Exchange Rate Volatility and Correlation Between China, Japan and the U.S

Zhuolun Wu[1*+], Conglin Xie[2+], Dongcheng Liang[3+], Boran Yang[4+]

*Corresponding author email: zhuolun@ucsb.edu

[1]College of Engineering & College of Letters and Science, University of California Santa Barbara, Santa Barbara, 93106, United States

[2]School of International Education Cooperation College, Tianjin University of Commerce, Tianjin, 300134, China, 3087656892@qq.com

[3]School of College of Art and Science, New York University, New York, 10012, United States, eddie030612@gmail.com

[4]School of Nature Science, University of Manchester, Manchester, M130JQ, United Kingdom, boran23619@163.com

+These authors contributed equally to this work and should be considered co-first authors.

Abstract. In this essay, we first examine the factors that influence the volatility of the exchange rates between China, Japan, and the United States from 2013 to 2023. And also explains the factors that affect the correlation between the three countries in currency exchange markets. We then establish a clear, explicit model for the role of exchange rate variations between China, Japan, and the United States before examining how and to what degree exchange rate fluctuations affect volatility and correlations in currency exchange rate markets. In this study, we gather the ten-year currency exchange rate and compute the volatility using RIDGE-Model and Python. According to the evidence in this research, local market volatility is mostly increased by larger currency exchange rate unpredictability. In addition, the correlation between the three nations reveals that while exchange rate changes between China and the U.S. are minimal, those between Japan and the U.S. are quite substantial.

Keywords: exchange rate volatility, correlation, the Ridge model.

1 Introduction

Due to the various economic landscapes, the value of the currency is different. For example, when the United States is economically developed, the value of the dollar is high, while Vietnam's economy is relatively backward, and the value of the Vietnamese Dong is low. Therefore, a country's currency against the currency of other countries provides a rate of exchange, that is, the exchange rate, which is the most important adjustment lever in international trade. Because the cost of the goods produced by a country is calculated according to its own currency, to compete in the international market, its commodity cost will be related to the exchange rate. The level of exchange rate affects the cost and price of the commodity in the international market, which directly affects the international competitiveness of the commodity.

ICBBEM 2024, March 29-31, Wuhan, People's Republic of China

DOI 10.4108/eai.29-3-2024.2347314

This paper develops a direct, explicit model for the role of exchange rate fluctuations between three countries: China, Japan and the United States, and examines how and to what extent volatility and correlations in currency exchange rate markets are influenced by exchange rate fluctuations. In addition, the impact of exchange rate fluctuations on transactions between countries and the reasons behind exchange rate fluctuations are also discussed. Evidence presented in this paper indicates that a higher currency exchange rate variability mostly increases local market volatility. In this paper, we collect the ten-year currency exchange rate and use Python to calculate the volatility. The result shows that the exchange rate fluctuations between Japan and the U.S. are very large, but the exchange rate fluctuations between China and the U.S. are small. Those patterns are observed both through rigorous statistical analysis and analysis of geopolitical and economic events.

Exchange rate fluctuations are affected by many factors, such as interest rates, inflation, and the macroeconomic policies of various countries. Take the interest rate as an example, if the ruler of a country raises the interest rate of the country and expects to raise the interest rate of the country's currency, then the inflow of foreign capital is undoubtedly attractive, and the demand for the country's currency will increase, and the exchange rate will rise. In the macroeconomic policies of various countries, especially the fiscal and financial policies, the exchange rate is greatly affected. Tight monetary policy, rising foreign exchange rate; Loose monetary policy, the foreign exchange rate of the currency fell. In the recent study, we became interested in studying volatility, and then we chose the US dollar, Japanese yen and RMB as research objects to explore the exchange rate volatility among these three currencies and the correlation between them.

2 Literature Review

2.1 Exploring Correlation and Volatility

Exchange rates serve as the foundation of international trade and financial interactions, exerting significant influence on economic policies and shaping the global financial landscape. This literature review delves deep into the correlation and volatility of exchange rates between China, Japan, and the U.S., striving to uncover the underlying reasons driving their fluctuations. Through the utilization of the Ridge model, this essay aims to offer a comprehensive understanding of the intricate dynamics governing these currencies. Through rigorous analysis using the Ridge model, this study provides a comprehensive exploration of the correlation and volatility of exchange rates among China, Japan, and the U.S. We consider into historical data and macroeconomic drivers to identify key factors that influence the correlation and fluctuations in these exchange rates.

2.2 Understanding Underlying Drivers

In this literature review, we scrutinize a plethora of factors that contribute to exchange rate fluctuations. Geopolitical events, monetary policies, economic indicators, and market sentiments are carefully examined to understand their roles in shaping the relationships between the currencies.

2.3 Implications for International Trade and Finance

The results of this statistical model analysis have significant implications for international trade and finance. Understanding the correlation and volatility dynamics allows policymakers, investors, and businesses to make informed decisions, manage risks, and devise effective strategies to navigate the ever-changing global economic landscape.

2.4 Effect of economic data on currency exchange market

There are many theoretical and empirical studies analyzing currency exchange market influences of real economic data swings. Fexco International Payments provides several examples of the influence factors of currency exchange rates [1]. Lai and Zhu reviewed the relationship between GDP and currency exchange rate [2]. Yadav and Jameel also mentioned the influence on the currency exchange rate by the GDP growth rate, inflation rate and interest rate [3]. Using various models and assumptions, theoretical studies showed currency exchange market effects of economic data and uncertain events [1,3,4,5]. As analyse by Lai and Zhu, in order to make sure the impact of GDP on the currency exchange market, different models and methods are used for visual data processing [2,5]. AKARSU shows the impact of the unemployment rate on the currency exchange market [6].

