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ORIGINAL ARTICLE

The effectiveness of foreign exchange interventions in Japan

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ABSTRACT

This study informs the academic and policy debate on the policy effectiveness of exchange rate interventions on exchange rate levels and volatility. Using a constructed data set comprising daily data on exchange rates, monetary policy fundamentals, exchange rate intervention dates and magnitudes of those interventions as well as financial news speculation of such interventions, we empirically estimate the policy effectiveness of Bank of Japan interventions in the exchange rate over the 12-year period between 2010 and 2022. This allows us to investigate the policy effectiveness of a variety of exchange rate interventions, or news of exchange rate interventions, across different time-horizons. We find that policy interventions in the yen exchange rate are more effective over short-horizons than long-horizons, more effective when the policy objective is a competitive devaluation of the yen rather than a revaluation, and more effective at influencing the level of the yen against major world currencies other than the US dollar. In fact, for the yen-dollar rate, we find that policy interventions may have the unintended consequences of weakening the yen (when the policy intention is to strengthen it) and increasing volatility in the yen-dollar exchange rate.

KEYWORDS

foreign exchange intervention; exchange rates; volatility; GARCH

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1. Introduction

Since the Federal Reserve Board of Governors announced its decision to raise the US policy rate above zero in March 2022, the Japanese yen has been on one of the most severe yen exchange-rate fluctuations in history. After six months of downward spiral, on 22 September 2022, as the yen depreciated to nearly 146 yen per US dollar, Japan's finance minister announced that Japan had intervened in the foreign exchange market to prop up the yen for the first time since 1998 (The Economist, 2022). The following month, with the yen continuing to hover at a 32-year low near 150 yen per dollar, it was revealed that Japan had spent a record ¥6.35tn ($43bn) in "masked" secret interventions to defend the currency on 21 October 2022 and 24 October 2022 (Inagaki, 2022).

Do such interventions work? There used to be a consensus among academic economists that currency interventions, while they might slow the movement of managed exchange rates (Yoshino et al., 2016), didn't really have an effective or lasting impact on exchange rates (Dominguez and Frenkel, 1993). Foreign exchange intervention was thought to have a potential role in stabilizing exchange rate volatility or smoothing out temporary fluctuations in the exchange rate, but such interventions were largely considered useless in "interfering with fundamental adjustments" (Mayer and Taniguchi, 1983). As discussed below, any temporary impacts from official foreign exchange interventions were thought to come through the so-called signaling channel of exchange rate intervention effectiveness, so the effectiveness of secret, or "masked", interventions, as they are called in Japan, was particularly suspect.

Recent research may have overturned this consensus. In a review of the existing literature on interventions in the yen, Spiegel (2003) notes that studies investigating the Bank of Japan's interventions up until that time generally found significant effects, although the direction of the impact on the exchange rate and the conditions for successful interventions remained unclear. A forthcoming study finds that large, systematic interventions may be effective, especially in shallow financial markets. Even so, questions remain about whether foreign exchange intervention can have any lasting impact on exchange rates in economies such as Japan with highly developed, deep capital markets and free capital mobility. The research debate remains unresolved and while it rages on, policymakers continue to spend eye-watering sums on interventions, most of them the unannounced, secret, or "masked" interventions that academics argue would be the least likely to have any effect.

This study contributes to the debate on the policy effectiveness of exchange rate intervention by investigating the effectiveness of the Bank of Japan's interventions in the yen on the level and volatility of the yen-dollar and yen-euro exchange rates during the twelve-year period between 2010 and 2022. Building on the current consensus in the theoretical literature, this study focuses on the signaling channel of exchange rate intervention policy transmission, empirically investigating the effects of both announced and secret interventions as well as news or speculation in the financial press related to the probability of interventions after controlling for monetary policy fundamentals.

This paper contributes to the existing research in several ways. Firstly, while many recent studies emphasize the causal relationship between exchange rate intervention policy and "beggar-thy-neighbor" trade competitiveness policy, we examine the effects of exchange rate interventions aimed at both strengthening and weakening the currency. Furthermore, in addition to analysis of the effectiveness of policy on exchange rate levels, we employ time-series analysis to empirically investigate the empirical effectiveness of exchange rate interventions in stabilizing the exchange rate: reducing its volatility, regardless of the level. Finally, we are able to explore the effects of exchange rate interventions per se, as well as the magnitude of the interventions. Our findings will help shape the policy debate around foreign exchange intervention policy, in particular informing policymakers as to how market reactions to interventions may differ depending on the policy objectives of the intervention.

The rest of the paper is organized as follows. The next section provides a brief overview of the history of foreign currency interventions in Japan. Section 3 reviews the existing literature and proposes several hypotheses about the effectiveness of exchange rate interventions in Japan. Section

4 explains the data and empirical methodology used in testing those hypotheses. The results of that empirical analysis are discussed in Section 5. Finally, Section 6 concludes the paper and discusses some possible directions for future research.

2. Foreign currency interventions in Japan

Although there had been reports in the press of presumed foreign exchange market interventions by the Japanese central bank even earlier, it was not until 1991 that the Japanese Ministry of Finance officially disclosed its first intervention in foreign exchange. After that initial intervention, in the 15-year period from 1991 to 2004, the BOJ made frequent, large interventions in the exchange market: sometimes intervening multiple times within a day. After 2004, the frequency of interventions fell dramatically. **Figure 1**, based on quarterly released data from the Japanese Ministry of Finance, presents the BOJ's interventions in the foreign exchange market from 1991 to 2022. Note from **Figure 1** that since 2004, the only interventions were in 2010, 2011 and then the recent interventions in 2022. However, as is illustrated in **Figure 1**, the announced intervention in September 2022 and the two "masked" secret interventions in October 2022 were quantitatively significant. In fact, the size of the interventions in 2022, designed to prop up a weakening yen, was unprecedented in the size of the purchase.

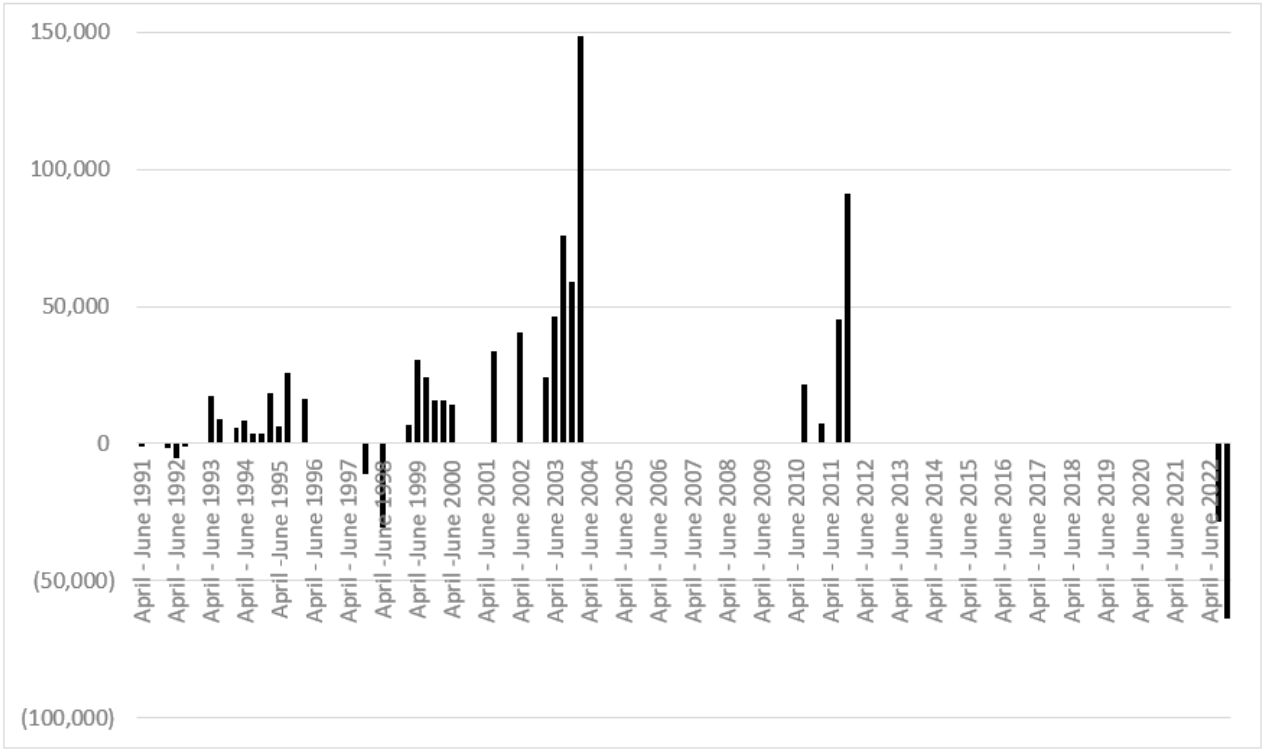

Figure 1. Bank of Japan's interventions in the foreign exchange market, 1991–2022.
Note: Quarterly aggregated data on the interventions led by the BOJ in the foreign exchange market from 1991 to 2022. Interventions are measured in 100 million yen.
Positive values represent interventions for which the Japanese yen was sold, while negative values represent interventions for which the Japanese yen was bought. Two interventions, taking place in 1991 and 1997, did not use the Japanese yen as one of the currencies bought or sold, and were not included in this figure. Interventions were made in US dollars, euro, German mark, and Japanese yen.
Source: Japanese Ministry of Finance.

