Japanese Foreign Exchange Interventions, 1971-2018: Estimating a Reaction Function Using the Best Proxy [a]

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Abstract

We analyze the history of Japanese foreign exchange interventions from 1971 to 2018. First, we provide the best proxy for monthly interventions for the period from 1971 to 1990, when the intervention timings and amounts were not officially disclosed. The accuracy of the proxy is tested for the period when the statistics were disclosed after 1991. The proxy explains 99.8% of actual settlement-based interventions. Second, we examine conditions under which the Japanese monetary authorities are likely to intervene by estimating a policy reaction function, using the long-term data, spanning the period when intervention data have been officially disclosed and the period where our proxy is available. Third, we analyze intervention timings and amounts for Japan, the US, and Germany. Fourth, we present the episode of international coordination represented by the Plaza and Louvre agreements as a case study of notable interventions during the period.

***JEL Classification*:** F31; E52; E58; G15

***Keywords*:** Central bank intervention; foreign reserves; ordered probit model; policy coordination; structural break

1. Introduction

Japan is known to have resisted rapid yen appreciation by occasionally conducting foreign exchange interventions since it departed from the Bretton Woods system in August 1971. The frequency and scale of interventions have been relatively large for a developed country, and Japan has been a popular country for studies in the intervention literature. The daily data of interventions for the period since April 1, 1991 have been officially made available to the public. However, intervention data before March 1991 have not been officially disclosed. Some researchers have relied on newspaper reports based on leaks and market rumors in order to analyze particular episodes. Others have used either changes in foreign reserves or the data titled "Treasury Funds and Others/Foreign Exchange" released by the Bank of Japan as a proxy for intervention. However, changes in foreign reserves, for example,

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include receipts of interest income on the foreign reserves, which are not interventions.

Ito and Yabu (2017) identified an accurate proxy for the monthly intervention amount for the period for which official data have not been disclosed. The accuracy of different possible proxies was tested against “transaction-based” interventions which took place during the period from which data are available. The best proxy, identified by Ito and Yabu, is more accurate than other popular proxies used in the existing literature, which include change in foreign reserves and the Bank of Japan’s "Treasury Funds and Others/Foreign Exchange."

In this paper, we first show that, in testing for the best proxy, it is important to distinguish “transaction-based” intervention from “settlement-based” interventions. Due to the market practice in the foreign exchange market, settlement is done two business days later than transactions—a rule known as $t+2$. We find that Ito and Yabu’s (2017) best proxy captures the movements of settlement-based interventions very well, explaining 99.8% of settlement-based interventions. Our first contribution is that we provide reliable data for intervention, from August 1971—the end of the Bretton Woods system—to March 1991. From April 1991, the official data for intervention are available.

Second, we analyze the conditions under which interventions are most likely to occur for the period from August 1971 to March 2018. The officially disclosed data are used for April 1991 to March 2018 and our proxy is used from August 1971 to March 1991. Since reaction functions, which represent the monetary authorities’ tolerance of and resistance to exchange rate volatility, are expected to have evolved and transformed over the 47 years under consideration, possible structural breaks in reaction functions will be carefully examined in this paper.

Third, the US and German monetary authorities have disclosed daily intervention data for the period beginning in 1973 and 1976, respectively. By analyzing intervention timings and amounts in the three countries, insights can be obtained on policy coordination or lack thereof, among the G3, in the past four decades.

Fourth, we present the episode of international coordination represented by the Plaza and Louvre agreements as a case study of notable interventions during the period under consideration.

The rest of the paper is organized as follows. Section 2 will review the foreign exchange intervention literature. Section 3 will review Ito and Yabu (2017) and show that in testing for the best proxy, it is important to distinguish transaction-based intervention from settlement-based intervention. Section 4 will provide an overview of the yen/dollar rates and interventions over the past 47 years. Section 5

will analyze the conditions under which the Japanese monetary authorities are likely to intervene in the foreign exchange market. Section 6 will present a case study on notable interventions during the period.

2. Literature

In July 2001, the Japanese Ministry of Finance released daily intervention records from April 1991 to the present. Since then, the Ministry of Finance has updated these records every quarter. The new data has stimulated academic research on Japanese intervention. One group of studies examined the effectiveness of intervention, i.e., whether intervention impacted exchange rate movements. This includes Ito (2003), Kearns and Rigobon (2005), Fatum and Hutchison (2006), Hoshikawa (2008), Chen, Watanabe, and Yabu (2012), and Fatum and Yamamoto(2014). Estimates vary across studies as to the estimated effect that one-trillion yen-selling interventions have had on the yen/dollar rate, ranging from 0.4 to 1.8 percent depreciation of the yen.

Another group of papers, including Ito (2003), Frenkel, Pierdzioch, and Stadtmann (2003, 2005), and Ito and Yabu (2007), examined the reaction function, i.e., under what financial conditions monetary authorities are more likely to intervene. Ito (2003) and Ito and Yabu (2007) identified factors that seem to trigger interventions: the deviation in the yen/dollar rate from long-run trends and recent movements of the yen/dollar rate. Moreover, the person or people in charge of interventions seem to influence the frequency and magnitude of interventions. For example, since June 1995, when Eisuke Sakakibara became Director General of the International Finance Bureau, the frequency of interventions lowered substantially but, when they occurred, the daily intervention amount increased significantly. The frequency and daily amount of intervention also had a distinctive pattern; for example, there were more frequent interventions during the 2003-04 period when Zenbei Mizoguchi was in charge of intervention.

However, given that intervention data before April 1991 has not been disclosed, we have to use a proxy to estimate past intervention data if, for example, we wish to examine and analyze interventions during the 1970s and 1980s.

In the literature several proxies have been proposed and adopted. These proxies can be obtained on a monthly basis. The most popular proxy is changes in the foreign reserves, namely, “Total Reserves excluding Gold,” also known as “Change in Reserve” for short. In an earlier study of intervention, this proxy was used by Dornbusch (1980), Takagi (1991) and others. Dornbusch (1980) and Takagi (1991) found that the Japanese monetary authorities followed a lean-against-the-wind policy during the 1970s. This is also a popular proxy when an international cross-country comparison is attempted,

as the statistics are readily available. For example, Dominguez, Hashimoto, and Ito (2012), in their large cross-country study, used “Change in Reserve,” but adjusted for interest income receipts.

