Analysis of the Impact of the Fed's Interest Rate Hike Policy Based on the Triple Exponential Smoothing Method

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Abstract: The US has been employing quantitative easing and printing money for more than a decade, fueling inflation while lifting government debt. To deal with the high CPI, the Federal Reserve (Fed) has resorted to a policy of interest rate hikes, especially in the past two years, when the US interest rates have been on an upward trend. This has led to divergence in the economic trends and policy directions of countries, with China facing a more complex and severe external environment. In this connection, first of all, this paper gathers the response policy of each country during the Fed's interest rate hikes, makes qualitative analysis of those response policies, and provides pertinent suggestions for China's economic activities based on its national realities. Then, this paper collects data on the US interest rates, CPI, changes in nonfarm payrolls, monthly rate of retail sales, ISM manufacturing index, and ISM non-manufacturing index starting from January 2022 to December 2023, builds a model using the Triple Exponential Smoothing Method and applying statistical analysis, and solves it with python programming. Finally, the paper analyzes changes in the macro-indicators of the results and forecasts data on each indicator for the next six months to derive the trend of the data on indicators concerning future interest rate hikes. By predicting the impact of future events on China's economy, investment, foreign trade and other aspects, the author expects the country to make corresponding regulatory plans and policy reserves.

1 Introduction

Since the US became an overseas net debtor nation in 1985, its deficit on many items and current account deficits have accumulated to build up an ever-growing huge net debt. Over the past decade or so, the US has been employing a policy of quantitative easing, constantly printing money and raising debt, thus raising government debt and aggravating inflation [1]. When President Biden took office in January 2021, the US national debt stood at USD 27.8 trillion; in October 2022 it was over USD 31.1 trillion, with severe problems with the debt and its monetization. After the outbreak of COVID-2019 in 2019, in response to the pandemic-triggered recession, the Fed kept its benchmark interest rate at 0-0.25% and launched a massive quantitative easing, with broad money supply (M2) soaring high. Under the influence of the US aggressive fiscal and financial measures, the global aggregate demand for the US dollar decreased against the trend. And at the same time, due to a substantial reduction in the effective supply within the US, price level, fiscal deficits, and the US treasury yields had all been rising, all setting new records and approaching the maximum level of inflation that was seen in the US during the oil crisis in the last century [2].

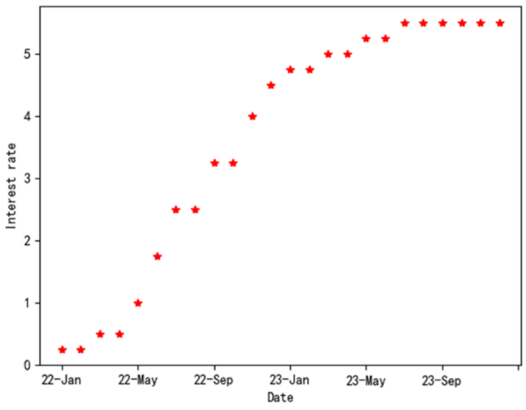

Fig. 1 Trends in the US Interest Rates from January 2022 to December 2023

To address high inflation, the Fed made its most intensive rate hike ever in 2022, ending the year with seven rate hikes totaling 425 basis points, as well as some amount of rate hikes throughout 2023. The specific trends and data on rate hikes are shown in Fig. 1. It can be seen that US interest rates have been on the rise for the past two years. The Fed has not answered whether it will raise rates in the future. What is the Fed's real intention behind the rate hikes? What are the effects and impacts of interest rate hikes? And how should China respond in the future? Therefore, a study of the impact brought about by changes in macro indicators, such as the US CPI, its unemployment

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rate, changes in the number of non-farm payrolls, the monthly rate of retail sales, the ISM manufacturing index and the ISM non-manufacturing index, is of significant practical significance for China to respond to the current complex and volatile challenges of the international environment, promote targeted reform and innovation of foreign exchange administration, and safeguard the balance of payments and its economic and financial security [3][4].