Central bank interventions in the foreign exchange market can take two forms: sterilized interventions and non-sterilized interventions. Sterilized interventions involve buying a specific currency, such as the Japanese yen, while simultaneously selling another currency to maintain the central bank's foreign reserves at a constant level. Sterilized interventions have been the most common type of intervention globally, since sterilized interventions maintain independence of monetary policy by leaving the money stock unchanged. All of the BOJ's interventions since 1991 have been sterilized, as noted by Glick and Hutchison (2000). The main currencies involved in the BOJ's interventions are the US dollar and the Japanese yen, although prior to 2004, interventions also included the euro, the Indonesian rupiah, and the German mark.

Another important characteristic of central bank interventions in the foreign exchange market is whether the interventions are coordinated actions among central banks to influence exchange rate movements or if they are unilateral actions taken by a single central bank. **Figure 2** and **Figure 3** depict the interventions in the foreign exchange market by the European Central Bank and the US Central Bank, particularly coordinated interventions with the BOJ. Before 2001, the BOJ's interventions were mainly coordinated, but this trend shifted between 2001 and 2004, with the BOJ leading unilateral interventions. In 2010 and 2011, three out of four interventions were unilateral, and all interventions in 2022 were unilateral and initiated by the BOJ. The most recent intervention by the BOJ to support its currency prior to 2022 dates back to 1998.

In summary, although Japan's foreign exchange interventions have all been sterilized and largely carried out against the US dollar, Japan is an interesting laboratory in which to study the effectiveness of exchange rate intervention policy because the interventions varied in terms of the size and direction of the interventions and in whether the interventions were coordinated or unilateral.

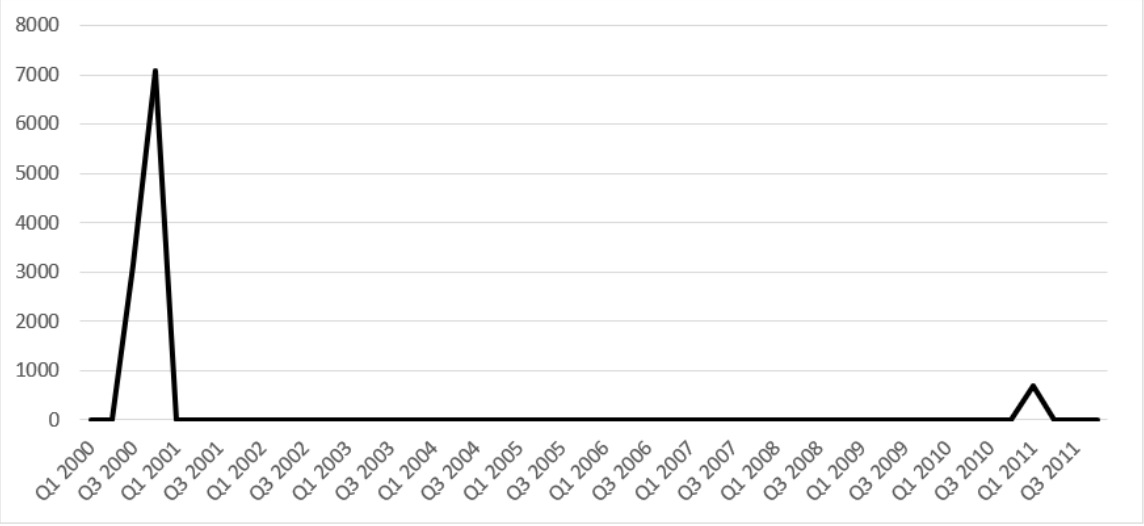

Figure 2. European Central Bank interventions in the foreign exchange market, 2000–2011.
Note: Quarterly aggregated data on interventions by the European Central Bank (ECB) in the foreign exchange market from 2000 to 2011. Interventions measured in millions of euros. Note that the euro exchange rate is not a policy target for the ECB. 2000 Q3 and 2011 Q1 interventions were coordinated, while 2000 Q4 interventions were unilateral.
Source: ECB.

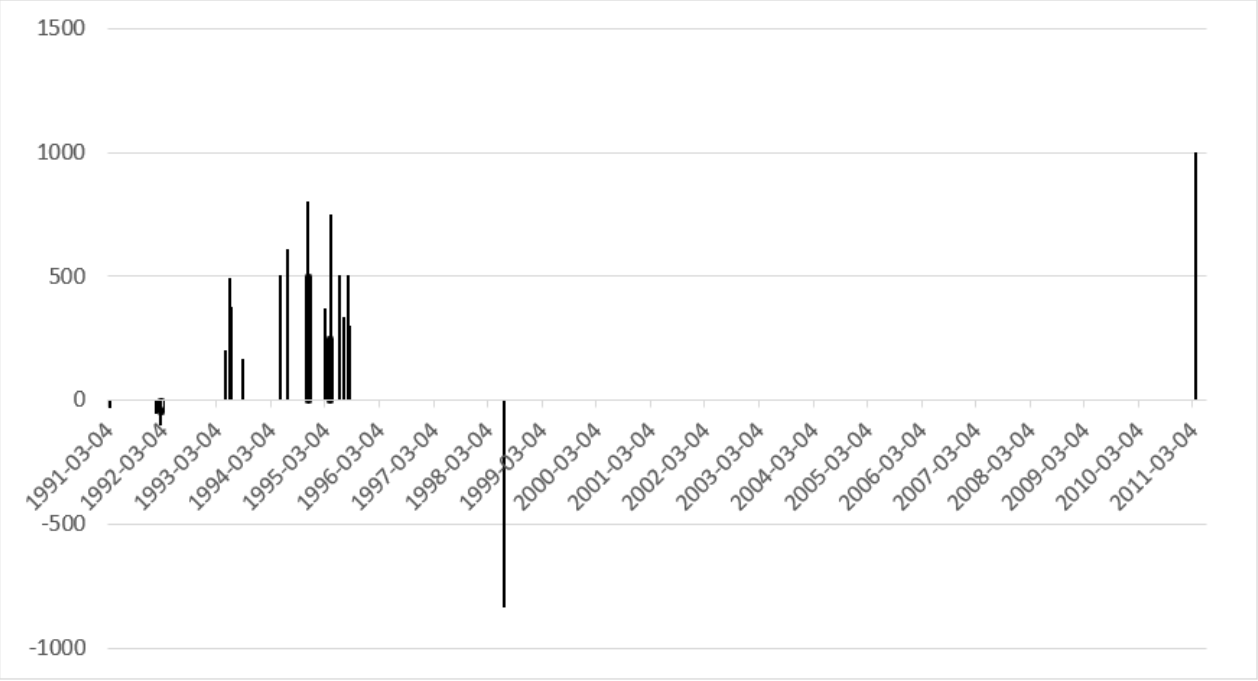

Figure 3. Federal Reserve's interventions in the foreign exchange market in yen/US dollars, 1991–2011.
Note: Daily data on the US interventions in the foreign exchange market in yen/US dollars from 1991 to 2011. Interventions are measured in millions of US dollars. Interventions were coordinated with the Bank of Japan.
Source: FRED, St. Louis FED, data taken from the Board of Governors of the Federal Reserve System.