2.5 Effect of Non-trade factors on the currency exchange market.

Some studies focus on how non-trade factors affect currency exchange rates. As highlighted by Lang and Li, “Trump’s tweets provide us with a unique perspective”, which has a negative impact on the currency exchange rate volatility [7]. And for events, like the China-US trade war in 2018, the Covid-19 epidemic in 2020, and the Russia-Ukraine war in 2022 have all had a great impact on the economy, leading to the depreciation of the country’s currency or the appreciation of other countries’ currencies, leading to fluctuations in currency exchange rates. Different documents provide specific analyzes for different events [8-12].

2.6 Correlation of different countries' currency exchange rate

As we can see, the world is an economic community. No matter which country has an economic crisis, it will affect the countries with which it trades more. Therefore, there is also a certain relationship between the currency exchange rates between countries [5]. The strength of relations between different countries also varies. At the same time, due to the impact of some political events and natural disasters, different countries are affected to different degrees, so there will be different results in the relationship between currency exchange rates [10,12,13].

3 Method

3.1 Data Collection

The first step in analyzing the volatility and correlation of foreign exchange markets is to collect the necessary data. Historical exchange rate data for the target currency pairs is essential for calculating both volatility and correlation. Our data consists of China, Japan and the U.S. currency exchange rate in terms of each other: CNY/JPY, CNY/USD, JPY/USD. The daily closing rates were obtained from the database DataStream for the period from 1 June 2013 to 1 June

2023, which corresponds to a total of 7832 data points. The choice of these countries is not just because they provide a good geographical representation of the continent, but they're very representative of the world's currencies according to the gross domestic product (see Table 1).

Table 1. US China Japan's share of global GDP in 2022 [Owner-draw].

#	Country	Share of World GDP
1	United States	24.08%
2	China	15.12%
3	Japan	6.02%

3.2 Calculation of Volatility

Volatility, a measure of price fluctuations, is a key parameter in assessing risk and market behavior. In this study, we utilize the standard deviation of a certain time window on daily closing values or variance of logarithmic returns to calculate volatility.

3.2.1 Fixed window size t Volatility Calculation

The volatility for a given currency pair on a certain time window n can be calculated using the following formula:

$$\sigma_t = \sqrt{\frac{\sum_{i=1}^{N}(x_i - \bar{x}_i)^2}{N-1}} \quad (1)$$

where x_i is daily closing value. Following common practice, first we chose every six months followed by a step size of 1 as a basic unit of data, because there are 180 days in a six-month period, and then subtracting the weekends, there are only 128 days left in the end, so in the calculations and subsequent results, every 128 days is a window size.

3.2.2 Logarithmic Returns Calculation

Alternatively, logarithmic returns can be used for a more accurate representation of percentage changes:

$$Return_t = \ln\left(\frac{Closing\ Price_t}{Closing\ Price_{t-1}}\right) \quad (2)$$

After calculating logarithmic returns, the variance of these returns can be computed to determine the volatility of the currency pair.

3.2.3Normalization of volatility

When we want to compare different volatilities of these three markets, We have noticed that each market exists a different magnitude of order in its exchange rate. This will affect the actual fluctuation when comparing each volatility with others due to the nature of the method. Specifically, the first method involves the standard deviation of the raw sample data. In order to compare resulting volatility from different sample data. We have to normalize the results by dividing them with their population mean. In this case, the effect of magnitude of currency pair is minimized to 1.

3.3 Calculation of Correlation

Correlation measures the degree to which two currency pairs move in relation to each other. A positive correlation indicates that the pairs move together, while a negative correlation suggests an inverse relationship. Pearson's correlation coefficient is commonly used to measure correlation between two currency pairs' returns. As a result, we choose the Log-calculated volatility to compute the correlation. But we could plot the different correlation graphs based on two different volatility calculation to see the pattern in the following section. The formula for calculating the correlation coefficient r between two sets of returns is:

$$r = \frac{\sum((X_i - \bar{X})(Y_i - \bar{Y}))}{\sqrt{\sum(X_i - \bar{X})^2 \sum(Y_i - \bar{Y})^2}} \quad (3)$$

Where: - $X_i$and Y_i represent the returns for currency pair X and Y on time unit i. $-\overline{X}$ and $\overline{Y}$ are the means of the respective returns.

3.4 Statistical Model

To interpret the results, additional statistical analysis is performed. This section aims to explore potential factors influencing the correlation, from factors related to inner data to economic events or geopolitical factors.

3.4.1 Linear Regression

To identify which components of the data can best explain the correlations between currency pairs, linear regression can be employed. Linear regression models the relationship between a dependent variable (correlation) and one or more independent variables (components of data). Each independent variable represents a potential explanatory factor.

3.4.2 Multicollinearity, VIF, and Ridge Model

Multicollinearity, the presence of high correlations among independent variables, can lead to unstable and unreliable regression estimates. Ridge regression is an effective technique to handle multicollinearity. It introduces a regularization term that helps stabilize the estimates by penalizing large coefficient values. One way to assess multicollinearity is by calculating the Variance Inflation Factor (VIF), which measures how much the variance of the estimated regression coefficients is increased due to multicollinearity, and is given by:

$$VIF(\widehat{\beta_j}) = \frac{1}{1 - R_j^2} \quad (4)$$

where:

$\widehat{\beta_j}$ is the estimated coefficient for predictor variable X_j,

R_j^2 is the coefficient of determination for the regression of X_j

A VIF of 1 indicates that there is no correlation among the kth independent variable and the remaining independent variables, and hence the variance of β is not inflated at all. As a rule of thumb, a VIF value that exceeds 5 or 10 indicates a problematic amount of multicollinearity.

Table 2. VIF for CNY-JPY and USD-CNY/ CNY-JPY and USD-JNY/ USD-JPY and USD-CNY. [Owner-draw].