2 Literature Review

In recent years, as the Fed continues to raise interest rates, many scholars and experts have conducted research on the subject, with the status quo of some of the domestic and international research shown below:

Chen Desheng et al [5] analyzed the mechanism of the impact of the Fed's interest rate hike cycle on the world economy, international economy and trade, monetary policy, and financial market stability, focusing on the impact on China's overall economy, the RMB exchange rate and monetary policy, as well as international economy and trade. However, this author failed to provide an in-depth analysis of the impact of the Fed's rate hike from a data modeling perspective.

He Liping [6] analyzed the rise of high interest rate after the Fed shifted to a policy of interest rate hikes in 2022 and 2023, concluding that labor supply growth, asset price changes, and continuing growth of Internet giants are unique to the recent economic cycle in the US. However, this author failed to consider the problem from a micro-modeling perspective.

Tai Jinyi et al [7] analyzed the characteristics of the monetary policy of the Fed in response to the 2008 financial crisis and the 2020 pandemic, and with this as the background, quantified the global economic liquidity, and used models to study the spillover effects of the Fed's monetary policy and changes in global economic liquidity on China. They concluded that the Fed's monetary policy had a big impact on the liquidity of China's cross-border capital and that appropriate foreign exchange control measures were needed.

Qiao Hong et al [8] analyzed the whole process of the two RMB exchange rate reforms in 2005 and 2015, and also analyzed the background and reasons for the Fed's interest rate hikes in 2022. They concluded the impact of the Fed's interest rate hikes on economic entities and operations, analyzed the pressure faced by RMB's two-way fluctuation, and proposed some suggestions to the relevant government authorities in light of the current macro-policy. However, this author did not dig deeper and analyze the data.

Cheng Haolan [9] used historical data on the prices of first-class digital currencies from 2018 to 2023 and constructed an ARIMA model without Fed interest rate hikes, to compare it with the reality, in order to understand the impact of interest rate hikes on the prices of digital currencies and predict the trend of the prices of digital currencies by using the model.

Yuhuan Y et al [10], by constructing a DSGE model of a small-scale open economy including cross-border capital flows and financial frictions of supply and demand, described the negative feedback mechanism formed by the interaction between the fluctuations of the domestic real economy and the financial risks of both supply and demand under the influence of the Fed's interest rate hikes, and studied how to coordinate the monetary policy and the macro-prudential policy under the goal of maintaining stable growth and preventing risk.

However, the above literature did not examine the combined evaluation impact of the Fed's interest rate hikes in conjunction with the unemployment rate. In summary, this paper first collects data on interest rate, CPI, changes in non-farm payrolls, monthly rate of retail sales, ISM manufacturing index, and ISM non-manufacturing index from January 2022 to December 2023, and uses the statistical analysis method to set up a model of Triple Exponential Smoothing Method, to analyze changes in these macro-indicators, so as to provide suggestions and references for the relevant authorities in China.

3 Empirical Analysis

3.1 Analysis of the Response Policies of Countries

Fed rate hike: it means that the US short-term interbank lending rate rises, and the Fed uses fiscal policy to raise the interest rate on depositors' deposits. Table 1 below shows countries' policy responses during the Fed's rate hikes.

Table 1 Policy responses by countries

Country\policy	Income subsidies for employees	State credit support for enterprises	Delayed payment of social security or provision of subsidies	Delayed debt service	Cash handouts for citizens
US	Yes	Yes	Yes	No	Yes
Japan	No	Yes	No	Yes	Yes
UK	Yes	Yes	Yes	Yes	No
Germany	Yes	Yes	Yes	No	No
China	No	Yes	Yes	Yes	No
India	No	No	No	No	Yes

Judging from the policy practices adopted by countries this time, the focus is not on expanding the scale of fiscal spending, but rather on coping with the impact of the pandemic on businesses and the residential sector. It is worthwhile to analyze further the details of the policies in response to the pandemic. First, they have provided sufficient liquidity to businesses to reduce their risk of bankruptcy, which has risen as a result of the pandemic

shock; and second, they have provided compensation to workers for loss of income to hedge against personal risks when many people are unable to work or lose their jobs as a result of reduced economic activity caused by the Fed's interest rate hikes, helping to tame the risk of rising unemployment as a result of the pandemic and allowing residential sector incomes to shore up private-sector consumption so that it doesn't fall off too quickly. It is worth noting that the guarantee of workers' income is also realized primarily through corporate channels, rather than being applied for by individuals.