However, a proxy that has been considered to be more accurate is data from the Bank of Japan titled “Treasury Funds and Others/Foreign Exchange” (hereafter, “BOJ FE”). Quirk (1977) was one of the earliest papers to argue that the “BOJ FE” was a better proxy than “Change in Reserve.” He also argued that the monetary authorities followed a lean-against-the-wind policy and that there was no “target” for the exchange rate in the 1970s. Meanwhile, Hutchison (1984) and Watanabe (1992) both used “BOJ FE.” Hutchison (1984) found that the monetary authorities adopted a lean-against-the-wind policy but were biased against yen appreciation in the 1970s. Watanabe (1992) concluded that before April 1980, the monetary authorities adopted a lean-against-the wind policy, whereas after April 1980, they began to try to achieve target levels of exchange rates.

Another proxy similar to “BOJ FE” is the Ministry of Finance statistics contained in the fiscal account “Receipts and Payments of the Treasury Funds; Foreign Exchange Equalization Fund” (hereafter, “MOF FEEF”). The difference between the “BOJ EF” and the “MOF FEEF” is that the latter include transactions related to issuance and redemption of government securities for the IMF quota. When an adjustment is made to the account by subtracting the balance of “Issuance and Redemption of Financial Bills in the Financial Market” (hereafter, “Adjusted MOF FEEF”), then it is believed to be much more representative of actual interventions. Both Suda (1999) and Nakada (1998) used “Adjusted MOF FEEF.” Suda (1999) pointed out a structural problem with the foreign exchange special account where profits were transferred to the general account while unrealized losses were carried over, whereas Nakada (1998) constructed a neural network model in order to forecast interventions.

At the time these proxies were proposed and adopted by the various authors mentioned above, actual intervention data had not yet been disclosed. After the actual intervention data disclosure, an academic interest in proxies was lost. However, actual intervention data have only been disclosed for the period after April 1991. Proxies are still needed for research and analysis of interventions that took place before April 1991. Since we have actual intervention data, we can test the proxies against the official data using a “test sample period” where both proxies and actual interventions are available. In fact, Ito and Yabu (2017) conducted such as test and identified the best proxy for actual interventions.[1]

[1] A similar test of proxies against the actual data was carried out by Neely (2000) for interventions in the United States, Switzerland and Germany. Neely used the correlation coefficient to judge whether the change in “Total Reserve excluding Gold” is a good proxy of true interventions. However, a test using a simple correlation is inconclusive at best. A regression can determine whether a proxy is an unbiased estimator.

3. In search of the best proxy

This section first introduces candidate proxies. Then, we will give an overview of the yet to be translated Japanese paper by Ito and Yabu (2017) and review their testing procedure and estimation results. Moreover, this section establishes that it is important to distinguish transaction-based intervention from settlement-based intervention in the testing procedure. This has not been discussed at all in the existing literature.

3.1. Candidates for Proxies

Data regarding actual interventions of the Japanese monetary authorities have been available with daily frequency since April 1, 1991. However, only proxies with a monthly frequency can be used for the period prior to April 1, 1991.

As discussed in section 2, four proxies have been used in the literature. Since actual intervention data are available on and after April 1, 1991, Ito and Yabu (2017) compared these proxies to actual transaction-based interventions for a period from April 1991 to March 1999. The end of the sample period for the test was determined by the point at which one of the proxies had a discontinuity in the classification. Each proxy is explained below in detail. (Table 1 lists brief summary of the proxies.)

<Table 1 about here>

(1) Change in Reserve

When large cross-country studies on interventions are conducted, foreign reserves (less gold) are often used. What is included and what is not is standardized by the International Monetary Fund (IMF) and the variable is readily available from the IMF (see IMF, 2013 for details). One drawback of using this as a proxy is that changes in foreign reserves include an amount of interest income received. Hence, in order to recover the amount of intervention, the estimated interest income should be deducted from the change in foreign reserves. However, for such an estimation, a researcher needs currency and maturity information on assets that are held as foreign reserves; this information is not available.

Conceptually, the first proxy for interventions is defined as follows:

$$\left[B_t - B_{t-1} - i_t^{US}\frac{(B_t + B_{t-1})}{2}\right]S_t$$

where B_t is the end-of-month *t* amount of foreign reserves (less gold) in USD; S_t is the yen/dollar rate average for the month; and i_t^{US} is the average yield of foreign reserve assets in month *t*. Dornbusch (1980) and Takagi (1991) used the 3-month T-bill rate as i_t^{US}. However, portfolios are not disclosed, meaning that the appropriateness of the 3-month T-bill rate cannot be tested. More recently, it can be inferred from interest incomes that the foreign reserves of several countries include treasury

bonds as well as T-bills. In order to check robustness with regard to portfolio interest rates, three different cases are considered: Change in Reserve, with T-bill (3 months); Change in Reserve, with T-bond (3 years); and Change in Reserve, with T-bond (10 years).

(2) BOJ EF

The BOJ EF captures an item in the flow of funds, the need of the government account. Hutchison (1984) and Watanabe (1992) used this data set in order to analyze the intervention record, policy intention, and effectiveness. The data are available from the Bank of Japan's website (http://www.stat-search.boj.or.jp/ssi/cgi-bin/famecgi2?cgi=$nme_s050_en). The series code is MD06'MASDM26.

(3) MOF FEEF

This series captures the Ministry of Finance's account that is used for all transactions in the foreign exchange market. This data is published monthly by the Ministry of Finance in *Ministry of Finance Statistics Monthly*. This is the counterpart of the Bank of Japan's account that is used for all transactions in the foreign exchange market. The data is available in Japanese on the Ministry of Finance's website (https://www.mof.go.jp/pri/publication/zaikin_geppo).

(4) Adjusted MOF FEEF

The source of this data set is the same as that for the MOF FEEF. The data set is adjusted for an item that is not related to intervention; namely, "Balancing of issuance and redemption of Financial Bills in the financial market," which is not related to intervention activities but rather to fees that the Ministry pays to issuing and redeeming securities. An adjustment is made to MOF FEEF by subtracting from it "Receipts and Payments of the Treasury Funds: Foreign Exchange Equalization Fund" in the fiscal operations statistics. Suda (1999) and Nakata (1998) used the Adjusted MOF FEEF.