	VIF Factor	Features
0	74702.224034	Const
1	572.252958	CNY-JPY
2	562.637387	USD-JPY
3	153.038877	USD-CNY
4	22.052911	Volatility of CJ
5	22.291821	Volatility of UJ
6	2.466919	Volatility of UC
Mean Squared Error:0.20907716252727732		

	VIF Factor	Features
0	74702.224034	Const
1	572.252958	CNY-JPY
2	562.637387	USD-JPY
3	153.038877	USD-CNY
4	22.052911	Volatility of CJ
5	22.291821	Volatility of UJ
6	2.466919	Volatility of UC
Mean Squared Error:0.15538983547660443		

	VIF Factor	Features
0	74702.224034	Const
1	572.252958	CNY-JPY
2	562.637387	USD-JPY
3	153.038877	USD-CNY
4	22.052911	Volatility of CJ
5	22.291821	Volatility of UJ
6	2.466919	Volatility of UC
Mean Squared Error:0.26340197240269647		

From the VIF test (see Table 2), we can see that we choose the volatility and exchange return rate as independent variables, and there are strong multicollinearity in these three correlations. Therefore, we will apply the Ridge Model to quantify the importance of the data. In Ridge Regression, the objective is to minimize the following cost function:

$$J(\beta) = \sum_{i=1}^{n} (y_i - X_i^T \beta)^2 + \lambda \sum_{j=1}^{p} \beta_j^2 \quad (5)$$

Where:

n is the number of data points, p is the number of predictor variables, y_i is the observed response for data point i, $\mathbf{x}_i$ is the vector of predictor variables for data point i, β is the vector of regression coefficients, λ is the regularization parameter controlling the strength of regularization.

The Ridge Regression solution is given by:

$$\hat{\beta}_{ridge} = (X^T X + \lambda I)^{-1} X^T y \quad (6)$$

Where:

$\hat{\beta}^{ridge}$ is the vector of Ridge Regression coefficients,

X is the design matrix of predictor variables, **y** is the vector of response values, **I** is the identity matrix.

Ridge Regression helps address multicollinearity and provides more stable coefficient estimates by introducing regularization into the linear regression framework.

4 Results

The methodology outlined above provides a robust framework for calculating volatility and correlation in the foreign exchange market. By utilizing rolling window or logarithmic returns and employing Pearson's correlation coefficient, this study aims to provide valuable insights

into the behavior and interdependencies of currency pairs within the dynamic foreign exchange market.

4.1 Analysis of Volatility from Plot

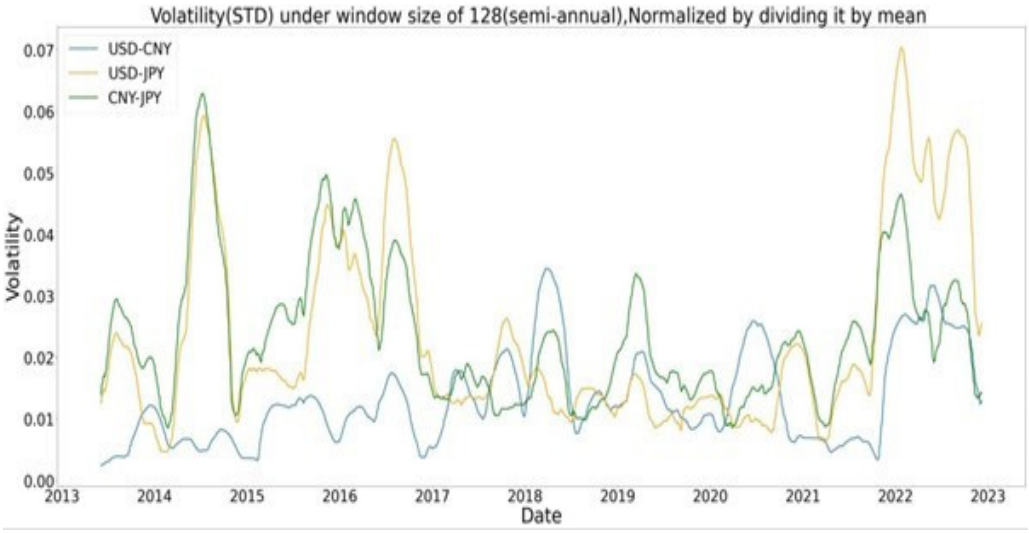

Fig. 1. shows the exchange rate volatility (sized for semi-annual, but excluding weekends [Owner-draw].

In this thesis, Fig. 1 offers a comprehensive illustration of the exchange rate volatility among the US dollar (USD), the Chinese yuan (CNY), and the Japanese yen (JPY) over ten years (June 2013 to June 2023). Figure 1 vividly displays significant volatility in the currency pairs USD/JPY (orange line), USD/CNY (blue line), and CNY/JPY (green line), representing their exchange rates. The USD/JPY currency pair (orange line) features the US dollar as the quoted currency and the Japanese yen as the base currency, both being prominent reserve currencies in the global financial landscape. Similarly, the USD/CNY pairing (blue line) has the US dollar as the quoted currency and the Chinese yuan as the base currency, both of which hold significant importance in international monetary systems. Moreover, the CNY/JPY currency pair (green line) showcases the Chinese yuan as the quoted currency and the Japanese yen as the base currency, being widely recognized and heavily traded in global financial markets. The depicted exchange rate volatility in Fig. 1 holds crucial significance for understanding the dynamic interactions between these major currencies over the ten-year period. As the thesis further investigates the underlying factors driving this volatility and correlation, it contributes to a comprehensive understanding of the implications for international trade and finance.