3. Literature review and hypotheses

Few questions are as studied in the field of international finance as the effectiveness of foreign exchange rate intervention. As reported in Dominguez and Frankel (1993), perhaps the first significant study on intervention effectiveness began after the collapse of the Bretton Woods system in 1982 when the Group of Seven (G-7) economic summit concluded that a comprehensive study of intervention policies was needed due to the significant exchange rate fluctuations associated with small, sterilized interventions. In 1983, the G-7 Working Group on Exchange Market Intervention concluded that interventions do not have a significant impact on exchange rates, and if there is an effect, it is only temporary.

Studies on interventions and exchange rates investigate two main theories to explain the effects of interventions: the portfolio balance channel and the signaling channel. Early studies on intervention effectiveness tended to focus on one of these channels to analyze exchange rate levels, volatility, and the reaction function. Edison (1993) reviewed the literature in the 1980s and 1990s and found that interventions became more frequent when the exchange rate deviated significantly from the targeted level. The portfolio balance channel showed little evidence of the significance of intervention effects on exchange rates, while investigations of the signaling channel suggested that interventions only had a short-lived effect on exchange rate levels, with the effect on exchange rate volatility being ambiguous and time-dependent.

Studies since the early 1990s have primarily focused on the signaling channel theory, which involves expectation formation and information transmission. Baillie and Humpage (1992) and Baillie and Osterberg (1991), used GARCH models to analyze exchange rate volatility and

concluded that central bank interventions, although having a small effect on exchange rate levels, did not significantly affect volatility. However, Dominguez (1993) investigated the signaling channel for the USD/JPY and USD/MARK exchange rates between 1985 and 1991 using daily and weekly GARCH frameworks with a conditional Student t distribution and found that interventions effectively impacted exchange rate volatility, although the distinction between official and secret interventions affected the correlation between interventions and volatility measures.

In the following decade, there were theoretical advances in the field. Dominguez (1998) expanded the understanding of intervention effectiveness. Applying GARCH conditional variance and implied volatilities techniques from foreign exchange options research to on daily exchange rates and interventions by central banks in the US, Germany, and Japan from 1977 to 1994, the findings of that study demonstrated that both the signaling and the portfolio balance channels could function simultaneously in explaining the effect of interventions on exchange rate volatility. This finding was also supported by Baillie and Osterberg (1997) using the Martingale-GARCH framework for USD/MARK and USD/JPY exchange rates.

Studies since 2000 built on the early studies' theoretical framework and expanded the scope of analysis on intervention effectiveness. These studies focus on different country cases, shifting the attention from Japan, Europe, and the US to Canada, Australia, and developing economies. Rogers and Siklos (2003), for example, investigated the effects of central bank interventions on exchange rate volatility and uncertainty in Canada and Australia between 1989 and 1998 using a different empirical framework: the implied volatilities of foreign currency futures options. The study found mixed effects, with the Bank of Canada's interventions not significantly affecting volatility and uncertainty, while larger interventions increased volatility and reduced uncertainty. The study also considered the impact of inflation target policies, revealing a significant role in shaping the results. Studies in the 2000s also focused on developing countries and economic crises. For instance, Vithessonthi (2014) examined the Bank of Thailand's intervention policy announcements and their effect on the Thai Baht exchange rate using an OLS method, covering both crisis and non-crisis periods from 2003 to 2011. The study found that monetary policy surprises during the 2007 crisis had an asymmetric impact on the THB/JPY return compared to the non-crisis period.

Recent innovative studies generally control for monetary policy by incorporating interest rate spreads, employ multivariate models to account for spillover effects, and consider the coordination effect of joint interventions by multiple central banks. For example, Chortareas et al. (2013) explores intervention effectiveness using 15-min intraday JPY/USD and JPY/EUR exchange rate data between 2000 and 2004. Applying a multivariate GARCH model to capture movements in conditional variance and covariance between the two exchange rates, their study reveals that Bank of Japan interventions reduced JPY/USD exchange rate volatility within five hours after the intervention. It also identified spillover effects on JPY/EUR exchange rate volatility, showing that the spillover effect lasted throughout the day after the intervention.

As one of the most volatile currencies in the world, there is of course a significant body of existing research on the effectiveness of exchange rate interventions on the yen[1]. Using official data from the Ministry of Finance on interventions conducted between 1991 and 2001 and applying

[1] We should also mention a strand in the literature that focuses on the reaction function—when and why interventions occur in the first place—such as Ito and Yabu (2020).

a standard GARCH framework to investigate their effects on the exchange rate level, Ito (2003) concluded that coordinated interventions were more effective than unilateral ones. Other studies on the Bank of Japan's interventions' impact on JPY/USD exchange rate volatility include Frenkel et al. (2005), which uses option-implied volatility, and Watanabe and Harada (2006), which applies a more conventional GARCH model from Bollerslev (1986) and the component GARCH model of Engle and Lee (1999) to daily exchange rate data. These studies yield mixed results, similar to findings on US interventions: the impact of interventions on exchange rate volatility could be either decreasing or increasing, and the effect seemed to diminish in the long run.

In a review of the literature of the policy effectiveness of foreign exchange rate interventions on the yen, Spiegel (2003) noted that studies investigating the Bank of Japan's interventions up until that time had generally found significant effects, although the direction of the impact on the exchange rate and the conditions for successful interventions remained unclear.

In the following subsections, we first consider the existing literature on the policy effect of exchange rate interventions on exchange rate levels (Sub-section 3.1) and then on exchange rate stability (Sub-section 3.2). In the literature on the policy effect of exchange rate interventions on exchange rate levels, the impact is often analyzed using Ordinary Least Squares techniques to estimate a reduced-form equation that includes exchange rate levels and intervention variables. The empirical techniques employed in the literature on the effectiveness of interventions on exchange rate volatility, on the other hand, are more complex and challenging to measure, often requiring a Generalized Autoregressive Conditional Heteroskedasticity (GARCH) framework.

3.1. The effect of foreign exchange interventions on the level of the yen

The signaling channel theory of interventions mentioned above was first proposed by Mussa (1981). According to the signaling channel theory, interventions send signals to the public, providing them with new information. Specifically, when interventions occur, they signal the future monetary stance. For instance, when the Bank of Japan (BOJ) supports its currency, it buys yen and sells foreign currencies to maintain a constant reserve of assets. This action signals to the public that the central bank will soon implement a contractionary monetary policy. The underlying mechanism is that the central bank can shift expectations by signaling relevant information to the public. These expectations, based on all available information, can then influence market agents to take immediate action. Consequently, the market conditions in the present change due to the altered expectations for the future.

Equations (1) to (3) below are from Dominguez's (1993) investigation into the effect of interventions through the signaling channel. Equation (1) represents the spot exchange rate S at time t, based on information available and external driving factors Z:

$$S_t = (1-\delta)\sum_{k=0}^{\infty} \quad \delta^k E_t(Z_{t+k}|\Omega_t) \tag{1}$$

Equation (2) states the necessary assumption that information available at time (t), (Ω_t), is less than the information available at time ($t + I$), (Ω_{t+I}):

$$\Omega_t < \Omega_t + I_t \tag{2}$$

Equation (3) mathematically articulates the case of an exchange rate intervention intending to

prop up or appreciate the domestic currency, under the assumption that the information set available in the case with an intervention is greater than the information set without the intervention:

$$S_t = (1-\delta)\sum_{k=0}^{\infty} \quad \delta^k E_t(Z_{t+k}|\Omega_t) > (1-\delta)\sum_{k=0}^{\infty} \quad \delta^k E_t(Z_{t+k}|\Omega_t + I_t) \tag{3}$$

Equations (1) to (3) clarify that if interventions signal information about monetary policy, they can potentially affect the spot exchange rate. For example, when the central bank intervenes to support its currency, it signals a forthcoming contractionary monetary policy. As a result, with the new information, the yen per US dollar exchange rate should be lower than before. A lower yen per US dollar indicates that the yen has appreciated, aligning with the intended outcome of the intervention.

Note that identification of the signal is crucial. For example, the credibility and reputation of the authority sending the information signal is a necessary condition for the signaling channel to be effective (Diebold and Nerlove, 1989). If the information provided through interventions is credible and clear interventions can bring the exchange rate to the desired level and, as we will discuss below, effectively reduce volatility.