3.2. Ito and Yabu (2017)

We review the testing procedure and estimation results of Ito and Yabu (2017). In order to test the accuracy of the proxies, monthly data of the four proxies from April 1991 to March 1999 are tested against actual interventions in the same period. The disclosed data regarding interventions were observed with daily frequency but have been aggregated to monthly values for the purposes of testing. The sample period ends March 1999, because in April 1999, "MOF FEEF" becomes impossible to adjust due to changes in categorization.

The tests are conducted with the following regression:

$$Int_t = \beta_0 + \beta_1 Proxy_t + u_t \quad (1)$$

where Int_t denotes the transaction-based intervention amount ($Int_t > 0$ implies selling yen, buying dollars) and $Proxy_t$ denotes a particular proxy. Both variables are measured in units of 100 million yen. The null hypothesis is $\beta_0 = 0$ and $\beta_1 = 1$. If the null is not rejected, it implies that a proxy is an unbiased estimator of actual interventions. Among the proxies that are shown to be unbiased estimators, the best estimator is the one in which R^2 is closest to 1.

Proxies to be tested are (1) Change in Reserve, 3-month T-bills; (2) Change in Reserve, 3-year T-bonds; (3) Change in Reserve, 10-year T-bonds; (4) BOJ EF; (5) MOF FEEF; and (6) Adjusted MOF FEEF. Table 2 shows the estimated results of Eq. (1) with the null hypothesis of H_0: $\beta_0 = 0$ and H_0: $\beta_1 = 1$.

<Table 2 about here>

The null hypothesis of H_0: $\beta_1 = 1$ is rejected when we adopt "BOJ EF" or "MOF FEEF." Thus, they are not unbiased estimators. Their coefficients of determination (R^2) are low as well. This is surprising, given that alternatives to "Change in Reserve" were popular among researchers before actual intervention data were made available to the public. The null hypothesis of an unbiased estimator is not rejected when either "Change in Reserve" with an interest income adjustment or "Adjusted MOF FEEF" is used. The estimated coefficient of β_0 is closest to 0 and β_1 is closest to 1 when "Adjusted MOF FEEF" is adopted. Moreover when "Adjusted MOF FEEF" is adopted, R^2 is 0.969 and higher than those with "Change in Reserve" (with any of the three possible interest rate assumptions): 0.928. Therefore, "Adjusted MOF FEEF" is concluded to be the best proxy for transaction-based interventions.

In order to determine the accuracy of the best proxy, Figure 1 shows the time series of transaction-based intervention amounts (Int_t) and the estimated errors of the proxy (Adjusted MOF FEEF), which are defined as:

$$Error_t = Int_t - Proxy_t.$$

The error is small overall; however, there is a negative serial correlation in the error ($Error_t$), meaning that when the error is positive in one month, there is a negative error of a similar amount the following month. This may suggest some accounting issue: When actual intervention takes place near the end of the month, settlement and booking may spill over into the next month. This may explain the negative correlation.

<Figure 1 about here>

3.3. Important adjustments in the test

In testing for the best proxy, it is important to distinguish transaction-based interventions from

settlement-based interventions. Due to the market practice in the foreign exchange market, settlement is done two business days after transactions—a rule known as $t+2$.

The following is true of any transaction in the foreign exchange market: For example, if Bank A buys yen from Bank B in exchange for US dollars on Monday, the transactions are recorded as having taken place on Monday. However, the currency is not actually sent to until Wednesday. Transactions between the monetary authority and its counterpart in the market are no exception. Supposing that the monetary authority intervenes in the market to purchase foreign currency (say, US dollars) by selling domestic currency (say, yen) on Monday, the market impact should be immediate. In the market, if it is impressed by the authority's move, foreign currencies will appreciate (preventing further depreciation) on Monday. However, actual payments of yen and receipts of the foreign currency by the authority do not take place until Wednesday. Official records, the balance sheets of the central banks, or the government's fiscal account that records actual changes in government's assets and liabilities do not change until Wednesday. Thus, any interventions that are so recognized by the market and so recorded in the official statistics of interventions during the last two business days of the month (say, m) will not be recorded as a change in the balance sheet or fiscal accounts of the central bank and the government in month m, but rather in month $m+1$. This fact is important in evaluating the precision of a monthly proxy, by using daily intervention amounts for the period that daily intervention amounts are officially disclosed.

Let us denote interventions conducted during the last two business days of the month by Int_t^{End}. These amounts are recorded in the fiscal accounts that are used in the monthly proxy of month $t+1$. Similarly, Int_{t-1}^{End} is recorded in the monthly proxy of month t. Thus, the proxy of month t should be compared against settlement-based intervention amounts, calculated as:

$$Int_t^{Settlement} = Int_t - \left(Int_t^{End} - Int_{t-1}^{End}\right).$$

In order to see the point of this discussion, the estimated errors of the best proxy ($Error_t = Int_t - Proxy_t$) are examined. We argue that this is mostly explained by the end-of-month interventions and the $t+2$ difference between transaction and settlement. We define the $t+2$ difference as $EoMDiff_t$ (abbreviation of "end of month difference"):

$$EoMDiff_t = Int_t^{End} - Int_{t-1}^{End}.$$

Figure 2 shows the time series of $Error_t$ and $EoMDiff_t$ where $Error_t$ is again computed using "Adjusted MOF FEEF" as a proxy. As expected, the "Errors" appear to be explained mostly as a result of end-of-month interventions and the $t+2$ settlement. To be statistically accurate, a regression is conducted:

$$Error_t = -8.200 + 1.074\, EoMDiff_t$$
$$(7.166) \quad (0.083) \qquad\qquad R^2 = 0.956$$

Here HAC standard errors are in brackets.[2] Neither H_0: $\beta_0 = 0$ nor H_0: $\beta_1 = 1$ is rejected; the deviation of the proxy from transaction-based interventions is well explained by the end-of-month interventions. In fact, 95.6% of the deviation is due to end-of-month interventions, as shown by $R^2 = 0.956$.