4.1.1 Factors that affect Volatility.

The concept of currency volatility, as defined by Taylor.J, revolves around the standard deviation of day-to-day changes in the logarithm of the exchange rate [14]. In the context of the exchange rate between the Chinese yuan (CNY), the US dollar (USD), and the Japanese yen, several significant factors can influence its volatility.

Political events hold a prominent position among these factors, as they can strongly impact investor sentiment and the perceived stability of a country's economy. Instances of trade tensions between China and the US, along with diplomatic conflicts, have been observed to lead to increased volatility in the exchange rate.

Social statements made by national leaders also play a role in influencing currency volatility. According to research by Lang and Li, negative tweets from former President Trump concerning China's economic and trade concerns correlate with an increase in volatility [7]. Moreover, this effect is further amplified by fluctuations in the VIX index and the leader's disapproval rating.

Economic data, such as GDP, inflation, and employment figures, along with changes in interest rates and market sentiment, contribute to fluctuations in currency exchange rates. Adjustments in a country's interest rates by its central bank can impact the attractiveness of its currency to investors seeking higher returns, thereby influencing currency strengthening or weakening. Market sentiment, reflecting the overall mood and outlook of investors, is another significant factor in the equation. Optimism about a country's economic prospects can bolster its currency, while pessimism can lead to depreciation and increased volatility.

4.1.2 Specific events

In early 2018, all three countries experienced relatively low unemployment rates, while their inflation rates exhibited an upward trend. China's unemployment rate witnessed a notable surge from less than four percent to over five percent, indicating potential challenges in its labor market. Meanwhile, both the United States and Japan maintained steady unemployment rates at around four percent, reflecting relative stability in their respective job markets. Additionally, during this period, inflation rates in China, Japan, and the United States all increased, albeit by varying amounts. These similar domestic economic conditions at the beginning of 2018 contributed to a positively correlated exchange rate relationship between the Chinese yuan (CNY), the US dollar (USD), and the Japanese yen (JPY). In other words, when the value of one currency increased, the values of the other currencies tended to rise as well, reinforcing their interdependence and shared economic linkages.

The outbreak of the COVID-19 pandemic in 2019 and early 2020 had a profound impact on the global economy, leading to significant changes in the economic conditions of the three countries. As the pandemic spread, China's inflation and unemployment rates experienced substantial rises due to the economic disruptions caused by lockdowns and restrictions. The measures implemented to contain the virus's spread had notable implications for China's labor market and overall economic activity. Similarly, the United States experienced a sharp and unprecedented increase in unemployment rates, reaching levels above 15 percent. The widespread job losses were a direct consequence of the pandemic's severe impact on businesses and various industries. In contrast, Japan, being relatively less affected by the virus compared to the US and China, saw relatively stable unemployment and inflation rates, indicating a more resilient economic performance during this challenging period.

Throughout the specified decade, the USD/JPY exchange rate exhibited notably higher volatility, which can be attributed in part to the impact of Abenomics, an economic policy introduced by Japanese Prime Minister Shinzo Abe in late 2012. Abenomics aimed to address Japan's economic challenges, including deflation, stagnant growth, and a strong yen, through three main

“arrows”: monetary easing, fiscal stimulus, and structural reforms. The effects of Abenomics on the USD/JPY exchange rate can be explained as follows:

Monetary Easing Measures: Under Abenomics, the Bank of Japan implemented aggressive monetary easing measures, including quantitative easing and purchasing government bonds, to increase the money supply and create a low-interest-rate environment. Consequently, the Japanese yen weakened relative to the US dollar, leading to an appreciation of the USD/JPY exchange rate. This made one US dollar capable of purchasing more yen, supporting Japan’s export competitiveness.

Inflation Target: As part of Abenomics, the Bank of Japan committed to raising the inflation target to 2 percent. This commitment further contributed to the depreciation of the yen. Investors anticipated that a higher inflation target would result in more monetary easing, leading to a weaker currency. This, in turn, added to the appreciation of the USD/JPY exchange rate, as the yen’s value declined relative to the US dollar.

Additionally, the uncertainty surrounding the UK’s Brexit referendum in June 2016 had a notable impact on the USD/JPY exchange rate. The uncertainty over the outcome of the referendum led investors to seek safe-haven assets, causing an appreciation of the Japanese yen against the US dollar. The perceived safe-haven status of the yen reinforced its demand and contributed to fluctuations in the USD/JPY exchange rate during the period leading up to and after the referendum.

Moreover, the outbreak of the COVID-19 pandemic in early 2020 induced widespread uncertainty and risk aversion among investors, leading to a surge in demand for safe-haven assets like the Japanese yen. Consequently, the yen appreciated against the US dollar, resulting in increased exchange rate volatility. The disruptions caused by the pandemic in global trade, supply chains, and economic activities further added to the fluctuations in the exchange rate during this period. In conclusion, the increased exchange rate volatility between the US dollar and the Japanese yen during the specified decade can be attributed to the combined effects of Abenomics and its monetary policies, the uncertainty and safe-haven demand triggered by Brexit, and the global risk aversion driven by the COVID-19 pandemic. These complex and interrelated factors significantly influenced the USD/JPY exchange rate, warranting close attention and analysis for traders and investors during the period under review.