We posit that the signal—in this case a clear statement by the Bank of Japan or the Ministry of Finance regarding its intent to intervene or information about the size of the intended intervention—may have higher clarity over shorter time periods than longer time periods. So, while an intervention may have some impact on the level of the exchange rate measured over a short time horizon, over a longer time horizon, the magnitude of the intervention (the actual amount of yen purchased or sold) becomes more important than the incidence of an intervention per se.

This study examines the policy effects of exchange rate interventions on the level of the yen against the dollar and the euro over the long time horizon of 2010 to 2022 as well as two particularly volatile short-term horizons: 2010–2011 and 2022.

Based on the institutional details delineated above in Section 2 and the signaling channel theory of exchange rate intervention effectiveness, we propose the following hypotheses:

H1: Long-horizon exchange rate changes

H1. In the long horizon (2010–2022 sample), neither BOJ interventions nor news about BOJ interventions credibly signal a future change in exchange rates, and therefore do not change either market expectations or the current exchange rate.

H2: Short-horizon currency devaluations

H2a. In the short-horizon 2010–2011 window, BOJ interventions or news about BOJ interventions credibly signal a future depreciation of the yen-dollar exchange rate, and the change in market expectations brings about a current depreciation.

H2b. In the short-horizon 2010–2011 window, BOJ interventions or news about BOJ interventions credibly signal a future depreciation of the yen-euro exchange rate, and the change in market expectations brings about a current depreciation.

H3: Short-horizon currency revaluations

H3a. In the short-horizon 2022 window, BOJ interventions or news about BOJ interventions do not credibly signal a future appreciation of the yen-dollar exchange rate, so market expectations do not change, and the interventions are not effective in bringing about a current appreciation.

H3b. In the short-horizon 2022 window, BOJ interventions or news about BOJ interventions do not credibly signal a future appreciation of the yen-euro exchange rate, so market expectations do not change, and the interventions are not effective in bringing about a current appreciation.

3.2. The effect of foreign exchange interventions on the volatility of the yen

While a flexible exchange rate system avoids permanent imbalances and discourages speculative behavior, a stable exchange rate facilitates trade and investment and leads to better investment decisions (Becker et al., 2015). For this reason, interventions are often used not to affect the level of the exchange rate, but rather to stabilize the exchange rate, reducing market volatility (Jara and Piña, 2023). However, the effectiveness of policy interventions to stabilize exchange rates varies, depending on the prevailing volatility and market conditions (Viola et al., 2019) and the time-horizon (Gardini et al., 2022): interventions tend to be less effective in the long term than in the short term.

Overall, the existing literature suggests that the impact of interventions on the conditional mean and conditional variance is limited (Brissimis and Chionis, 2004), and their effects are highly specific to countries and regimes (Brandner et al., 2006). Countries with more variable interest systems are prone to asymmetric shocks, while those adopting fixed exchange rates are typically small economies and experience larger losses (Bayoumi and Eichengreen, 1998). In the longer term, when mean reversion occurs, which is usually cointegrated with risk reversal (Hui et al., 2022), interventions can actually increase volatility, leading to later exchange rate rebounds (Hoshikawa, 2017).

As discussed above in the case of the policy effectiveness of exchange rate interventions on the level of the exchange rate, the credibility and reputation of the authority sending the signal are crucial (Diebold and Nerlove, 1989). If the information provided through interventions is credible and interpreted unanimously, interventions can effectively reduce volatility. Uncredible or unclear signals can backfire, leading to increased volatility.

Based on the institutional details delineated above in Section 2 and the existing literature on the policy effectiveness of exchange rate intervention on exchange rate stability, we propose the following hypotheses:

H4: Long-horizon currency volatility

H4. In the long horizon (2010–2022 sample), larger magnitude BOJ interventions in the exchange rate do not send a credible signal to market participants, are not able to create market consensus, and therefore increase volatility in the exchange rate.

H5: Short-horizon currency volatility

H5. In the short horizon (2010–2011 window or 2022 window), larger magnitude BOJ interventions in the exchange rate send a credible signal to market participants, creating market consensus, and therefore reducing volatility in the exchange rate.

4. Data and methodology

4.1. Data

To empirically investigate the hypotheses developed above, a daily data set covering the period 2010–2022 was constructed combining daily exchange rate spot rate data from the Bank of Japan, news related to exchange rate interventions from Bloomberg, actual yen intervention data from the Japanese Ministry of Finance and daily overnight interest rate data from the Bank of Japan, Federal Reserve Board and European Central Bank.

Daily morning (9 a.m.) spot exchange rate data for the JPY/USD and JPY/EUR from the Bank of Japan database, covering the period from 1 January 2010 to 31 December 2022. The daily 9 a.m. spot exchange rate data excludes weekends and special holidays when the exchange market is closed. As the Bank of Japan only provides data for JPY/USD and USD/EUR exchange rates, the JPY/EUR exchange rate is derived by multiplying the other two rates. To calculate the exchange rate volatility, this study considers the difference in the logarithm of the exchange rate at time t and $t - 1$. The model estimation is based on this logarithmic difference.

The data also include variables related to interventions and news regarding interventions, as well as the spread between the interest rates of the Federal Reserve (Fed) or European Central Bank (ECB) and the Bank of Japan (BOJ), which is used to control for the monetary policy effect. The data span from 1 January 2010 to 31 December 2022.

Interventions data, obtained from the Japanese Ministry of Finance, provide information on the date of intervention, the amount of US dollars spent, and the currencies bought and sold. The dummy variable for interventions takes the value of one on the days when the Bank of Japan intervened and zero otherwise. Additionally, the interventions variable is represented numerically by the amount in billion US dollars spent on the intervention.

News data obtained from the Bloomberg Terminal includes information about the source, date, and content of the news. The news is retrieved by searching for news related to the Bank of Japan on the Bloomberg Terminal, using keywords such as “interventions”, “Bank of Japan”, and “Yen”. The search is refined to consider only news from 2010, 2011, and 2022. The selected news specifically mentions speculations on the likelihood of an intervention by the BOJ in the near future. This study includes only the first news mentioning a general or specific opinion. In other words, it considers the first day when a particular opinion from a specific source is mentioned. The news considered includes private sources such as investment banks, foreign exchange market specialists, financial news institutions, and monetary authorities like the Bank of Japan’s statements on interventions and the current monetary policy. The dummy variable for news takes the value of 1 on the days when the news was first released and zero otherwise.

Lastly, the interest rate spread between the BOJ and the Fed is calculated using daily overnight interest rate data obtained from the respective databases. The spread is computed as the BOJ’s interest rate minus the Fed’s interest rate. Similarly, the spread between the BOJ and the ECB is calculated as the BOJ’s call rate minus the ECB’s short-term rate. It is important to note that the ECB short-term rate data is only available from 2019 onwards. Therefore, this study uses data from 2022 to calculate the interest rate spread between the BOJ and ECB.

Table 1 provides the summary statistics for the 3181 observations of the time series data, including the daily morning JPY/USD and JPY/EUR exchange rates, the percentage change between time t and $t-1$, the interest rate spread, news related to exchange rate interventions and any actual interventions reported by the Japanese Ministry of Finance.

Table 1. Summary statistics; JPY/USD and JPY/EUR exchange rates and interventions.

Variable	Mean	Min	Max	Standard deviation	Kurtosis	L-Jung box test	*N*
JPY/USD exchange rate level at time *t*	104.6	75.77	150.17	15.12	–	–	3181
JPY/USD percentage change at time *t* (difference in log between time *t* and *t* − 1)	0.01	–4.64	4.02	0.59	5.03	3.98**	3181
JPY/USD squared percentage change	0.35	0.00	21.56	0.92	168.02	17.61***	3181
JPY/EUR exchange rate level at time *t*	124.86	94.24	149.52	11.31	–	–	3181
JPY/EUR percentage change at time *t* (difference in log between time *t* and *t* − 1)	0.00	–5.25	4.37	0.70	4.25	13.84***	3181
JPY/EUR squared percentage change	0.49	0.00	27.53	1.22	122.29	81.71***	3181
Interest rate spread BOJ-Fed at time *t* (BOJ's interest rate—Fed's interest rate)	0.62	–0.03	4.40	0.90			3181
Interest rate spread BOJ-ECB at time *t* (BOJ's interest rate—ECB's interest rate)	–0.04	–1.97	0.59	0.82			245
Interventions in 100 millions Japanese yen	80.51	0.00	80,722	2091.09			3181
Interventions	Dummy variable that takes value 1 on the day an intervention occurs.						3181
News related to interventions	Dummy variable that takes value 1 on the day a news is released.						3181

Notes: The null hypothesis of the L-Jung box test that the autocorrelation in the data is zero, is rejected at standard levels of statistical significance for the percentage change and squared percentage change of all the exchange rate series, indicating the existence of significant autocorrelation.