<Figure 2 about here>

We further examine how close settlement-based intervention data are to various proposed proxies for the period after the disclosure, April 1991. Table 3 shows the regression results of Eq. (1) with the dependent variable being settlement-based interventions ($Int_t^{Settlement}$). As shown, the explanatory power of proxies is much improved, compared to the one in Table 2. For the regression using "Adjusted MOF FEEF," the R^2 improves from 0.968 in Table 2 to 0.998 in Table 3.[3] This is a confirmation that the proxy is an accurate measure, explaining 99.8% of the movements of settlement-based interventions.

<Table 3 about here>

The above detailed examination in search of the best proxy for interventions is thus concluded with both encouraging and discouraging results. We are encouraged to have found that "Adjusted MOF FEEF" is the best proxy with 99.8% accuracy. However, our enthusiasm must be tempered slightly given that this accuracy is measured against settlement-based interventions. Hence, considering that daily data are not available prior to April 1991, the available monthly interventions data for months (t) covers the period from the last two days of month $(t-1)$ to the third to last business day of month (t). This may pose a problem in analyzing the effectiveness of interventions or the reaction function of the monetary authorities when intervention actions are concentrated at the end of the month. However, an adjustment can be applied when such circumstances are suspected based on the volatility of the exchange rate; for example, one can use the exchange rate from the third to last business day as the monthly exchange rate. This is what we will do in section 5 when estimating the reaction function of the monetary authorities.

[2] The long-run variance is constructed based on the quadratic spectral window with the truncation parameter being selected via the Andrews' (1993) plug-in method.

[3] For the regression adopting "Change in Reserve," the R^2 improves from 0.928 in Table 2 to 0.950 in Table 3, which means that this popular proxy is for settlement-based interventions, not for transaction-based interventions. Researchers interested in this proxy for interventions in other countries should keep this point in mind.

4. Patterns of intervention

Figure 3, panels (a) and (b), show monthly data of the yen/dollar rate and amounts of interventions by the Japanese monetary authorities.[4] Panel (a) shows the movement of the yen/dollar rate. The dotted line represents the past-five-year moving-average of the yen/dollar rate.

<Figure 3 about here>

Panel (b) shows that in the 1970s and 1980s, interventions were very "frequent and symmetric": yen-selling interventions as well as yen-buying interventions were frequently conducted. The yen had been on a long-term appreciation trend, as shown in panel (a), throughout the 1970s and 1980s. It has been well documented that the authorities intervened in an attempt to stop this appreciation, presumably to prevent adverse effects on export industries.

However, it was little publicized that yen depreciation was also resisted by selling the dollar. Three hypotheses could explain the symmetric interventions. First, the authorities genuinely believed that the long-run trend could not be resisted, yet it was the authorities' role to reduce "excess" volatilities, upside and downside. Second, merely resisting yen appreciation by buying US dollars, would only have resulted in ever-accumulating foreign reserves that would have been exposed to increasing evaluation losses, which could have triggered political criticism. Third, the interest rate in Japan was similar or even higher than the US interest rate during the 1970s and 1980s; hence, building up foreign reserves meant that interest income might not cover domestic interest payments to fiscal bills that are liabilities in the foreign exchange special accounts. The "quasi-fiscal" costs were real concerns in Japan during the 1970s and 1980s.

For the reasons mentioned above, whenever the yen depreciated to some extent, like in 1973 and 1979 (due to the oil crises), 1981-82, and 1989, the yen was bought back, which appears to slow the yen's depreciation and to keep foreign reserves at a reasonable level. This attitude of symmetric interventions changed in the 1990s. After 1992, the only instance of sizable dollar-selling interventions was 1997-98 when the banking crisis of Japan caused a sharp yen depreciation. The magnitude of interventions became distinctively large while the frequency of interventions was reduced. In particular interventions in 2003-04 and 2011 were very large.

Table 4 shows the details of interventions by fiscal year (April to March): intervention frequencies (the number of months), intervention (cumulative) amounts (by fiscal year), and the average (per

[4] In the analysis below, intervention amounts below 30 billion yen for the period from August 1971 to March 1991 are assumed to be 0, as intervention amounts for the period are estimated based on the proxy and the proxy is likely to contain a certain degree of estimation error. The intervention amounts are in units of 100 million yen. The monthly yen/dollar rate is the Tokyo close rate on the third to last business day for the period before April 1991, since the proxy is for settlement-based interventions. After April 1991, we use the end-of-month New York close rate for the monthly yen/dollar rate.

month) magnitude of interventions (year total divided by the number of intervention months). This clearly shows that the frequency has declined, but also that the per-month magnitude has become larger since 1995. Prior to 1995, there were 178 months featuring intervention, amounting to 46 trillion yen in total. Thus, average per-month intervention was 257 billion yen. After 1995, interventions occurred during 41 months, with intervention totals reaching 78 trillion yen. The average per-month intervention amount was 1.9 trillion yen—more than 7 times the amount before 1995. Neely (2011) described and examined the fact that interventions had become infrequent over time in major countries: frequent interventions were ceased in the UK in 1993; in the US, Germany, and Switzerland in 1995; in Canada in 1998, and in Japan in March 2004.

<Table 4 about here>

Figure 4 shows the changing ceiling and floor exchange rates for intervention over time. The last selling rate is the yen/dollar rate when the dollar was sold by the Japanese monetary authorities, while the last buying rate is the yen/dollar rate when the dollar was bought by the Japanese monetary authorities. The band between the two prices implies the tolerance range, or target zone, for the fluctuation of the exchange rate for the authorities. Between 1971 and 1990, both the ceiling and floor of the tolerance band shifted gradually toward yen appreciation. The figure shows that the Japanese authorities had a moving band of symmetric interventions. Although the band shifted over time, the floor and ceiling had a significant spread most of the time. Until 1992, interventions were symmetric, but the range had shifted, gradually allowing for a long-run trend of yen appreciation.