3.2 Data Collection and Preprocessing

By searching relevant information and literature and the Fed's related websites, the author gathered information on the US interest rate, CPI, unemployment rate, changes in non-farm payrolls, monthly rate of retail sales, ISM manufacturing index, and ISM non-manufacturing index between January 2022 and December 2023, as shown in Table 2 below.

Table 2 Data on Various Macro Indicators Related to Interest Rate Hikes in the US from January 2022 to December 2023

Date	US interest rate	CPI	US unemployment rate	Changes in nonfarm payrolls/10,000 people	Monthly rate of retail sales	ISM manufacturing index	ISM non-manufacturing index
January 2022	0.25%	0.60%	4.00%	36.40	4.90%	57.60	59.90
February 2022	0.25%	0.80%	3.80%	90.40	0.30%	58.60	56.50
March 2022	0.50%	1.20%	3.60%	41.40	0.50%	57.10	58.30
April 2022	0.50%	0.30%	3.60%	25.40	0.90%	55.40	57.10
May 2022	1.00%	1.00%	3.60%	36.40	-0.30%	56.10	55.90
June 2022	1.75%	1.30%	3.60%	37.00	0.80%	53.00	55.30
July 2022	2.50%	0.00%	3.50%	56.80	0.00%	52.80	56.70
August 2022	2.50%	0.10%	3.70%	35.20	0.30%	52.80	56.90
September 2022	3.25%	0.40%	3.50%	35.00	0.00%	50.90	56.70
October 2022	3.25%	0.40%	3.70%	32.40	1.30%	50.20	54.40
November 2022	4.00%	0.10%	3.70%	29.00	-0.60%	49.00	56.50
December 2022	4.50%	-0.10%	3.50%	23.90	-1.10%	48.40	49.60
January 2023	4.75%	0.50%	3.40%	47.20	3.20%	47.40	55.20
February 2023	4.75%	0.40%	3.60%	24.80	-0.20%	47.40	55.20
March 2023	5.00%	0.10%	3.50%	21.70	-1.00%	46.30	51.20
April 2023	5.00%	0.40%	3.40%	21.70	0.40%	47.10	51.90
May 2023	5.25%	0.10%	3.70%	28.10	0.30%	46.90	50.30
June 2023	5.25%	0.20%	3.60%	10.50	0.20%	46.00	53.90
July 2023	5.50%	0.20%	3.50%	23.60	0.70%	46.40	52.70
August 2023	5.50%	0.60%	3.80%	16.50	0.80%	47.60	54.50
September 2023	5.50%	0.40%	3.80%	26.20	0.70%	49.00	53.60
October 2023	5.50%	0.00%	3.80%	10.50	-0.10%	46.70	51.80
November 2023	5.50%	0.10%	3.70%	17.30	0.30%	46.70	52.70
December 2023	5.50%	0.30%	3.70%	21.60	0.60%	47.40	50.60