The summary statistics table (**Table 1**) reveals important characteristics of the JPY/USD and JPY/EUR exchange rates. Firstly, both exchange rates exhibit a substantial standard deviation, indicating significant fluctuations in their values over the study period. The range between the minimum and maximum values further emphasizes the magnitude of these changes.

Secondly, the percentage change in both exchange rates also demonstrates a noteworthy standard deviation, with a mean close to zero. This implies that, on average, there is no gain or loss when buying or selling yen from one day to the next, regardless of the chosen exchange rate. The zero mean suggests that the JPY/USD and JPY/EUR exchange rate returns (percentage changes) are stationary, indicating a stable average level of returns.

Furthermore, the L-Jung box tests for the percentage change in both exchange rates indicate significant serial correlation at a 95% confidence interval. This suggests that the JPY/USD and JPY/EUR rate of returns are correlated with their past values. Additionally, the L-Jung box tests for the squared percentage change in both series are also significant, indicating serial correlation in the

squared percentage change. The presence of significant autocorrelation in both percentage change and squared percentage change suggests the existence of conditional heteroskedasticity.

The interest rate spread between the Federal Reserve, the ECB, and the Bank of Japan also exhibits significant variations throughout the analyzed period. This variability in the interest rate spread is relevant for examining its correlation with changes in the exchange rates.

This research incorporates various variables, including interventions, news, the interest rate spread, and the percentage change in the exchange rate, to investigate the volatilities of the JPY/USD and JPY/EUR exchange rates, as well as any spillover effects between them. Detailed definitions of the variables can be found in **Table 2**.

Table 2. Variable definitions.

Variable	Symbol	Variable treatment
Exchange rate change	Δs_t	The log change in the spot JPY/USD or the JPY/EUR exchange rate
Information set	Ω_{t-1}	All information available at time $t-1$
Intervention	I_t^{BOJ}	Dummy variable that takes value 1 or the actual amount of the intervention when the BOJ intervenes in the foreign exchange market
News	N_t	Dummy variable that takes value 1 when there is news on exchange rate at time t
Interest rate spread	Δi_t	Spread between the BOJ and the Fed or BOJ and the ECB overnight policy interest rate
GARCH error term	ε_t	Error term
GARCH conditional volatility	v_t	Volatility, meaning that a change in the conditional variance affect the conditional mean

4.2. Methodology

This study explores the correlation between the volatilities of the JPY/USD and JPY/EUR exchange rates and various factors, including Bank of Japan (BOJ) interventions in the foreign exchange market, news or speculation in the financial press about such interventions, and the interest rate spread between the BOJ and other central banks.

To account for the characteristics of the time series data, several observations were made. Firstly, it was determined that the data does not follow a normal distribution, as indicated by a kurtosis value exceeding 3.0. Additionally, the presence of conditional solid heteroskedasticity in the JPY/USD and JPY/EUR exchange rates, along with clustering volatility, was observed.

To analyze the data, a standard and multivariate Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model with a Student t distribution was employed. It is important to note that the spot exchange rate data was found to be non-stationary. Conversely, the log change in the exchange rate was identified as stationary and serially correlated. Similarly, the squared log change in the exchange rate exhibited serial correlation.

Figures 4 and **5** depict the log change of the JPY/USD and JPY/EUR exchange rates for the duration of the study period.

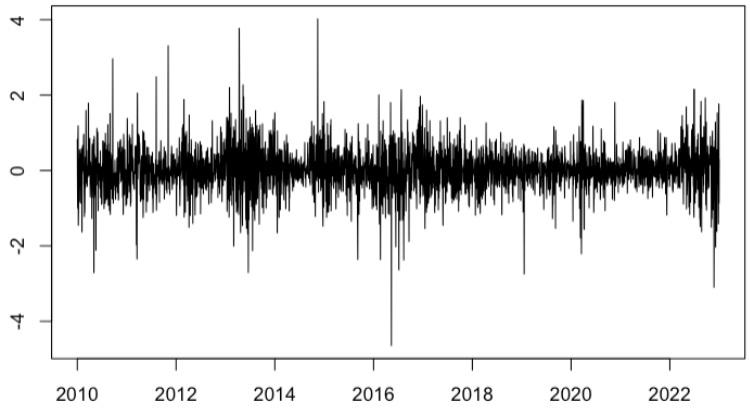

Figure 4. Return in the daily spot JPY/USD exchange rate from 2010 to 2020.

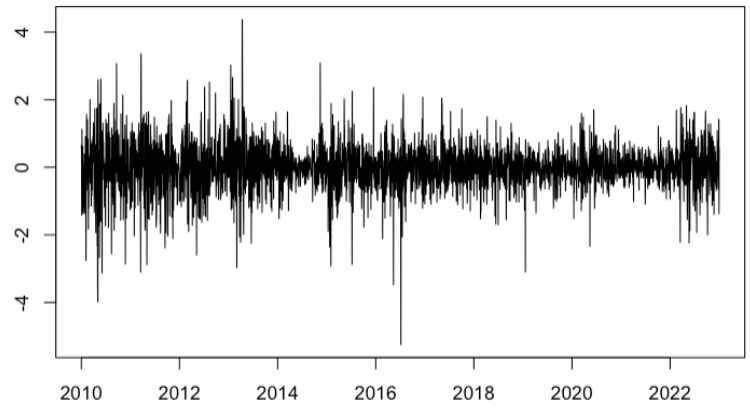

Figure 5. Return in the daily spot JPY/EUR exchange rate from 2010 to 2020.

This research examines the impact of interventions, news, and the interest rate spread on the conditional mean equation, which captures the explanatory effect of the change in either the JPY/USD or the JPY/EUR exchange rate, as well as on the conditional variance equation, which elucidates the influence on the volatility of the JPY/USD or the JPY/EUR exchange rate. In this study, we utilize Equations (4) to (6) to represent the modified univariate GARCH (1,1) model with a Student t distribution. These equations are applied initially to the JPY/USD exchange rate and subsequently to the JPY/EUR exchange rate, taking into account the specific adjustments made for this research:

$$\Delta s_t = \beta_0 \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 v_{t-1} + \beta_1 I_t^{BOJ} + \beta_2 N_t + \beta_3 \Delta i_t + \varepsilon_t \quad (4)$$

$$\varepsilon_t | \Omega_{t-1} \sim f_v(\varepsilon_t | \Omega_{t-1}) \quad (5)$$

$$v_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 v_{t-1} + \psi_1 \left| I_t^{BOJ} \right| + \psi_2 N_t + \psi_3 \Delta i_t \quad (6)$$

where all variables are defined as above in **Table 2**.

These equations allow us to analyze the relationship between interventions, news, the interest rate spread, and the conditional mean and variance of the JPY/USD and JPY/EUR exchange rates.

Figures 4 and **5** demonstrate a convergence towards zero in both the JPY/USD and JPY/EUR exchange rate returns. The application of the GARCH (1,1) model enables us to estimate the mean

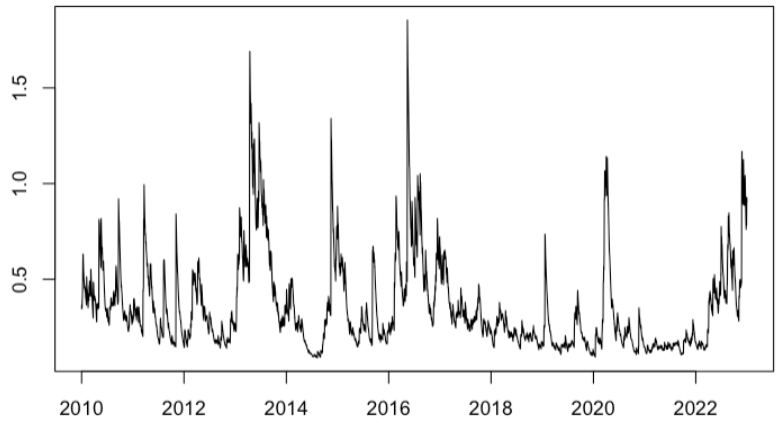

Figure 6. Volatility of the daily JPY/USD exchange rate from 2010 to 2022.

