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The Impact Study of Yield Curve Control on the Yen Exchange Rate and Japanese Inflation

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Abstract: Yield Curve Control (YCC) is fundamentally an interest rate tool that aims to maintain the yield curve at targeted levels across different maturities. The Bank of Japan (BOJ) initiated zero interest rates and quantitative easing in 2001, followed by qualitative and quantitative monetary easing policies starting in April 2013, and introduced negative interest rates in January 2016. It announced the implementation of Yield Curve Control policy as a policy objective for quantitative and qualitative easing. Amid the current global economic downturn, many Western countries have adopted interest rate hikes to ensure currency stability. However, Japan continues to implement Yield Curve Control policy to address the global economic slowdown. This paper, based on literature review and utilizing Japanese economic data from 2003 to 2022, employs correlation and regression analyses to delve into the impact of Yield Curve Control on the Japanese yen's exchange rate and inflation. The study reveals that Japan's Yield Curve Control policy has a certain positive impact on both the yen's exchange rate and inflation, although this effect is relatively moderate. Therefore, the government should consider enhancing the use of other monetary policy tools and employing a comprehensive approach to influence exchange rates and inflation more effectively.

Keywords: Yield Curve Control, ultra-loose monetary policy, government bond yields, inflation rate, Japanese yen foreign exchange

1. Introduction

In the current international society, including countries in Europe and America, there has been a trend of implementing tighter monetary policies. Since 2022, the Federal Reserve has been consistently raising its policy interest rates, and the European Central Bank has also abandoned its previous negative interest rate policy. However, Japan continues to adhere to its unique monetary policy, known as Yield Curve Control (YCC). As a core policy of the Bank of Japan, its objective is to maintain an extremely loose monetary policy.

Currently, the Bank of Japan has set a fluctuation range of ±0.25% for long-term interest rates represented by the 10-year government bond yield. When the 10-year government bond yield exceeds 0.25%, the Bank of Japan will engage in unlimited purchases of 10-year government bonds to keep the yield below 0.25%.

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The prolonged quantitative easing policy and the widening interest rate differential between Japan and the United States have led to the depreciation of the Japanese yen, further exacerbating inflation and causing import-driven inflation. According to statistics from Japan's Ministry of Internal Affairs and Communications, in 2022, the comprehensive Consumer Price Index (CPI) excluding fresh food increased by an average of 2.3% compared to the previous year. The inflation rate during the period from September to December exceeded 3.0%, and in December, it reached 4.0%, marking the highest level in nearly 41 years. The general rise in prices has significantly increased procurement costs for businesses' raw materials and components, thereby squeezing their profit margins. On the other hand, household consumption bears the consequences of rising prices, especially for middle and low-income families who allocate a higher proportion of their budget to daily consumer goods. They face more financial pressure. Meanwhile, due to the nominal wage growth rate failing to keep up with the pace of inflation, the real wage income of the Japanese working class has shrunk. According to statistics from Japan's Ministry of Health, Labour and Welfare, in 2022, Japan's nominal average wage increased by 2.1% compared to the previous year, but the real average wage, adjusted for inflation, decreased by 0.9%. This means that disposable income for households has further reduced.

Research by Li and Lu shows that regarding the ongoing loose monetary policy and its impact on the yen's depreciation in the international market, there are proponents and opponents [1]. However, exchange rates are determined by the market, and both the Japanese government and the central bank find it challenging to control directly. Therefore, instead of debating whether the depreciation of the yen is good or bad, it is more worthwhile to discuss how to leverage the effects of yen depreciation.

In foreign research, it is generally believed that Yield Curve Control policy has had a certain impact on Japan's exchange rate and inflation. Researchers have employed various methods such as VAR models, Monte Carlo simulations, event studies, and synthetic control approaches to analyze the situation and have reached some consistent conclusions. For instance, Gilles's research in 2022 found that controlling the yield curve can effectively influence the yen's exchange rate, and the effect is significant [2]. Studies by Hattorl et al. indicated that the policy can impact market participants' inflation expectations, thereby positively affecting inflation [3, 4]. However, research by Haruhiko and Wang suggested that the effects of Yield Curve Control on the yen's exchange rate and inflation expectations are not consistent and may be influenced by other factors [5]. External factors like adjustments in the US economic policy and their impact on global financial markets, fluctuations in international commodity prices, and geopolitical issues might outweigh the effects of Yield Curve Control. Satoshi's study in 2020 explained the negative interest rate policy adopted by the Japanese government since 2013 and suggests that reforming the management approach of Yield Curve Control policy should be considered due to the need for further action [6].