<Figure 4 about here>

The above figure shows that after 1991, the last selling rate consistently remained above 125, while the last buying rate stayed below 125. Since the last dollar-selling intervention was in 1998, the last selling rate has not changed. Since 1991, the last buying rate only went down toward the appreciated level, while the last selling rate only went up toward the depreciated level. Thus, the tolerance band has widened to the range of 77.5-140.6, which is a spread of 63 yen.

Intervention became more unilateral after 1998, only changing the point of intervention on the appreciation side, mitigating the speed of yen appreciation and defending the particular level, such as 75 to 80 yen per dollar in 2010-12.

5. Reaction Function

In this section, we estimate the monetary authorities' reaction function using the data from August 1971 to March 2018. Most papers analyzing interventions before March 1991 have used "Change in Reserve" or "Treasury Funds and Others/Foreign Exchange" as a proxy for interventions. What

differentiates this paper from these previous papers is the use of the proxy Ito and Yabu (2017) identified and also the adoption of a state-of-the-art reaction function proposed by Ito and Yabu (2007).

5.1. Ordered Probit Model

Almekinders and Eijffinger (1996) were the first to derive a reaction function from a loss function of monetary authorities. Ito and Yabu (2007) extended their model by allowing for a more realistic formulation of the target exchange rate and a cost function of interventions to derive a reaction function as an ordered probit model.

The ordered probit model of Ito and Yabu (2007) is the following[5]:

$$IInt_t = \begin{cases} +1 & if \quad \mu_2 < y_t^* \\ 0 & if \quad \mu_1 < y_t^* < \mu_2 \\ -1 & if \quad y_t^* < \mu_1 \end{cases} \tag{2}$$

where $y_t^* = X_t\beta + \varepsilon_t$ with $\varepsilon_t \sim i.i.d.N(0, \sigma^2)$ and

$$X_t\beta = \beta_1(s_{t-1} - s_{t-2}) + \beta_2(s_{t-1} - s_{t-1}^{MA}) + \beta_3 IInt_{t-1}.$$

Here $IInt_t$ takes a value of $+1$ if there is dollar-purchasing intervention, -1 if there is dollar-selling intervention, and 0 if there is no intervention. The log of the monthly yen/dollar rate is denoted by s_t and the log of the moving average yen/dollar rate over the past five years by s_t^{MA}.[6] The lag of $IInt_t$ is included to explain a positive autocorrelation of interventions, i.e., when there is intervention one month, it is likely that intervention will take place in the following month. The latent variable y_t^* represents the optimal amount of intervention and intervention does not take place as long as y_t^* is inside a "neutral band" of no intervention, i.e., $[\mu_1, \mu_2]$.

Regarding the parameters of the model, the parameter β_1 takes a negative value ($\beta_1 < 0$) when there is lean-against-the-wind intervention and β_2 takes a negative value ($\beta_2 < 0$) when policy makers have a long-run target in mind. On the other hand, the parameter β_3 takes a positive value ($\beta_3 > 0$) when there is intervention one month and intervention is likely to take place in the following month. Here, μ_1 represents the cost of dollar-selling intervention while μ_2 is the cost of dollar-buying intervention. The cost of interventions is introduced to explain the fact that interventions do not take place every month.[7] We estimate this model using the maximum likelihood method but identify only

[5] Ito and Yabu (2007) include the daily change in the yen/dollar rate as an explanatory variable. However, this paper analyzes monthly data and thus omits the daily change in the yen/dollar rate.

[6] We also adopted different windows to check the robustness of results such as the past one year as well as the past three years. However, our main results did not depend on the choice of the window.

[7] Ito and Yabu (2007) explained the cost of interventions as "Political costs reflect costs of discussion with Minister of Finance of own country and other major countries of intervention currencies. In order to carry out intervention, an explanation to the Minister of Finance, and in some cases to other ministers, including the Prime Minister, is necessary and a tacit approval, if not coordinated intervention, of other countries has to be sought. Political costs are most likely independent of the magnitude of the intervention.

the normalized parameters $\beta_i^* \equiv \beta_i/\sigma$ and $\mu_i^* \equiv \mu_i/\sigma$, not the parameters β_i and μ_i themselves.

5.2. Structural Break Test

Before Ito and Yabu (2007), most papers estimated a model similar to the following:

$$IInt_t = \varphi_0 + \varphi_1(s_{t-1} - s_{t-2}) + \varphi_2(s_{t-1} - s_{t-1}^{MA}) + \varphi_3 IInt_{t-1} + \nu_t \quad (3)$$

This model is considered to be a linearized version of Eq. (2). Note that $\varphi_1 < 0$ when there is a lean-against-the wind intervention and $\varphi_2 < 0$ when policy makers have a long-run target in mind; $\varphi_3 > 0$ when there is a positive autocorrelation in interventions.

Ito and Yabu (2007) analyzed the data from April 1991 to December 2002 to find that there was a structural break in the reaction function in June 1995 when Eisuke Sakakibara took charge of interventions. Ito (2007) and Watanabe and Yabu (2013) asserted that when Zenbei Mizoguchi was in charge of the intervention from January 2003 to July 2004, the frequency and daily amount of intervention had a distinctive pattern—more frequent interventions of greater magnitude. We take these observations as given and examine whether there exist any additional structural breaks between August 1971 and May 1995.

Here we analyze the data from August 1971 to May 1995 to conduct Andrews' (1993) *sup F* test and search for an unknown structural break date.[8][9] The possible structural break dates are assumed to be the middle 70% of the sample period. The first and last 15% of dates are excluded from break candidates. (We set the trimming parameter at 0.15). The standard Chow test is conducted to obtain the *F*-statistic at each break candidate.

Figure 5 shows the sequence of *F*-statistics for each break candidate. In the figure, the break dates are given on the horizontal axis and the *F*-statistics on the vertical axis. As shown, the *F*-statistic has the largest value in November 1981 at 4.80. This is larger than the 5% critical value of 4.09 but slightly lower than the 1% critical value of 5.12. Therefore, we reject the null hypothesis of no break and accept the alternative of a structural break. In addition, based on the figure, the *F*-statistic is single-peaked, implying that there are no other structural breaks.[10] The structural break date of November 1981 is a year and a half after a break date pointed out by Watanabe (1992) without

However, once the approval is secured, then intervention can be carried out over the course of several days in a row, if the situation does not change dramatically."