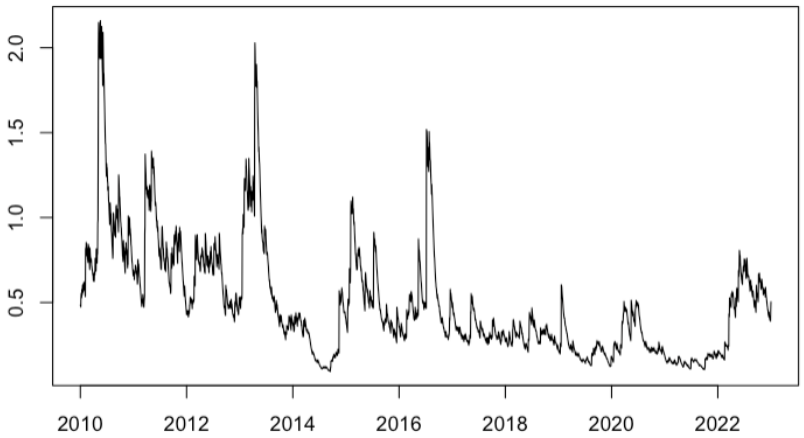

Figure 7. Volatility of the daily JPY/EUR exchange rate from 2010 to 2022.
Note: Calculation based on the daily morning spot JPY/USD and JPY/EUR exchange rates from 01/01/2010 to 31/12/2022, data retrieved from the Bank of Japan. Volatility is estimated through the GARCH (1,1) model without external variables. The model considers volatility as a function of past errors and volatilities alone.

equation (described by Equation (4)) and the variance equation (described by Equation (6)). The mean equation captures the fluctuations of the yen, encompassing appreciation or depreciation, based on past errors, past volatility, and external variables. Conversely, the variance equation considers the volatility of the exchange rate, taking into account past errors, past volatility, and external variables. In **Figures 6** and **7** presented below, we visually depict the estimated JPY/USD and JPY/EUR exchange rate volatilities derived from the GARCH (1,1) model without incorporating external variables into the estimation.

The figures (**Figures 6** and **7**) depict the estimated volatility patterns for both the JPY/USD and JPY/EUR exchange rates. Notably, there has been a substantial increase in the volatility of the JPY/USD exchange rate since the start of 2022. Peaks in volatility are observed during specific periods, namely in 2013, towards the end of 2016, and at the beginning of 2020. These spikes in volatility correspond to periods characterized by heightened economic instability or exceptional circumstances. The figures clearly illustrate that under such severe or unusual economic conditions, the exchange rates experience relatively high levels of volatility, resulting in increased uncertainty among market participants.

The model specifications for the standard and multivariate GARCH (1,1) model incorporate three

external variables: Bank of Japan interventions (as a binary variable and the actual amount spent on interventions), news related to interventions, and the interest rate spread between the Bank of Japan and major central banks. However, the standard GARCH (1,1) model has several limitations, including the omission of asymmetries and the leverage effect in the model, as well as the neglect of the correlation between the JPY/USD and JPY/EUR exchange rates. Building upon the work of Black (1976) on the leverage effect, Hoffman and Schlagenhauf (1985) demonstrate the significance of "news" or unanticipated positive or negative shocks in exchange rate determination. In other words, the nature and magnitude of news impact exchange rate volatility differently: negative news tends to increase volatility to a greater extent than positive news decreases it. To account for this asymmetry, Engle (1990) proposed the Asymmetric GARCH model. However, after conducting careful investigations into potential asymmetries in the time series, this study concludes that no significant asymmetry exists, and therefore, only the standard GARCH (1,1) model is considered.

One limitation of the standard GARCH model is its inability to account for covariance between two time series, such as the JPY/USD and JPY/EUR exchange rates. To address this limitation, this study adopts the multivariate GARCH framework introduced by Bollerslev (1990). The key distinction between the univariate and multivariate GARCH models is that the latter assumes co-movements between currencies. As a result, the model incorporates time-varying conditional covariance using matrix notation, which is added to the structure of the univariate GARCH (1,1) model that assesses the conditional variances. Equations (7) and (8) below extend the univariate GARCH model by introducing the matrix H and the parameter ρ to specify the correlation between currencies:

$$Var(\varepsilon_t|\Omega_{t-1}) = H_t \tag{7}$$

$$\rho_{ij,t} = h_{ij,t}/\sqrt{(h_{ii,t}h_{jj,t})} \text{ where } -1 \leq \rho_{ij,t} \leq 1 \tag{8}$$

The estimation of the GARCH (1,1) model and the multivariate GARCH models relies on the Maximum Likelihood function, as outlined by Berndt et al. (1974). This approach involves maximizing the likelihood function to find the parameter values that best fit the observed data. By maximizing the likelihood, the models can estimate the coefficients and parameters that characterize the conditional mean and conditional variance equations. The Maximum Likelihood method is widely used in econometric modeling to estimate various types of models, including GARCH models, and has been proven to provide reliable and efficient parameter estimates.

5. Results

5.1. The effect of foreign exchange interventions on the level of the yen

We start our discussion of the empirical results by considering the policy effectiveness of exchange rate interventions on the level of the yen as articulated in Hypotheses 1–3. The results obtained from estimating Equation (4), the GARCH conditional mean equation, are presented in **Tables 3** and **4**.

The results presented in **Tables 3** and **4** indicate that interventions had no significant impact on either the yen-dollar exchange rate or the yen-euro exchange rate over the entire sample period from

Table 3. Results for the GARCH conditional mean equation, dummy interventions.

	2010–2022		2010–2011		2022	
	¥/$	¥/€	¥/$	¥/€	¥/$	¥/€
α_0	0.004 * (1.77)	0.002 *** (2.68)	0.000 (0.00)	0.060 * (1.67)	0.020 (0.95)	0.006 (1.61)
α_1	0.065 *** (3.21)	0.039 *** (14.54)	0.012 *** (3.79)	0.047 * (1.75)	0.102 (1.52)	0.000 (0.00)
α_2	0.925 *** (37.89)	0.959 *** (1279.79)	0.985 *** (391.32)	0.885 *** (17.55)	0.879 *** (11.61)	0.991 *** (739.66)
ψ_1	0.006 (0.03)	0.130 (0.30)	0.015 (0.09)	0.505 * (1.67)	0.043 (0.45)	–0.562 (–1.38)
ψ_2	0.178 (1.24)	0.001 (0.00)	0.440 (0.34)	1.001 * (1.82)	0.023 (0.14)	–0.159 (–0.71)
ψ_3	–0.001 (–0.18)	–	0.035 (0.07)	–	0.008 (0.23)	0.012 (0.23)
Cov1: Dcca1	0.037 *** (5.55)		0.043 *** (2.07)		0.095 *** (3.67)	
Cov2: Dccb1	0.951 *** (94.39)		0.928 *** (25.68)		0.847 *** (22.69)	
Log-likelihood	–4898.25		–1027.55		–467.46	
L-Jung box test	0.25	0.43	0.89	0.52	0.94	0.83

*Note: The t-value is written between parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Note that the null hypothesis of the L-Jung box test that the autocorrelation in the data is zero, is not rejected at standard levels of statistical significance.*

Table 4. Results for the GARCH conditional mean equation, magnitude interventions.