On the domestic front, research by Wang et al. employed model-based reasoning and suggests that using loose monetary and financial policies as solutions to address issues such as inflation and economic stagnation is concerning [7]. They propose shifting the operational focus of quantitative easing monetary policy to controlling the yield curve of government bonds. Furthermore, they argue that the Bank of Japan is not omnipotent and should align the methods of Yield Curve Control with economic growth strategies. The qualitative quantitative easing monetary policy, with the goal of increasing the base money supply, has an impact on Japan's exports, direct investments, and Gross Domestic Product (GDP). Zong pointed out that the yield curve of government bonds is more influenced by expectations and term premiums [8]. The key to maintaining long-term interest rates at low levels lies in stabilizing short-term interest rates and inflation expectations at low levels. Adjusting short-term interest rates to influence long-term rates and using the bond market for interest rate transmission can effectively maintain the flexibility and liquidity of the bond market and enable the market to play a decisive role in allocating financial resources [9].

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In conclusion, despite some dissent, both domestic and foreign research indicates that Yield Curve Control policy has had varying degrees of impact on the Japanese yen's exchange rate and inflation. However, there are still unresolved issues, such as quantifying and analyzing the extent of this policy's effects further and distinguishing the effects brought about by this policy from the interactions of other factors. Hence, this paper adopts correlation analysis and regression models to further explore the impact of Yield Curve Control policy on Japan's exchange rate and inflation.

2. Method

2.1. Indicator Selection and Data Source

This study uses various economic indicators of the Japanese economy as research samples, covering the period from 2003 to 2022, totaling 220 observations. To ensure the accuracy and completeness of the data, original data were collected from multiple databases and cross-verified. The selection of multiple variables aims to reflect changes in different economic factors under the same monetary policy impact from various perspectives, which can to some extent provide an overall picture of Japan's economic situation [10].

Table 1: Definitions of Variables.

Variable	Name	Definition	Symbol
Dependent Variable	Japanese Average Annual Exchange Rate to the United States	Represents the Japanese exchange rate	JU
	Japanese Average Annual Exchange Rate to the United States	Represents the degree of inflation in Japan	IR
Explanatory Variable	One-Year Government Bond Yield	Reflects market expectations for the coming year's interest rates, indicating the effectiveness of the Japanese government's control over yield	GBY
Control Variable	Japanese Nominal GDP	Reflects the extent of domestic economic growth	GDP
	Money Supply	Reflects the degree of central bank control over the economy	M2
	U.S. Nominal GDP	Reflects foreign economic conditions	UGDP
	Japan-U.S. Interest Rate Differential	Reflects changes in interest rate differentials	IRD
	Japanese Stock Market Index	Reflects financial market volatility	NSA

Considering that the United States is a significant trading partner for Japan, this study empirically employs the annual average exchange rate from Japan to the United States (JU) and Japan's inflation rate (IR) as dependent variables, and the one-year government bond yield (GBY) as an explanatory variable. Additionally, five control variables were selected to account for domestic economic growth, monetary policy, foreign economic conditions, interest rate differentials, and financial market volatility: Japan's nominal GDP (GDP), money supply (M2), U.S. nominal GDP (UGDP), Japan-U.S. interest rate differential (IRD), and Japan's stock market index (NSA).

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The data primarily originate from the Wind database, while macroeconomic data were sourced from Japan's Ministry of Finance, the Bank of Japan, and the Cabinet Office. The specific variable definitions and symbol representations are provided in the following Table 1:

3. Results and Discussion

3.1. Research Design

3.1.1. Variable Measurement

Descriptive statistics are used to analyze the data, and the results are presented in Table 2 below.

Table 2: Descriptive Statistics Results.

	Minimum	Maximum	Average	S. D.
JU	79.0	121.0	105.1	12.199
IR	-1.400	2.700	0.340	0.983
GBY	-0.239	0.689	0.069	0.253
GDP	494938	557911	5304	20443.34
M2	682.6	1212.8	882.9	167.283
UGDP	10459	23430	16971	3688.759
IRD	0.150	5.350	1.405	1.658
NSA	8297	29195	16928	6913.036

The descriptive statistics results indicate that there are a total of 20 samples (from 2003 to 2022). The average value of one-year government bond yield (GBY) is 0.06931, leaning towards the minimum value. This reflects Japan's monetary policy of maintaining low government bond yields to ensure an ultra-loose monetary policy, which leads to the depreciation of the yen and enhances Japan's trade position in the international market.

The maximum value of Japan's inflation rate (IR) is 2.7, and the minimum value is -1.4, with a range of 4.1 between the two extremes. This suggests that under this monetary policy, the yen's inflation rate can be relatively stable and controllable. The average value of 0.34 for inflation rate indicates that it is relatively mild, which is beneficial for economic development.

The average exchange rate of the yen against the US dollar (JU) is 105.1, leaning towards the maximum value of 121. This implies that Japan's economy is still heading in a relatively positive direction. However, it also highlights the possibility of a "weak economy, strong currency" phenomenon.