8 There is a possibility of endogeneity in this analysis. However, Perron and Yamamoto (2015) found that we can test for structural changes and consistently estimate the break dates using the standard methods even when endogenous regressors are present. This is because when true parameters change, the probability limits of the OLS parameter estimates also change simultaneously.

9 The sample period starts from August 1971 when the Bretton Woods system collapsed, but some may argue that the sample period should start from March 1973 when the floating rate system started. Therefore, we checked the sensitivity of our results to the starting date to find that our main results are robust to the selection of the starting date.

10 We also conducted the Bai and Perron (1998) multiple break tests for the period from August 1971 to May 1995 and confirmed that there was only one break, which occurred in November 1981. This result is consistent with our visual impression from Figure 5.

conducting any structural break test.

5.3. Conventional Regression

We split the full sample into five subperiods and estimate a linearized version of the reaction function Eq. (3) for each subsample. As discussed in section 5.2, the sample before May 1995 is divided into two periods: 1) August 1971 to November 1981; and 2) December 1981 to May 1995 just before Eisuke Sakakibara took charge of interventions. In addition, taking into account large-scale and frequent interventions by Zenbei Mizoguchi, the sample after June 1995 is divided into three periods: 3) June 1995 to December 2002; 4) January 2003 to July 2004; and 5) August 2004 to March 2018.

Table 5 summarizes the estimated results of Eq. (3) for each subsample. In the first period (August 1971 to November 1981), the parameter φ_1 is significantly negative, but φ_2 is not significantly different from zero. The monetary authorities adopted a lean-against-the-wind policy without setting any long-run targets. They were only intent on reducing monthly volatility in the exchange rate. These results are consistent with the findings of Quirk (1977), Hutchison (1984), and Watanabe (1992). On the other hand, the parameter φ_3 is significantly positive and thus there was a positive autocorrelation in interventions.

<Table 5 about here>

In the second period (December 1981 to May 1995), the parameter φ_2 is significantly negative, but φ_1 is not significantly different from zero. That is, the monetary authorities had long-run targets in mind, but they were not mindful of reducing monthly volatility in the exchange rate. These results are sharp contrast to the results of the first period but are consistent with the findings of Watanabe (1992). The parameter φ_3 has a large value of 0.713, a strong positive autocorrelation of interventions. Adjusted R^2 has the largest value of 0.598 among the subsamples. Interventions were easiest to predict among the subsamples.

In the third period (June 1995 to December 2002), we obtain results similar to Ito and Yabu (2007), which analyzed the same period using daily data. Both parameters of φ_1 and φ_2 are significantly negative. In other words, the monetary authorities paid attention to changes in the exchange rate as well as long-run targets. In contrast to the results of the first and second periods, the parameter φ_3 is now close to zero and no longer significant. There was no evidence of autocorrelation of interventions in this period.[11] Adjusted R^2 is smaller than it was in the previous two periods and

[11] Ito and Yabu (2007) found using daily data that the parameter φ_3 was close to zero yet significantly different from zero. The reason we missed this autocorrelation is partly because the number of observations is much smaller than in Ito and Yabu (2007).

thus interventions became more difficult to predict.

In the fourth period (January 2003 to July 2004), the parameter φ_3 is significantly positive, while both parameters φ_1 and φ_2 are not significantly different from zero. The monetary authorities, thus, intervened only because they had intervened the month before. As Ito (2007) and Watanabe and Yabu (2013) have pointed out, the monetary authorities may have had other motives to conduct interventions.

For the last period (August 2004 to March 2018), the parameter φ_2 is significantly negative, while both parameters φ_1 and φ_3 are not significantly different from zero. Therefore, the monetary authorities had long-run targets in mind but were not intent on reducing the volatility of the exchange rate. In addition, there was no positive autocorrelation of interventions. Therefore, interventions during the previous month did not significantly increase the likelihood of interventions occurring during the following month. Adjusted R^2 has the smallest value of 0.069 among the subsamples because interventions took place during only 5 months of the 14-year period which also shows the difficulty of predicting interventions.

5.4. Ordered Probit Regressions

Table 6 presents the estimated results of the ordered probit model Eq. (2) for each subsample. When these results are compared with the ones from the linearized model in section 5.3, the signs of the estimated coefficients and their significances are almost the same. Consequently, we only discuss estimates of new parameters in the ordered probit model: μ_1^* and μ_2^*, which respectively represent the cost of dollar-selling interventions and the cost of dollar-buying interventions. Note that in the last two periods, there was no dollar-selling intervention at all and thus, the parameter μ_1^* is not estimated in the regression.

<Table 6 about here>

In the first period, μ_1^* is significantly negative while μ_2^* is not significantly different from zero. The monetary authorities were accordingly more inclined to buy rather than sell dollars due to the difference in cost. This point was also raised by Hutchison (1984).

For the second period, the parameter μ_2^* is significantly positive. Due to international political pressure, it might have been difficult for the monetary authorities to purchase dollars to induce yen depreciation. The parameter μ_1^* is significantly negative and larger in terms of absolute values than the corresponding parameter from the first period, which means that there was a higher cost for dollar-selling interventions. Moreover, μ_2^* is larger than μ_1^* in terms of absolute values and thus, the cost

of dollar-selling interventions was higher than the cost of dollar-buying interventions. The monetary authorities are more inclined to resist yen appreciation than yen depreciation. The neutral band of no intervention is wider here than that of the first period.

For the third period, both parameters μ_1^* and μ_2^* are significantly different from zero. As was the case for the second period, μ_1^* is larger than μ_2^* in terms of absolute values and thus, the cost of dollar-selling interventions was larger than the cost of dollar-buying interventions. The monetary authorities were more inclined to prevent yen appreciation than yen depreciation, and the neutral band of no intervention was even wider than that of the second period. Note that μ_2^* is lower than the corresponding parameter for the second period, which means that the cost of dollar-buying interventions becomes lower in this period.