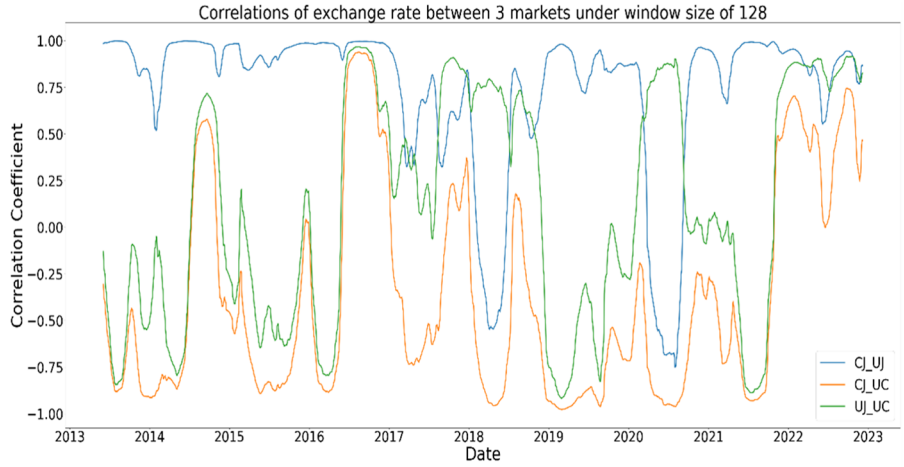

Fig. 2. Correlation of Exchange Rate Between 3 markets [Owner-draw].

Fig. 3. GDP Growth, Inflation and Unemployment Rate (2013-2023).

4.2 Analysis correlation of exchange rate

4.2.1 Data Analysis

Figure 2 shows the correlation between the three market exchange rates from 2013 to 2023, with the blue line representing the correlation between the Japan-China exchange rate and the Japan-US exchange rate, the orange line representing the correlation between the Sino-Japanese exchange rate and the Sino-US exchange rate, and the green line representing the correlation between the US-Japan exchange rate and the US-China exchange rate. From Figure 3, we can see that the orange line and the green line go in roughly the same direction, while the blue line goes in a slightly different direction from the other two.

Figure 3 shows GDP growth, inflation, and unemployment for China, the United States, and Japan from 2013 to 2023, with the blue line for China, the orange line for the United States, and the grey line for Japan. On the GDP growth chart, we can see that the blue line is the highest, the second is the orange line, the grey line is the lowest, and the trend of the three lines is basically the same. In the inflation chart, we can see that the three lines are not in the same direction, where the grey line is more stable, and the blue and orange lines are more variable. In the unemployment rate plot, the orange line is higher, the blue line and the grey line are lower, and the trend is downward.

Table 3. Three countries' economic data [Owner-draw].

Country Name	Country Code	Indicator Name	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
China	CHN	Unemployment, total (% of total labor force) (national estimate)	4.05	4.1	3.8	4	3.9	4.93	5.15	5.61	5.11	5.62
United States	USA	Unemployment, total (% of total labor force) (national estimate)	7.37	6.17	5.28	4.87	4.36	3.9	3.67	8.05	5.35	3.65
Japan	JPN	Unemployment, total (% of total labor force) (national estimate)	4.04	3.59	3.39	3.13	2.82	2.47	2.35	2.81	2.83	2.6

Country Name	Country Code	Indicator Name	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022

China	CHN	GDP growth (annual %)	7.766	7.4258	7.0413	6.8487	6.9472	6.7498	5.9505	2.2386	8.4475	2.9908
United States	USA	GDP growth (annual %)	1.8419	2.2878	2.7064	1.6675	2.2419	2.9454	2.9444	-2.7678	5.9455	2.0616
Japan	JPN	GDP growth (annual %)	2.0051	0.2962	1.5606	0.7538	1.675	0.6433	-0.4022	-4.2786	2.1424	1.0286

Country Name	Country Code	Indicator Name	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
China	CHN	Inflation, GDP deflator (annual %)	2.1633	1.0311	-0.0029	1.4073	4.2327	3.4997	1.2867	0.4925	4.5533	2.2473
United States	USA	Inflation, GDP deflator (annual %)	1.7509	1.8699	1.0005	1.0022	1.8996	2.4041	1.7939	1.3049	4.4928	7.0053
Japan	JPN	Inflation, GDP deflator (annual %)	-0.3544	1.6863	2.1112	0.4199	-0.0743	-0.0002	0.6348	0.9442	-0.2275	0.2445

Table 3 shows that, in 2018, the unemployment rates in all three countries were relatively low than in other years. China's unemployment rate is growing from less than 4% to nearly 5%. Meanwhile, the U.S. unemployment rate stabilized at around 4%. And Japan's unemployment rate for 2018 stayed at a steady value of around 3%. At the same time, the inflation rate in all three countries, China, Japan, and the United States, rose by some amount in early 2018. Turning to GDP, China's robust GDP growth of 6.74% with the United States 2.94% and Japan's 0.64%. According to Table 3 in 2020, the unemployment rate of China is about 5.61%, while the U.S. unemployment rate experienced a sharp increase, reaching levels above 8%, and Japan with 2.81%. The GDP growth is all decreased in three countries. And the inflation rate is low in three countries, 2.23%, -2.76%, -4.27% respectively.

4.3 Year-Specific Discussions

4.3.1 In 2014

The currency exchange rate is defined as the price of the currency from one country against the currency of another country so that the exchange rate can be valued or expressed in the currency of another country [5]. Fexco International Payments lists inflation, political stability, and terms of trade as the major causes of the change in currency exchange rate [1]. Kartono et al. also confirm a relationship between the GDP and the exchange rate [5]. In Table 1, it can be seen that in 2014, the correlation between orange, green and blue lines was high, exceeding 0.5. From