	2010–2022		2010–2011		2022	
	¥/$	¥/€	¥/$	¥/€	¥/$	¥/€
α_0	0.004 * (1.78)	0.002 *** (2.68)	0.000 (0.00)	0.063 (1.62)	0.020 (0.95)	0.006 (1.09)
α_1	0.065 *** (3.24)	0.039 *** (14.55)	0.012 *** (3.17)	0.049 * (1.75)	0.102 (1.51)	0.000 (0.00)
α_2	0.925 *** (38.42)	0.958 *** (1277.52)	0.985 *** (293.94)	0.878 *** (15.79)	0.879 *** (11.55)	0.992 *** (875.73)
ψ_1	–0.000 (–1.26)	0.000 (–0.02)	–0.000006 *** (–3.05)	0.000 (0.61)	0.000 (1.56)	–0.000 (–0.22)
ψ_2	0.177 (1.22)	0.003 (0.01)	0.431 (0.34)	1.015 * (1.83)	0.026 (0.17)	–0.153 (–0.69)
ψ_3	–0.001 (–0.17)	–	0.069 (0.14)	–	0.010 (0.28)	0.018 (0.38)
Cov1: Dcca1	0.036 *** (5.54)		0.042 ** (2.29)		0.092 *** (3.51)	
Cov2: Dccb1	0.950 *** (93.99)		0.927 *** (29.73)		0.848 *** (22.29)	
Log-likelihood	–4899.87		–1028.26		–467.22	
L-Jung box test	0.22	0.44	0.73	0.52	0.91	0.78

*Note: The t-value is written between parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Note that the null hypothesis of the L-Jung box test that the autocorrelation in the data is zero, is not rejected at standard levels of statistical significance.*

2010 to 2022, confirming Hypothesis 1.

Even when considering the shorter time period of 2010–2011, neither BOJ interventions nor news of BOJ interventions per se, were found to have a statistically significant impact on the yen-dollar exchange rate (**Table 3**, column 3), but both BOJ interventions and news of BOJ interventions led to a statistically significant depreciation of the yen against the euro (**Table 4**, column 4). Similar results are found for the yen-euro rate when the magnitude of the intervention is taken into account in **Table 5**: news of BOJ interventions led to a statistically significant depreciation of the yen against the euro at the 90% confidence interval (**Table 5**, column 4). Surprisingly, when the magnitude of the intervention is taken into account, BOJ interventions led to a small but highly statistically significant appreciation of the yen against the dollar in 2010–2011.

Table 5. Results for the GARCH conditional variance equation, dummy interventions.

	2010–2022		2010–2011		2022	
	¥/$	¥/€	¥/$	¥/€	¥/$	¥/€
α_0	0.004 (1.28)	0.002 ** (2.39)	0.000 (0.00)	0.084 (0.37)	0.020 (0.50)	0.002 (0.21)
α_1	0.066 ** (2.06)	0.041 *** (13.26)	0.006 (0.57)	0.067 (0.69)	0.106 (0.66)	0.000 (0.00)
α_2	0.924 *** (24.57)	0.957 *** (1003.2)	0.992 *** (808.49)	0.841 *** (2.82)	0.876 *** (6.75)	1.000 *** (1216.1)
ψ_1	0.000 (0.00)	0.000 (0.00)	0.000 (0.00)	0.000 (0.00)	0.000 (0.00)	0.000 (0.00)
ψ_2	0.000 (0.00)	0.000 (0.00)	0.000 (0.00)	0.000 (0.00)	0.000 (0.00)	0.000 (0.00)
ψ_3	0.000 (0.00)	–	0.000 (0.00)	–	0.000 (0.00)	0.000 (0.00)
Cov1: Dcca1	0.036 *** (5.44)		0.036 ** (2.06)		0.089 *** (3.79)	
Cov2: Dccb1	0.951 *** (93.39)		0.931 *** (30.20)		0.852 *** (27.41)	
Log-likelihood	–4906.05		–1033.07		–473.45	
L-Jung box test	0.29	0.02	0.18	0.04	0.93	0.73

*Note: The t-value is written between parentheses. * p < 0.1; ** p < 0.05; *** p < 0.01. Note that the null hypothesis of the L-Jung box test that the autocorrelation in the data is zero, is not rejected at standard levels of statistical significance.*

However, when and negative correlation with yen-dollar exchange rate movements at a 99% confidence interval, particularly when the magnitude of the intervention is considered as reported in **Table 4**. Additionally, at a 90% confidence interval, BOJ interventions were found to significantly depreciate the yen against the euro during 2010 and 2011, when intervention is represented as a dummy variable as shown in **Table 4**.

Although the estimated coefficients for interventions are relatively small in magnitude, these results suggest that interventions in 2010–2011 were associated with the appreciation of the yen against the dollar and a depreciation of the yen against the euro on the day following the intervention. Considering the policy intent of the interventions conducted during that period 2010–2011, it can be inferred that interventions effectively influenced the JPY/EUR exchange rate level in

the direction desired by policymakers, but that the JPY/USD exchange rate moved in the opposite direction.

Thus, Hypothesis 2a, pertaining to the short-horizon effect of BOJ interventions or news of BOJ interventions on the yen-dollar exchange rate is rejected, while Hypothesis 2b, pertaining to the short-horizon effects of the BOJ interventions or news of BOJ interventions on the yen-euro rate, is supported. It is worth noting that one potential reason for the insignificance of the yen/USD exchange rate could be the fact that many other major currencies are pegged to some extent with the USD. The current research only considers two exchange rate time series and their covariance, neglecting other factors that contribute to the equilibrium of the foreign exchange market.

Turning next to the short-horizon analysis of exchange rate movements in year 2022, both Hypotheses 3a and 3b are supported. The market exchange rate does not exhibit significant fluctuations that would indicate an effective signal effect of currency support, as the market is aware that such behavior is more of a temporary strategic threat to short positions rather than a continuous and regular selling of foreign reserves by the central bank.

Turning to a discussion of the other results reported in **Table 3** and **Table 4**, we note that the estimates for the GARCH-in-mean, represented by α_2, are highly statistically significant at a 99% confidence interval and close to positive one for both periods. These significant estimates suggest that higher volatility led to yen depreciation, whether against the US dollar or the euro, over the analyzed period. As this study employs the multivariate GARCH model, two covariance coefficients (Dcca1 and Dccb1) are estimated using the DCC-GARCH approach to assess the co-movement between the JPY/USD and JPY/EUR exchange rates. The joint significance of these coefficients indicates that both exchange rates tend to move together in the same direction. Finally, the L-Jung box test results indicate that the standardized residual is serially uncorrelated for both exchange rates and periods.

5.2. The effect of foreign exchange interventions on the volatility of the yen

We next turn to a discussion of the empirical results on the policy effectiveness of exchange rate interventions on the volatility of the yen as articulated in Hypotheses 4–5. The results obtained from estimating Equation (6), the GARCH conditional volatility equation, are presented in **Tables 5** and **6**.

We first consider the results reported in **Table 5**, which explore the policy effect of a dummy variable indicating an actual BOJ intervention or news about a BOJ intervention, on the GARCH conditional volatility. As expected, there is no statistically significant effect of an intervention or news of an intervention per se on exchange rate volatility in either the long-horizon or short-horizon estimation windows.

Our interest centers around the empirical analysis presented in **Table 6**, where we take into account the actual magnitude of the interventions. Looking at the first two columns of **Table 6**, we note that for the full-sample period long-horizon estimation window, BOJ policy interventions in the exchange rate have a statistically significant positive impact on GARCH variance of both the yen-dollar exchange rate and the yen-euro exchange rate. This demonstrates that, as we stated in Hypothesis 4, in the long-time horizon, BOJ interventions increase volatility in the yen against both the US dollar and the euro. Hypothesis 4 is supported.

Table 6. Results for the GARCH conditional variance equation, magnitude interventions.