For the fourth period, μ_2^* is not significantly different from zero. Therefore, there is no evidence of a neutral band, which means that there was no international political pressure from other countries when the monetary authorities intervened in the foreign exchange market. As Taylor (2006), who served as the Under Secretary of the Treasury for International Affairs during the George W. Bush administration, documented, the US Treasury has been critical of interventions but approved Japanese interventions during this period in order to show support for the quantitative easing policy adopted by the Bank of Japan. (See Taylor, 2006 for details). In fact, Watanabe and Yabu (2013) found that when yen-selling interventions supplied yen funds to the market, the Bank of Japan offset 60% of the yen funds through market operations, while the remainder remained in the market for a while.

On the other hand, for the fifth period, μ_2^* has the largest value of 8.405. Hence, its neutral band was the widest among all subsamples. This is because interventions took place only on rare occasions, such as when the yen appreciated sharply due to the Great East Japan Earthquake in March 2011 and when the yen/dollar rate appreciated to 75 yen per dollar, setting a historical record in August 2011. Therefore, the monetary authorities were not able to intervene in the market due to international political pressure, except in cases when it was clear that excess volatility and disorderly movements in the yen/dollar rate would damage economic and financial stability. In contrast to the results in the linear regression, this period has higher explanatory power ($pseudo - R^2$) than other periods. This is due to the fact that the model is now rich enough to predict zero intervention by introducing a neutral band of no intervention.

6. International Coordination or non-Coordination

6.1. Policy coordination on exchange rates

The Group of Seven (G7) monetary authorities were engaged in interventions very frequently during

the 1970s and 1980s. However, the frequency of interventions declined during the 1990s. Frequent interventions by the US, Germany and the UK ceased by 1995. The frequency of Japanese intervention also declined after 1995, apart from 14 months of frequent interventions from January 2003 to March 2004.

During the period of frequent interventions, there were many cases where two or three of the G3—the US, Japan and Germany—intervened in the same direction simultaneously. There were also cases of US-Japan joint interventions; US-German joint interventions and even three-way interventions. When engaging in joint interventions, they must have shared the same views in terms of the level and movement of the exchange rate, such as the idea that since the US dollar is overvalued, the US should buy German marks and Japanese yen, while Germany and Japan should sell US dollars. When two or three authorities intervene in the same direction in the same month, we refer to them as "coordinated interventions" throughout the rest of the paper.

Figure 6 shows that the number of months per year during which the authorities coordinated their interventions from 1976 to 1995. For example, in 1979, US-German joint interventions were conducted during nine months and US-German-Japanese joint interventions were conducted during three months. In September 2000, there was a joint ECB-US-Japan intervention in order to stop further depreciation of the euro. On March 18, 2011, the G7 countries intervened to reverse the direction of yen appreciation that had progressed following the Great East Japan Earthquake. One of the proposed reasons for this appreciation was based on speculation that Japanese insurance companies would need to liquidate assets abroad and convert them to yen to pay for claims. (See Neely 2011). The aforementioned coordinated intervention, the first since 2000, played a crucial role in stabilizing the yen.

<Figure 6 about here>

Policy coordination on exchange rates among the G5 countries occasionally had dramatic effects during the 1970s and 1980s. The most prominent example of this was the period bookended by the Plaza agreement of September 1985 and the Louvre accord of February 1987.

6.2. Case Study: Policy coordination under the Plaza and Louvre agreements[12]

With newly estimated intervention amounts for the Japanese authorities, we are able to examine one of the most dramatic policy coordination events of the post-Bretton Woods era, namely the Plaza and Louvre agreements.

[12] This section heavily draws on Ito (2016).

The meeting of G5 Finance Ministers and Central Bank Governors was called primarily to rectify an overvaluation of the US dollar on September 22, 1985. The real effective US dollar appreciated by about 40% from January 1981 to March 1985, due to the policy of Reaganomics which resulted in large fiscal deficits. This meeting resulted in what would come to be known as the Plaza Agreement.

The communiqué stated the following:[13]

> "*The Ministers and Governors agreed that exchange rates should play a role in adjusting external imbalances. In order to do this, exchange rates should better reflect fundamental economic conditions than has been the case. They believed that agreed policy actions must be implemented and reinforced to improve the fundamentals further, and that, in view of the present and prospective changes in fundamentals, some further orderly appreciation of the main non-dollar currencies against the dollar is desirable. They stand ready to cooperate more closely to encourage this when to do so would be helpful.*" (Underlines by the author.)

The communiqué itself did not mention "intervention" or a targeted level of appreciation for the non-dollar currencies, although they were part of the discussion that was kept confidential at the time. According to Funabashi (1988), the non-paper draft stated that intervention shares were 25% for the US, Japan, and Germany, followed by 12.5% for the UK and France. With German objection, the US revised the ratios for the US and Japan to 30%; followed by Germany at 25%; France at 10%; and the UK at 5%. The obligation to intervene in order to achieve the exchange rate goals was also discussed. According to Gyohten (2013), 18 billion US dollars were committed over a period of six weeks. Countries would be relieved of their intervention obligation if the necessary currency adjustments were achieved. All G5 members committed themselves to these goals and interventions willingly.

The communiqué was announced on Sunday, September 22, 1985. Meanwhile, the Tokyo market was to be closed on Monday, September 23, for a national holiday. Initial interventions were conducted in the European and US markets on September 23 and in Tokyo on September 24.[14] Gyohten (2013, p. 77) stated in his memoir that, over the seven days that followed the Plaza announcement, Japan sold USD 1.25 billion; surpassing the USD 635 million sold by France, the USD 480 million sold by the US; the USD 247 million sold by West Germany, and the USD 174 million sold by the UK. The proxy largely corroborates the numbers in the memoir.

The proxy shows that the Japanese monetary authorities intervened to buy yen, selling the US dollars,

[13] The statement is available at http://warp.ndl.go.jp/info:ndljp/pid/8779816/www.mof.go.jp/english/international_policy/convention/g7/g7_850922.pdf

[14] According to Gyohten (2013, pp. 69-70), "As far as [non-dollar] currency appreciation, Japan was the most forthcoming. Finance Minister Takeshita expressed [during the Plaza meeting] that Japan could accept yen appreciation up to 200 yen/dollar."

in the amount of 705 billion yen over three months: September, October and November. The US sold USD 1.44 billion over the same three months. Consequently, the USD/JPY rate became 200 by the end of November. There were no interventions by the Japanese or US authorities in December. So it appeared that the target had been achieved.