the macro analysis, it is affected by the economic cycle. In 2014, China's economy continued to grow, with increased demand for exports to Japan and the United States. While the economies of Japan and the United States are recovering, demand for Chinese goods has also increased. The second is influenced by policy. In 2014, the Chinese government introduced a series of policies to promote exports, which made the prices of Chinese goods in Japan and the United States relatively lower, and the export demand for Japan and the United States increased [15]. Therefore, the correlation between the China-Japan market and the China-US market increased in 2014. For exports and imports, the relationship between exchange rate fluctuations and trade is reversed. The reasons for the high correlation can be analysed according to Table 3 of GDP growth, inflation and unemployment rate. In 2014, China's GDP growth rate was 7.4%, and the GDP growth rate of the United States and Japan showed an upward trend [2]. It can be seen that the economic development of the United States, Japan and China is developing in a good direction. The second is inflation. In 2014, inflation in China, Japan and the United States did not exceed 2%. Inflation is low, market prices are stable and the value of the currency is stable, so the exchange rate between the two is positive [3]. The third chart is the change in the unemployment rate. As can be seen from this chart, the unemployment rate of the three countries showed a downward trend in 2014, indicating that the market economy of the three countries is developing well. From these three aspects, it can be seen that the exchange rate between the US dollar and the Japanese yen is positively correlated, the exchange rate between RMB and the Japanese yen is positively correlated, and the exchange rate between the US dollar and Japanese yen is positively correlated, so the correlation between blue, orange and green lines becomes higher in Table 1 of 2014.

4.3.2 In 2016

In Figure 2, the orange and green lines have become higher since 2016. The higher orange line indicates that the correlation between the exchange rate of Japan-China and the exchange rate of China-US is higher, and the higher green line indicates that the correlation between the exchange rate of Japan-US and the exchange rate of the United States and China is higher. From the macro analysis, in 2016, China's economy slowed down, which may lead to Chinese capital outflows in search of better returns [4]. That could make Chinese investors more inclined to invest their money in overseas markets, including the U.S. and Japan. This could lead to an increased correlation between the Chinese and Japanese markets. At the same time, in 2016, Sino-US trade relations were tense, which could lead to an increased correlation between Chinese and US markets [15]. If the trade relationship between the two countries is tense, then the markets between them may affect each other. For example, if trade frictions between the two countries intensify, it could cause the stock prices of some companies to fall, which could affect their trading in both markets. According to the analysis of Figure 2, in 2016, China's GDP growth rate was relatively high, at 6.7%, while Japan and the United States GDP growth rate was relatively low, at about 2% [2]. However, the GDP growth rate of Japan and the United States had a slight increase, so the national economic development was growing. As can be seen from the inflation chart, the inflation rate of these three countries is very low, within the normal range, so price fluctuations are not large, and market stability is conducive to economic development [3]. China's inflation rate is higher than that of the United States and Japan, so the exchange rate of the yuan against the dollar and the yen has depreciated to some extent, but it has moved in the same direction. So, the correlation between them is relatively high. As can be seen from the picture of the unemployment rate, the unemployment rate of the three countries showed a downward trend in 2016, but the unemployment rate of China was relatively high, at 5%. From the information in these charts, the RMB depreciated slightly at that time, while the

yen and US dollar appreciated, and the appreciation rate of the yen was greater than that of the US dollar. Therefore, the exchange rate between them is changing in a positive way. Therefore, in Table 1 of 2016, the orange and green lines become higher.

4.3.3 In 2018

During 2018, the unemployment rate affected the volatility of the currency exchange rate by consumer confidence. High levels of unemployment can lead to a decline in consumer confidence, as people become less optimistic about their job prospects and spending power. This can lead to a reduction in consumer spending, which can slow economic growth and lead to a weaker currency. A weaker currency can increase volatility in the currency exchange rate, as investors may become more hesitant to invest in the currency if they perceive it to be less stable. When a country has a high inflation rate, the purchasing power of its currency decreases, which means that it can buy fewer goods and services. This makes the country's exports less attractive to foreign buyers, as they will have to pay more for the same goods in the country's currency. As a result, the demand for the country's currency decreases, which leads to a decrease in its exchange rate relative to other currencies. Turning to GDP growth in Table 3, China's robust GDP growth of 6.5 %s may increase investor confidence in the country's economy, leading to higher foreign investment and demand for the CNY. As a result, the exchange rate of the CNY against the JPY and the USD may strengthen. This could lead to a positive correlation between the CNY/JPY and CNY/USD exchange rates. This proves that the domestic economic situation of all three countries was basically similar at the beginning of 2018, so their currency exchange rate relationship was positively correlated during this period. This led to a positively correlated exchange rate relationship between China, Japan and the United States during this period. According to the research, conclude that "the effect of the U.S.-China trade war on the dependences of EUR-CNY is apparently muted" [10]. The EUR-CNY dependence continues to fluctuating with a slightly upward trend in the post-war period. And for Japan, which is not directly exposed to the trade war between China and the U.S., we expect appreciation in JPY and lower dependencies with CNY because of the hedging attribute of JPY."

4.3.4 In 2020

In 2020, the COVID-19 pandemic had a severe impact on the global economy, leading to significant changes in the economic conditions of these countries. According to Table 3, China's inflation rate and unemployment rate both saw significant rises, likely due to the economic disruption caused by lockdowns and restrictions. Similarly, the U.S. unemployment rate experienced a sharp increase, reaching levels above 8 %s, due to widespread job losses caused by the pandemic's impact on businesses. Narayan reveals that the Covid-19 pandemic has a temporary effect on the shock to the Yen-US ex-change rate [9]. Japan, being less affected by the covid-19, saw relatively stable unemployment and inflation rates. The significant changes in economic indicators and unemployment rates in China and the U.S. during this period could have led to a negative correlation in the exchange rate relationship between these countries. A negative correlation means that when the value of one currency increases, the value of the other currency tends to decrease. This suggests that during the pandemic, while the exchange rates of the USD and JPY remained stable or strengthened, the exchange rate between the RMB and USD moved in the opposite direction, likely weakening relative to the USD. Japan's GDP growth rate of 1 % suggests moderate economic expansion. While the JPY might not experience significant appreciation or depreciation, it could still respond to global economic trends and changes in investor sentiment. The exchange rate of the JPY against the CNY and USD may remain relatively

stable, resulting in a weaker correlation with other currencies. It's important to note that exchange rate correlations are influenced by multiple factors, and GDP growth is just one of them. Other economic indicators, interest rates, trade balances, and political events also play significant roles in shaping the exchange rate relationships between these countries.