The correlation coefficient is a statistical measure used to assess the strength of the linear relationship between two variables. Its calculation formula is as follows:

$$\rho_{ij} = \sum XY / (\sum X^2 \sum Y^2) \quad (1)$$

Based on the descriptive statistics of the indicators mentioned above, we can get a general idea of their trends and certain correlations. Next, we will conduct correlation analysis on the data to further describe the relationships between different variables using correlation coefficients. The results are presented in Table 3, and the visual representation of the data can be seen in Figure 1.

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Table 3: Correlation Coefficient Analysis Results.

	JU	IR	GBY	GDP	M2	UGDP	IRD	NSA
JU	1.000							
IR	0.303	1.000						
GBY	-0.080	-0.066	1.000					
GDP	0.752***	0.401*	-0.383*	1.000				
M2	0.137	0.383*	-0.655***	0.591***	1.000			
UGDP	0.099	0.419*	-0.560**	0.588***	0.975***	1.000		
IRD	0.462**	-0.109	0.438*	0.315	-0.365	-0.324	1.000	
NSA	0.442*	0.378	-0.486**	0.759***	0.896***	0.884***	-0.007	1.000

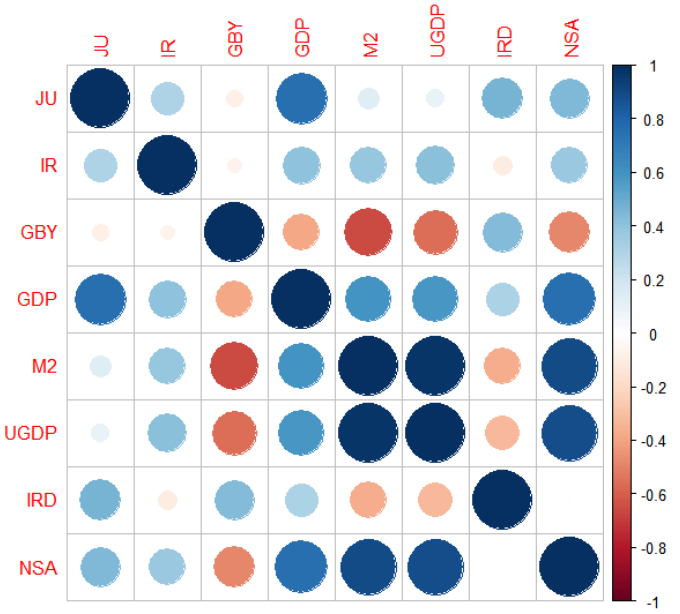

Figure 1: Visualization of Correlation Coefficient Analysis Results.

From the above chart, it can be observed that the one-year government bond yield (GBY) shows a weak negative correlation with both Japan's annual average exchange rate against the US dollar (JU) and Japan's inflation rate (IR). However, this correlation is not significant. Therefore, in the following analysis, we will establish regression models to further explore these relationships in-depth.

3.1.2. Model Construction

To better explore the impact of yield curve control on exchange rates and inflation and their mutual relationships, we will analyze the effect of the explanatory variable (one-year government bond yield) on the dependent variables (Japan's annual average exchange rate against the US dollar and Japan's inflation rate) through the construction of a multiple linear regression model.

The general form of a multiple linear regression model can be represented as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_6 X_6 + \varepsilon \quad (2)$$

Y represents the dependent variable (such as Japan's annual average exchange rate against the US dollar and Japan's inflation rate). X1 represents the explanatory variable (one-year government bond

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yield). X2, X3, X4, X5 and X6 represent the control variables (Japan's GDP, money supply, US GDP, Japan-US interest rate differential, and Japan's stock market index). β0 represents the intercept. β1, β2, β3, β4, β5, and β6 represent the regression coefficients of the explanatory and control variable. ε represents the error term.

3.2. Impact of Yield Curve Control on Exchange Rates

3.2.1. Baseline Regression Results

The parameter estimation results are shown in Table 4 below:

Table 4: Parameter Estimation Results of the Impact of Yield Curve Control on Exchange Rates.

	Estimate	t value	Pr(>|t|)
(Intercept)	-1.584e+02	-2.949	0.010*
GBY	8.130	1.237	0.236
GDP	5.948e-04	5.441	8.7e-05 ***
UGDP	-41646e-03	-4.944	0.0002 ***
IRD	-2.756	-2.200	0.0451*
NSA	1.778e-03	3.487	0.0036 **

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ', Adjusted R-squared: 0.8231

The results of the model parameter estimation show that the coefficient of one-year government bond yield (GBY) is greater than 0, with a p-value of 0.2365, indicating that the parameter estimation is statistically significant. The adjusted R-squared of the model is 0.8231, suggesting that the explanatory variable can explain approximately 82.31% of the variation in the dependent variable, Japan's annual average exchange rate against the US dollar (JU).

