasting. After using the moving average, although the result was relatively becoming smooth, because of the lag problem, the result did not achieve the ideal state, so Zhifang used second moving average and exponential moving average to get the ideal state for both indices. The result shows that the pending home sales index might decrease, which was not benefit for the U.S. dollar, but because the whole reduced range is slow, it would not harm the market to a huge extent. For ISM manufacturing index, the forecast shows that the economic situation would grow gradually. What's more, the simple moving average would

be suitable for time series that have less random, and the secondary and exponential moving average could increase the accuracy of forecast [10].

The time series is applied not only in the manufacturing indies and pending home sales index, but it also are used to analyze the unemployment rate, an important index that is interrelated with other important national indices, in the United States. Leirong Xue and Pengjun Shao built the ARIMA model to analyze the United States unemployment respectively. Leirong used data started from July in 2000 to July in 2009 from World Bank and ARIMA and GARCH models to analyze. Through the observation of the original data, Leirong discovered that the fluctuation of the data is large, lacking the stability, which means it might have unit root. Thus, he made the unit root test on this dataset, built the ARIMA model to forecast, used ARCG to test, and used GARCH model to forecast again. Following the results, the high unemployment in the United States is because of the lack of the motivation for its own economic growth. And, also the economic structure of the nation should be considered as the reason because the ratio of promotive industries which could provide a lot of job occupations decrease [11]. Peng jun also chose to use the ARIMA model to forecast the United States unemployment rate and make the analysis, but because he thought about the seasonality that would probably affect the data, he built SARIMA model as well. The dataset he chose is from January in 1948 to December in 2019. He used the Mean Squared error (MSE) as the model test index to figure out relative accurate forecast model. Through the tests, he discovered that comparing the ARIMA (2,2,0) with the SARIMA (2,2,0), MSE for ARIMA (2,2,0) is slightly lower than SARIMA (2,2,0), which shows ARIMA (2,2,0) is better than SARIMA (2,2,0) on forecasting the United States unemployment rate [12].

Furthermore, as the research for China, there also is the research for the United States about the income inequality. Shunwei Cui and Yanan Li created the research based on 1973 to 2017 macro time series dataset of the United States and the time series analysis models to explain the effect of financial development on the income inequality. They used Gini index as well. Firstly, Shunwei Cui and Yanan Li used unit root test and Johansen Co-integration test. Then, they analyzed the data and found out that the relationship between the development of finance and income inequality is like an inverted “u” shape, which means when the financial development increases, more money would come to the capitalist, leading the income inequality to increase dramatically [13].

3. Conclusion

The purpose of this paper is to find the answer of the question: How is the application of time series in the macro economy in both China and the United States? Through the research and reviewing several papers, time series already applied into the macro economy to a big extent in both China and the United States. For China, experts already cover lots areas of macro economy, including foreign investment, income inequality, and the effects of the reformed financial sector to the national economy. For the United States, experts cover the unemployment rate, several important indices, and also the income inequality. Researches for both countries contain strong evidences, steps, and explanations, which means that those researches that this paper review all applied time series carefully and professionally into the area of the macro economy. Furthermore, it shows that the time series application is popular over at least these two countries. However, this paper chooses only ten research paper to review, so it has limits that it does not cover all the applications of time series in the macro economy in both China and the United States. Through the review, this paper discovers that most papers prefer to use more complex models than simple models because research papers display less appearance of the moving average or simple exponential moving average. It is probably because simple models or methods have fewer steps, which means they probably dispose the data less. Data that is not being conducted into a good state could not achieve the purpose to forecast a precise value, analyze correctly, or adjust into a better state for later steps. But simple models could not be denied that it has its own value. Therefore, in the future, experts in the field probably could combine the

simple models with complex models together to achieve their purpose, and they could continue to develop new area in the macro economy that did not apply the time series now.

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