4.4 Results from Ridge Model

In this section, we present the results of the analysis using the Ridge regression model to study the correlation between currency pairs in the foreign exchange (forex) market. The Ridge regression model has been widely used in financial analysis due to its ability to handle multicollinearity and potentially improve predictive accuracy. The objective here is to assess the correlation structure among different currency pairs and gain insights into their interactions.

4.4.1 Correlation Analysis

We applied the Ridge regression model to study the correlation among currency pairs. The model allows us to quantify the strength and direction of relationships between exchange rates while controlling for potential confounding variables. The resulting coefficients provide insights into the impact of each currency pair on the others.

4.4.2 Results and Interpretation

In this work, the analysis revealed several interesting findings regarding currency pair correlations (see Figure 4, Figure 5, Figure 6). The Ridge model coefficients indicate the relative importance of each currency pair in predicting the exchange rates of other pairs. Positive coefficients suggest a positive correlation, while negative coefficients indicate a negative correlation.

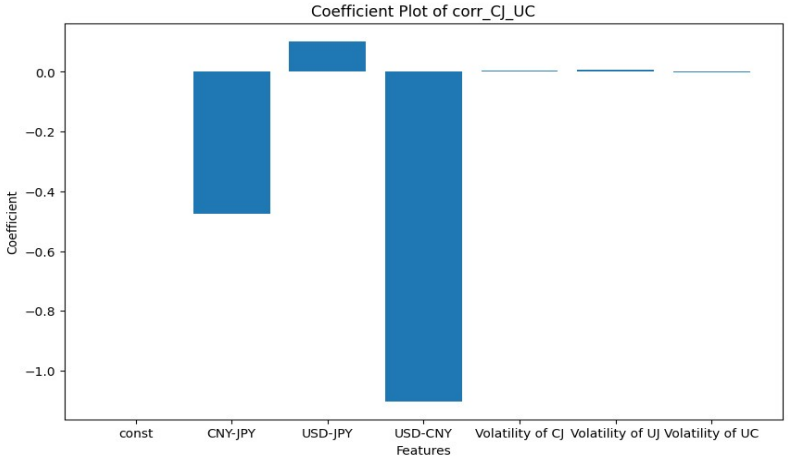

Fig. 4. Ridge coef for CNY-JPY and USD-CNY [Owner-draw].

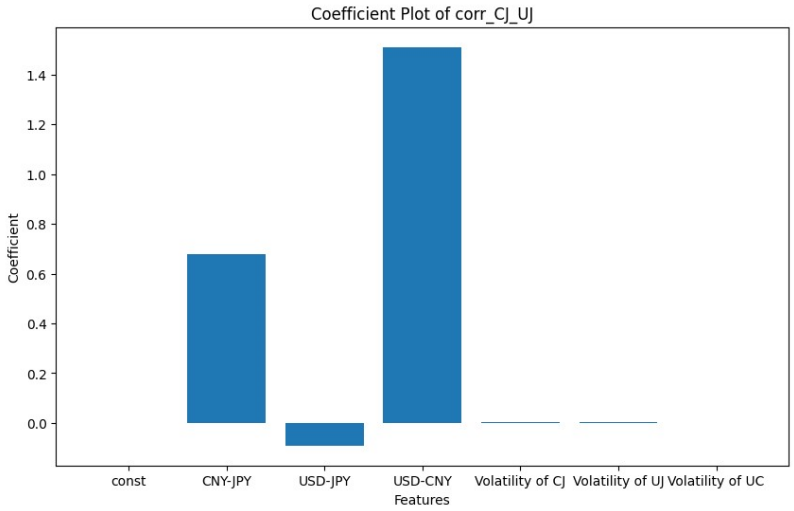

Fig. 5. Ridge coef for CNY-JPY and USD-JNY [Owner-draw].

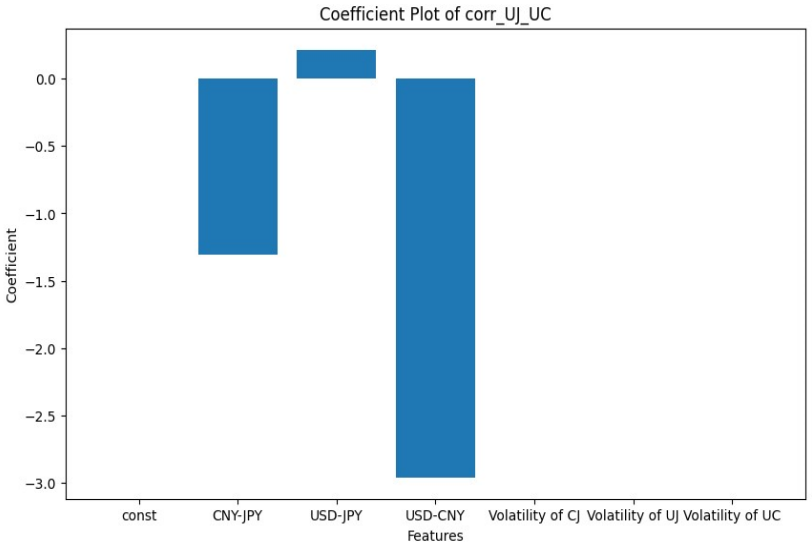

Fig. 6. Ridge coef for USD-JPY and USD-CNY [Owner-draw].