Considering the inclusion of four significant control variables, namely Japan's GDP at current prices (GDP), US GDP at current prices (UGDP), Japan-US interest rate differential (IRD), and Japan's stock market index (NSA), it can be concluded that Japan's yield curve control has a moderately significant positive impact on the exchange rate. This implies that when Japan's yield curve is relatively high, investors holding the country's currency can earn higher interest income, attracting more capital inflow into the country. This increased demand for the currency will drive the exchange rate higher.

3.2.2. Heteroskedasticity Analysis

The heteroskedasticity test results from Table 5 indicate that there is no statistically significant evidence supporting the presence of heteroskedasticity in the given model. Specifically, the chi-square test statistic for the heteroskedasticity test is 0.416 with 1 degree of freedom, and the corresponding p-value is 0.518.

Based on the judgment criterion that the p-value is greater than the significance level (typically 0.05), we fail to reject the null hypothesis, which assumes constant variance of the residuals. Therefore, according to the results of this heteroskedasticity test, it can be concluded that the model's residual variance is constant, indicating the absence of heteroskedasticity.

Table 5: Heteroskedasticity Test Results.

Chisquare	Df	p
0.416	1	0.518

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3.3. Impact of Yield Curve Control on Inflation

3.3.1. Baseline Regression Results

The parameter estimation results are shown in Table 6 below:

Table 6: Parameter Estimation Results of the Impact of Yield Curve Control on Inflation.

	Estimate	t value	Pr(>|t|)
(Intercept)	-1.584e+02	-2.949	0.010 *
GBY	8.130	1.237	0.236
GDP	5.948e-04	5.441	8.7e-05 ***
UGDP	-41646e-03	-4.944	0.0002 ***
IRD	-2.756	-2.200	0.045 *
NSA	1.778e-03	3.487	0.003 **

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ', Adjusted R-squared: 0.2024

The results of the model parameter estimation show that the coefficient of one-year government bond yield (GBY) is greater than 0, with a p-value of 0.1306, indicating that the parameter estimation is statistically significant. The adjusted R-squared of the model is 0.2024, suggesting that the explanatory variable can explain approximately 20.24% of the variation in the dependent variable, Japan's inflation rate (IR).

Considering the inclusion of two significant control variables, namely Japan's GDP at current prices (GDP) and Japan-US interest rate differential (IRD), it can be concluded that Japan's yield curve control has a relatively significant positive impact on inflation.

A higher yield implies higher returns on stocks or other financial assets, which attracts more investors to invest. The increased investment demand will stimulate economic activity and demand growth, thus exerting a positive impact on inflation. Additionally, a higher yield can be seen as an optimistic expectation for future economic growth. Investors may believe that economic growth will bring higher dividend returns, leading them to increase investments and stimulate economic activity and demand growth, further contributing to a positive impact on inflation.

3.3.2. Heteroskedasticity Analysis

The heteroskedasticity test results from Table 7 indicate that there is no statistically significant evidence supporting the presence of heteroskedasticity in the given model. Specifically, the chi-square test statistic for the heteroskedasticity test is 0.392 with 1 degree of freedom, and the corresponding p-value is 0.531.

Based on the judgment criterion that the p-value is greater than the significance level of 0.05, we fail to reject the null hypothesis, which assumes constant variance of the residuals. Therefore, according to the results of this heteroskedasticity test, it can be concluded that the model's residual variance is constant, indicating the absence of heteroskedasticity.

Table 7: Heteroskedasticity Test Results.

Chi-square	Df	p
0.392	1	0.531

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4. Conclusion

After considering significant control variables such as Japan's GDP, U.S. GDP, Japan-U.S. interest rate differentials, and Japan's stock market index, this study used a multiple linear regression model to investigate the impact of Japan's yield curve control on exchange rates and inflation. The findings indicate that Japan's yield curve control has a moderate positive effect on exchange rates and inflation.

In conclusion, Japan's yield curve control policy has a certain positive impact on the country's exchange rates and inflation, but this impact is relatively moderate. Japan's GDP has shown significant effects on both exchange rates and inflation in this study. The government can implement measures to encourage investment, improve productivity, and drive structural reforms to boost economic growth and raise Japan's GDP level. This will have positive effects on exchange rates and inflation.

The study found that the interest rate differentials between Japan and the United States also have significant effects on inflation. The government should closely monitor international interest rate trends and adjust domestic interest rates appropriately to maintain reasonable interest rate differentials. This will contribute to economic stability and help achieve inflation targets.

Considering that Japan's yield curve control policy has relatively moderate effects on exchange rates and inflation, the government should consider enhancing the use of other monetary policy tools. By comprehensively utilizing various monetary policy instruments, such as interest rate adjustments and monetary supply control, the government can more effectively influence exchange rates and inflation, ensuring a more stable economic development.

Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

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