	2010–2022		2010–2011		2022	
	¥/$	¥/€	¥/$	¥/€	¥/$	¥/€
α_0	0.005 ** (2.32)	0.002 *** (2.89)	0.000 (0.02)	0.109 (1.38)	0.015 (1.36)	0.009 (1.19)
α_1	0.074 *** (6.06)	0.041 *** (46.09)	0.009 (0.81)	0.077 ** (2.33)	0.099 (1.34)	0.000 (0.07)
α_2	0.913 *** (54.96)	0.956 *** (709.39)	0.989 *** (2639.48)	0.800*** (17.17)	0.883 *** (17.35)	0.987 *** (422.95)
ψ_1	0.000004 *** (3.21)	0.000002 *** (46.09)	0.000 (0.00)	0.000 (1.22)	0.000008 *** (277.96)	0.000 (0.00)
ψ_2	0.000 (0.00)	0.000 (0.00)	0.000 (0.00)	0.000 (0.00)	0.000 (0.00)	0.000 (0.00)
ψ_3	0.000 (0.00)		0.000 (0.00)		0.000 (0.00)	0.000 (0.00)
Cov1: Dcca1	0.035 *** (5.28)		0.041 ** (2.04)		0.082 *** (3.15)	
Cov2: Dccb1	0.950 *** (90.24)		0.925 *** (22.94)		0.846 *** (21.49)	
Log-likelihood	–4871.19		–1035.44		–469.39	
L-Jung box test	0.37	0.02	0.17	0.05	0.99	0.85

*Note: The t-value is written between parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Note that the null hypothesis of the L-Jung box test that the autocorrelation in the data is zero, is not rejected at standard levels of statistical significance.*

Even in the short-time horizons, 2010–2011 and 2022, in which case we hypothesized that policy interventions of appropriate magnitude would send a credible signal to market participants, reducing volatility and achieving the presumed policy intent of stabilizing the exchange rate, we find that neither policy interventions nor news about policy interventions statistically significantly reduce exchange rate volatility in either the yen-dollar market or the yen-euro market. In fact, contrary to expectations, we find that large BOJ interventions in the short-time horizon of 2022 actually increase volatility in the yen-dollar exchange rate as reported in **Table 6**, column 5. Thus, Hypothesis 5 is rejected.

While contradicting our stated Hypothesis 5, these results corroborate anecdotal evidence that policy interventions are not very effective at incentivizing investors holding short positions to unwind those positions (Duguid, 2022). On the contrary, since interventions are not systematic, even large policy interventions may diversify market perceptions rather than consolidating them, leading to higher volatility (Lewis and Inagaki, 2022).

5.3. Summary of findings

In assessing the stated research question posed at the start of this study, whether foreign exchange interventions in Japan are effective, we need to start with an understanding of the purpose of foreign exchange interventions. Unfortunately, the policy objectives behind foreign exchange interventions are often not clearly communicated. In fact, interventions are often conducted in secret: it may not even be publicly announced that an intervention has taken place. The academic literature usually assumes that foreign exchange interventions are conducted with the intention of influencing either

the level of the exchange rate or its volatility, so we organize our discussion around those goals. We note, however, that central bank interventions may be more likely when the exchange rate is relatively appreciated or depreciated relative to historical levels, and during periods of relatively high volatility. The factors that trigger an intervention and would be an interesting area for further.

Overall, we find that exchange rate interventions in Japan are relatively ineffective at influencing either the direction or the volatility of the yen over both the short horizon and long horizon. While we do find that exchange rate interventions aimed at competitively devaluing the yen against the euro are somewhat effective at moving the yen/euro exchange rate in the desired direction over a short horizon, in general we find that exchange rate interventions are not effective at influencing either the level of yen against other currencies or its volatility over either a short horizon or long horizon.

Table 7 summarizes the main findings of this study. Since there is as yet no consensus as to the effectiveness of exchange rate interventions in the existing academic research, it is difficult to state conclusively whether these results are in line with the existing literature. Consistent with the results reported here, one seminal study on the effects of US, German and Japanese monetary and intervention policies on exchange rate volatility, Dominguez (1998), found that central bank intervention is usually associated with greater exchange rate volatility rather than less. However, in a review of the literature on the effectiveness of exchange rate interventions in Japan in particular, Spiegel (2003) concludes that in Japan foreign exchange interventions can have "persistent, albeit temporary, impacts on the exchange rate". In a recent cross-country study, Fratzscher et al. (2019) conclude that exchange rate interventions are overall effective about 60% of the time at changing the direction of the exchange rate and about 80% of the time at smoothing exchange rate volatility. None of the studies cited here look explicitly at differences explored in this study: the effectiveness of interventions over the short vs. long horizon, devaluations vs. revaluations or the exchange rate against the euro vs. USD. Thus, this study may help establish a path for future research in this area.

Table 7. Summary of findings.

Hypotheses	Validation	Discussion
H1: Long-horizon exchange rate changes H1. In the long horizon (2010–2022 sample), neither BOJ interventions nor news about BOJ interventions credibly signal a future change in exchange rates, and therefore do not change either market expectations or the current exchange rate.	Supported	Policy interventions aimed at changing the level the yen against other currencies are not effective in the long-horizon analysis. Over a long horizon, exchange rates are determined by economic fundamentals, not temporary policy interventions.
H2: Short-horizon currency devaluations H2a. In the short-horizon 2010–2011 window, BOJ interventions or news about BOJ interventions credibly signal a future depreciation of the yen-dollar exchange rate, and the change in market expectations brings about a current depreciation.	Rejected	Policy interventions or news of policy interventions aimed at competitively devaluing the yen against the US dollar are not effective, even in the short-horizon analysis, perhaps because of US dollar's unique role as a global reserve currency.
H2b. In the short-horizon 2010–2011 window, BOJ interventions or news about BOJ interventions credibly signal a future depreciation of the yen-euro exchange rate, and the change in market expectations brings about a current depreciation.	Supported	Policy interventions or news of policy interventions aimed at competitively devaluing the yen against the euro are effective in the short-horizon analysis.

Table 7. (*Continued*).

Hypotheses	Validation	Discussion
H3: Short-horizon currency revaluations		Policy interventions or news of policy interventions aimed at propping up the yen against other currencies are not effective, even in the short-horizon analysis, as market participants understand that even large policy interventions are ad hoc rather than systematic policies.
H3a. In the short-horizon 2022 window, BOJ interventions or news about BOJ interventions do not credibly signal a future appreciation of the yen-dollar exchange rate, so market expectations do not change, and the interventions are not effective in bringing about a current appreciation.	Supported	
H3b. In the short-horizon 2022 window, BOJ interventions or news about BOJ interventions do not credibly signal a future appreciation of the yen-euro exchange rate, so market expectations do not change, and the interventions are not effective in bringing about a current appreciation.	Supported	
H4: Long-horizon currency volatility		Policy interventions aimed at stabilizing the yen against other currencies are not effective in the long-horizon analysis.
H4. In the long horizon (2010–2022 sample), larger magnitude BOJ interventions in the exchange rate do not send a credible signal to market participants, are not able to create market consensus, and therefore increase volatility in the exchange rate.	Supported	
H5: Short-horizon currency volatility		Even in the short-horizon analysis, policy interventions aimed at stabilizing the yen against other currencies are not effective. Co-movement of other currencies may need to be considered.
H5. In the short horizon (2010–2011 window or 2022 window), larger magnitude BOJ interventions in the exchange rate send a credible signal to market participants, creating market consensus, and therefore reducing volatility in the exchange rate.	Rejected	

Since the end of the Global Financial Crisis, central banks report that their focus is on limiting exchange rate volatility and that reducing exchange rate volatility is now the main objective of exchange rate interventions (Blanchard et al., 2015; Mohanty and Berger, 2013). The policy objectives of exchange rate interventions in Japan and how those objectives influence the effectiveness of exchange rate interventions would be an interesting direction for future research.

6. Conclusions and directions for future research

This research offers empirical evidence regarding the impact of policy interventions in the foreign exchange market in Japan across different time windows and policy objectives. The findings suggest that interventions aimed at currency depreciation are more likely to be perceived a signal and therefore to influence market expectations, aligning with the causality of devaluation. On the other hand, interventions aimed at protecting the value of the currency and supporting the yen are seen as temporary threats to short positions and have a limited effect on the exchange rate. Although interventions may be intended to mitigate abnormal currency volatility, over longer periods of time, the dominant factors influencing exchange rates are economic fundamentals such as productivity, efficiency, and output, rather than policy interventions. In fact, the cumulative abnormal influence resulting from interventions may eventually lead to increased volatility.

Future research on Bank of Japan policy interventions in exchange rates should consider that their impact tends to be short-lived, suggesting the relevance of utilizing intraday data. Additionally,

exploring alternative GARCH specifications beyond the standard or multivariate GARCH models could enhance and potentially influence the results obtained in this study.

Author contributions

Conceptualization, OG and HM; methodology, OG, HM and DS; software, OG; validation, OG, HM and DS; formal analysis, OG, HM and DS; investigation, OG, HM and DS; resources, OG; data curation, OG and HM; writing—original draft preparation, OG, HM and DS; writing—review and editing, OG, HM and DS; visualization, OG and HM; supervision, HM; project administration, OG, HM and DS. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

The authors report there are no competing interests to declare.

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