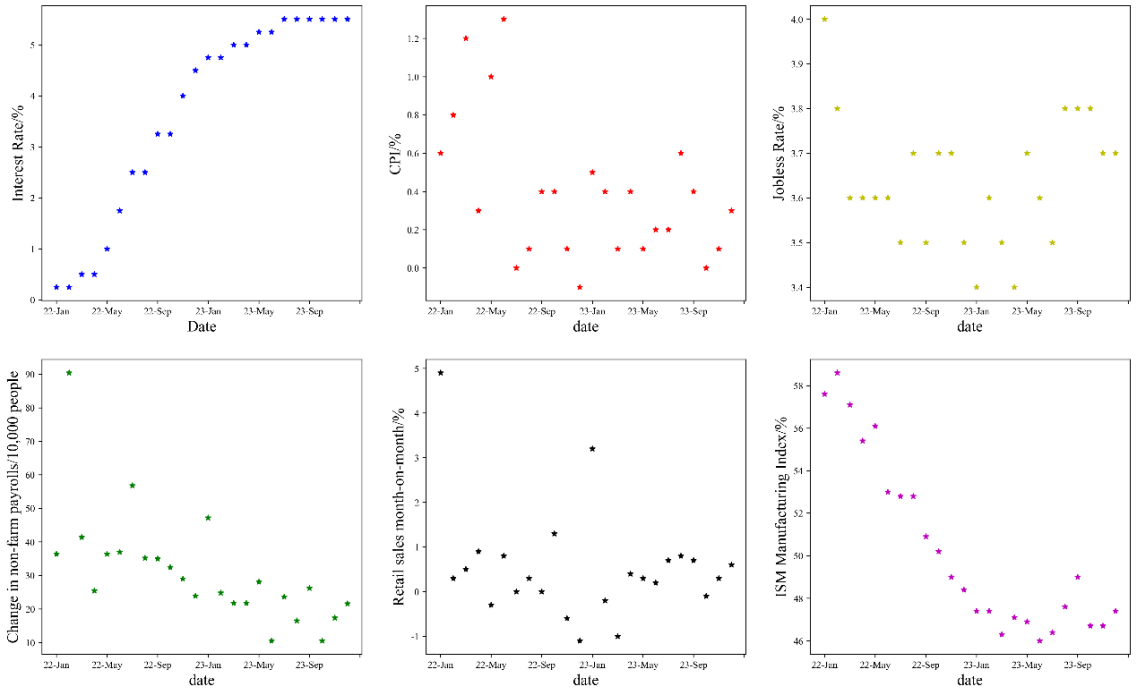

Fig. 2 Visual presentation of data on each indicator

As shown in Fig. 2 above, as interest rates keep increasing, the data on the US CPI shows a downward trend in general, the number of non-farm payrolls and the ISM manufacturing index show a downward trend, while the unemployment rate and the monthly rate of retail sales show a fluctuating trend. This suggests that there is a negative correlation between CPI, nonfarm payrolls, and ISM manufacturing index and interest rates, and there is no significant correlation between unemployment rate and the monthly rate of retail sales and unemployment. Based on the above analysis, it is possible to use the Triple Exponential Smoothing Method to establish a time series forecasting model [11], to forecast the data on each macro indicator, dig out the impact of changes in the Fed's interest rate hike policy, and offer some suggestions and countermeasures for China's relevant authorities to cope with those changes.

3.3 Modeling

3.3.1 Determining initial values and weighting factors

When the number of periods of this original time series is less than 25 items, it can be assumed that the initial value has a big impact on the prediction results, and thus the average value of the first three periods of the original data is chosen as the initial value. The weighting factorα is a scale factor that plays a different role in the prediction process for old and new data $0 < \alpha < 1$. Normally, different trends and fluctuations in the time series correspond to different αvalues.

3.3.2 Calculation formula

Triple exponential smoothing is a further smoothing based on second exponential smoothing, as calculated by the formula below:

$$\begin{cases} S_t^{(1)} = \alpha y_t + (1-\alpha) S_{t-1}^{(1)} \\ S_t^{(2)} = \alpha S_t^{(1)} + (1-\alpha) S_{t-1}^{(2)} \\ S_t^{(3)} = \alpha S_t^{(2)} + (1-\alpha) S_{t-1}^{(3)} \end{cases} \quad (1)$$

The prediction model of the Triple Exponential Smoothing Method is

$$\hat{y}_{t+m} = a_t + b_t m + c_t m^2, m = 1,2,\dots,n \quad (2)$$

In this formula,

$$\begin{cases} a_t = 3S_t^{(1)} - 3S_t^{(2)} + S_t^{(3)} \\ b_t = \frac{\alpha}{2(1-\alpha)^2}[(6-5\alpha)S_t^{(1)} - 2(5-4\alpha)S_t^{(2)} + (4-3\alpha)S_t^{(3)}] \\ c_t = \frac{\alpha^2}{2(1-\alpha)^2}\left[S_t^{(1)} - 2S_t^{(2)} + S_t^{(3)}\right] \end{cases} \quad (3)$$