We observed that in each of the three correlations, the USD-CNY exchange rate plays the most important role in this loop of market, and it makes a positive correlation with the CNY-JPY and USD-JPY markets, and shows a negative correlation with the other two pairs of markets (see Figure 4, Figure 6). Furthermore, the Ridge model allowed us to identify currency pairs that have a significant impact on the overall forex market dynamics, which is the USD-CNY market, showing that it may act as leading indicators for market movements or serve as useful inputs for future predictive models. In this section, the paper presented the results of the analysis using the

Ridge regression model to study currency pair correlations in the forex market. The model provided valuable insights into the relationships among different currency pairs, contributing to a better understanding of market dynamics and potential trading strategies. The next section will discuss the implications of the findings and provide concluding remarks for the study.

5 Conclusion

This paper presents an analysis illustrating exchange rate volatility among the US dollar, Chinese yuan, and Japanese yen over a ten-year period (June 2013 to June 2023). The graph highlights significant fluctuations in exchange rates between the three major currencies, with political events, social statements, economic data, and market sentiment playing significant roles. In 2018, China experienced low unemployment rates and inflation rates, while the US and Japan maintained steady unemployment rates. The COVID-19 pandemic in 2019 and 2020 significantly impacted the global economy, leading to increased unemployment and inflation rates. The USD/JPY exchange rate exhibited higher volatility during this period due to the impact of Abenomics, which aimed to address Japan's economic challenges through monetary easing, fiscal stimulus, and structural reforms. The uncertainty surrounding the UK's Brexit referendum in 2016 also contributed to the exchange rate fluctuations. To explain the correlations between each of the markets, this paper also presents a statistical regression model to analyze the components of the Forex market and their own significance of the role in each correlation set of data. And the result shows that the USD-CNY currency exchange market plays the most important role, both positively and negatively, in the three correlation relationships we discussed in the paper. Taken together, these findings add substantially to our understanding of currency exchange rates are influenced by factors such as inflation, political stability, and terms of trade. This article also outlines the results of the analysis of the relationship between currency exchange rate fluctuations among the three countries in four time points, 2014, 2016, 2018, and 2020. In 2014, the correlation between orange, green, and blue lines was high, exceeding 0.5, due to China's economic growth, policy initiatives, and stable inflation rates. The US dollar, Japanese yen, RMB, and US dollar exchange rates showed positive correlations, indicating good market economy development. In 2016, the correlation between Japan-China, China-US, and the United States and China was higher than in 2016, due to China's slowdown, tense Sino-US trade relations, and the relatively high GDP growth rate of China at 6.7%. The unemployment rate in China was relatively high at 5%, indicating a positive correlation between the three countries. In 2020, the COVID-19 pandemic significantly impacted the global economy, leading to significant changes in economic conditions. China's inflation and unemployment rates both saw significant rises, while the U.S. unemployment rate experienced a sharp increase. Japan, being less affected by the pandemic, saw relatively stable unemployment and inflation rates. The Yen-US exchange rate was temporarily affected by the pandemic, with Japan experiencing relatively stable unemployment and inflation rates.

References

[1] Fexco International Payments (2023). Accessed on August 8, 2023. URL: https://international-paym fexco.com/news-insights/factors-that-influence-exchangerates/.

[2] Lai, P. and T. Zhu (2022). “Deflating China’s nominal GDP: 2004–2018”. In: China Economic Review, p. 71.
[3] Yadav, D.K. and S. Jameel (2020). “Pattern of GDP Growth Rate, Inflation, Interest Rate in Post Reform Period: A Comparative Analysis of India China and USA.” In: SSRN Electronic Journal.
[4] Jacob, J.T. (2016). AEI Banner. Accessed on August 8, 2023. URL: http://aei.pitt. edu/80817/.
[5] Kartono et al., (2021). “Foreign currency exchange rate prediction using non-linear Schrodinger¨ equations with economic fundamental parameters”. In: Chaos, Solitons amp; Fractals.
[6] AKARSU, Guls¨ um (2020). “Unemployment, Exchange Rate and Exchange Rate Volatility Relation: Analysis for Turkey”. In: Cankiri Karatekin Universitesi Iktisadi ve Idari Bilimler Fakultesi Dergisi.
[7] Lang, K. and A.X. Li (2021). “Disapproval rating, VIX index, COVID-19 cases and Trump’s tweeting against China”. In: Applied Economics Letters 29, pp. 1–7.
[8] Amiti, M., S.J. Redding, and D.E. Weinstein (2019). “The Impact of the 2018 Tariffs on Prices and Welfare”. In: Journal of Economic Perspectives.
[9] Narayan, P.K. (2020). “Has COVID-19 Changed Exchange Rate Resistance to Shocks?” In: Asian Economics Letters.
[10] Xu, Y. and D. Lien (2020). “dynamic exchange rate dependences: The effect of the U.S. China trade war”. In: Journal of International Financial Markets, Institutions and Money 68, p. 101238.
[11] Li, K., N. Devpura, and S. Cheng (2022). “How did the oil price affect Japanese yen and other currencies? Fresh insights from the COVID-19 pandemic”. In: Pacific-Basin Finance Journal 75, p. 101857.
[12] Lang, K. and Y. Li (2021). “Social media and exchange rates: Evidence from Twitter and the foreign exchange market”. In: *Journal of International Economics* 131, p. 103427.
[13] Sethi, M., R. Dash S.R.and Kumar Swain, and S. Das (2021). “Economic Consequences of Covid-19 Pandemic: An Analysis of Exchange Rate Behaviour.” In: Organizations and Markets in Emerging Economies 12(2), pp. 258–284.
[14] Taylor, J. (1987). “Exchange rate volatility and international trade: Some empirical results”. In: Exchange rate volatility and international trade: Some empirical results. 6(2), pp. 191–207.
[15] Bottelier, Pieter (2018). In: Economic Policy Making in China (1949–2016).