$\hat{y}_{t+m}$ is data on the current US CPI, unemployment rate, change in nonfarm payrolls, monthly rate of retail sales, and ISM manufacturing index; mis the number of periods over which forecasts are made; a_t、b_t、$c_t$is the forecast factor of the tth year; $S_t^{(1)}, S_t^{(2)}, S_t^{(3)}$ are the values of the first, second, and triple index smoothing corresponding to the tth year, respectively; $\alpha$is the weighing factors and$0 < \alpha < 1$; and$S_{t-1}^{(1)}, S_{t-1}^{(2)}, S_{t-1}^{(3)}$ are the initial smoothing values of the first, second, and triple index smoothing, respectively.

3.3.3 Conducting data forecasting

Substitute the obtained initial value and weighing factorα into formula (1) to get the value of the new series of first, second and triple smoothing; calculate the prediction factors of each year according to formula (3) to provide a basis for the calculation of triple exponential smoothing; according to the triple exponential smoothing formula (2), select suitable indexes of advance prediction to forecast the future data, and get the final results.

3.4 Solving the Model and Analyzing the Results

By substituting the above data into the established time series model and solving it using Python programming, the results are shown in Table 3 below, giving the forecast data for each macro indicator for the next six months. It can be observed that the forecast data shows some fluctuations, which is close to the reality and has a high fidelity.

Table 3 Results of macro data forecasts by indicator for January-June 2024

Date	US interest rate	CPI	US unemployment rate	Changes in nonfarm payrolls/10,000 people	Monthly rate of retail sales	ISM manufacturing index	ISM non-manufacturing index
January 2024	5.39%	0.82%	3.61%	43.20	4.85%	47.23	55.58
February 2024	5.31%	0.77%	3.75%	32.28	1.41%	58.60	55.61
March 2024	5.42%	0.53%	3.64%	22.94	0.91%	57.10	52.76
April 2024	5.27%	0.70%	3.56%	24.95	2.40%	55.40	53.45
May 2024	5.40%	0.59%	3.83%	35.89	2.48%	56.10	52.37
June 2024	5.35%	0.69%	3.77%	22.18	2.71%	53.00	55.95

The forecast data shows that in the next six months, US interest rates are likely to remain unchanged or decline slightly, CPI data shows a downward trend, the number of non-farm payrolls is decreasing, and the unemployment rate and the ISM manufacturing index will fluctuate at a certain level. In general, CPI could not fall further after reaching this point, and it will rebound. This suggests the limited effect of interest rate hikes. If interest rates continue to rise, the negative effects may even engulf the US economy [12]. Now US companies can not endure cost rises brought about by interest rate hikes, and are eagerly expecting the Fed to lower interest rates, but the Fed is non-committal. The US used to take a consistent policy of low interest rates to stimulate economic growth, and this

time, the intensive interest rate hikes are abnormal. However, the interest rate adjustment will backfire and is not sustainable, and will certainly move into a track of interest rate cuts.

4 Conclusion

In this paper, after analyzing the policies of countries to respond to the Fed's interest rate hike, the author collected data on macro indicators related to the US interest rate hikes from January 2022 to December 2023, and after making descriptive statistical analysis and correlation analysis, used the theory of triple exponential smoothing method to conduct time-series modeling, predicted the data of each indicator in the next six months, analyzed the impact brought about by changes in the US interest rate hikes, and finally made some conclusions.

Today, the world is undergoing unprecedented changes and problems of uncertainty, instability and imbalance in the world economic recovery are still prominent, and divergences have emerged in the economic trends and policy directions of countries, making the external environment faced by China even more complex and severe [13] [14]. Drawing on international experience, China can use the impact stress test and the policy of expanding domestic demand and other ways to anticipate the impact path and shock effect of the Fed's unexpected interest rate hikes on its economy, investment, foreign trade and other aspects, and make appropriate management and control plans and policy reserves [15].

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