On the DEM/USD markets, both the US and German authorities intervened to appreciate the German mark over the same three months. The mark reached 2.5 marks per dollar by the end of November, with interventions of USD 1.86 billion by the US and DEM 3 billion by Germany over the three months starting in September. In short, the US, Japanese and German authorities conducted coordinated interventions for three months and achieved the agreed exchange rate targets by the end of November.

The yen continued to appreciate beyond 200 in 1986. The USD/JPY rate dipped into the 190s in January 1986, to the 180s in February, and finally to the 170s in March. Given that this movement was unacceptable to the Japanese authorities, they began to intervene in the opposite direction, namely selling the yen, in April 1986. However, in 1986, interventions were conducted by the Japanese authorities alone. It was unilateral intervention as opposed to coordinated intervention. Japan requested to have another agreement to stabilize the exchange rate.

<Table 7 about here>

The Plaza agreement was followed by the Louvre agreement of February 1987, in which the G7 authorities agreed that "their currencies [are] within ranges broadly consistent with underlying economic fundamentals." Thus, "they agreed to cooperate closely to foster stability of exchange rates around current levels" in their statements. The market interpreted that the authorities have committed to a target zone around the "current levels." The authorities indeed started to intervene in a coordinated manner; that is, both the Japanese and U.S. authorities intervened, selling the yen and buying the dollar, to counter yen-appreciation pressure. The coordinated interventions continued through April 1988.

7. Concluding Remarks

This paper confirms that "Adjusted MOF FEEF" is the best proxy for settlement-based interventions. In fact, the proxy explains 99.8% of the movements of settlement-based interventions. The monthly intervention data are presented in the appendix and are also available on the authors' websites.[15] At least in the monthly frequency, it has become possible to research topics related to Japanese interventions from August 1971 to the present day. One caution: most researchers are interested in

[15] The data are available at
http://www3.grips.ac.jp/~t-ito/JapaneseIntervention1971-2018.xlsx
http://www.fbc.keio.ac.jp/~tyabu/JapaneseIntervention1971-2018.xlsx

transaction-based interventions when analyzing the effectiveness of interventions or in the reaction function of the monetary authorities since the exchange rate reacts to the buy and sell in the market transactions. The difference is the last two business days of the month. Therefore, when we use settlement-based interventions as transaction-based interventions, we must use the exchange rate returns using the third to last business day as the monthly exchange rate.

This paper has analyzed the reaction function of the Japanese monetary authorities. The following points stand out. First, the reaction functions were not stable over time. In fact, we observed four break dates and thus five regimes: August 1971 to November 1981, December 1981 to May 1995, June 1995 to December 2002, January 2003 to July 2004, and August 2004 to March 2018. These policy shifts might be associated with changes in the impact of interventions on the yen/dollar rate. Therefore, we need to exercise caution when analyzing the effectiveness of interventions. Second, the neutral band of the reaction function widened over time, apart from during the period in which it did not exist, between January 2003 to July 2004. This implies that the Japanese monetary authorities have experienced increased political pressure from other countries over time concerning their intervention or proposed intervention in the foreign exchange market. Third, the cost of selling-dollar interventions was higher than the cost of buying-dollar interventions. This implies that the monetary authorities were more inclined to resist yen appreciation.

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Table 1: List of proxies for interventions

Change in Reserve	Changes in the “Total Reserve Excluding Gold” available in the Balance of Payments statistics.
BOJ EF	Bank of Japan. "Treasury Funds and Others/Foreign Exchange," Statistical category: Sources of Changes in Current Account Balances at the BOJ and Market Operations.
MOF FEEF	Ministry of Finance. “Receipts and Payments of the Treasury Funds: Foreign Exchange Equalization Fund” in the fiscal operations statistics.
Adjusted MOF FEEF	Ministry of Finance. Subtracting “Balancing of Issuance and Redemption of Financial Bills in the Financial Market” from “Receipts and Payments of the Treasury Funds: Foreign Exchange Equalization Fund” in the fiscal operations statistics.

Table 2: Proxies used for transaction-based intervention

Sample period: April 1991 – March 1999

$Int_t = \beta_0 + \beta_1 Proxy_t + u_t$

	Change in Reserve			BOJ	MOF	
	3 months	3 years	10 years	EF	FEEF	Adjusted FEEF
β_0	-176.544	-27.292	48.409	-24.279	-24.287	0.448
	(130.508)	(129.000)	(128.572)	(264.463)	(264.463)	(33.421)
β_1	1.026	1.024	1.025	0.751**	0.751**	0.995
	(0.056)	(0.057)	(0.057)	(0.109)	(0.109)	(0.020)
R^2	0.928	0.928	0.928	0.757	0.757	0.969

Note: (1) Both transaction-based intervention amounts and proxies are in units of 100 million yen. (2) HAC standard errors are presented in brackets; The long-run variance is constructed based on the quadratic spectral window with the truncation parameter being selected via the Andrew's (1993) plug-in method. (3) The null hypothesis is H_0: $\beta_0 = 0$ and H_0: $\beta_1 = 1$, tested independently with t-statistics; Asterisks (*, **, ***) denote the 10%, 5%, and 1% significance of the hypothesis testing, respectively. (4) The sample period ends March 1999, since one of the proxies has a discontinuity in the classification.

Table 3: Proxies used for settlement-based intervention

Sample period: May 1991 – March 1999

$Int_t^{Settlement} = \beta_0 + \beta_1 Proxy_t + u_t$

	Change in Reserve			BOJ	MOF	
	3 months	3 years	10 years	EF	FEEF	Adjusted FEEF
β_0	-214.191	-64.378	11.486	-28.087	-28.095	-5.264
	(120.814)	(118.523)	(117.537)	(267.028)	(267.028)	(10.951)
β_1	1.027	1.025	1.026	0.751**	0.751**	0.996
	(0.053)	(0.053)	(0.054)	(0.109)	(0.109)	(0.004)
R^2	0.950	0.950	0.950	0.778	0.778	0.998

Note: (1) Both settlement-based intervention amounts and proxies are in units of100 million yen. (2) HAC standard errors are presented in brackets; The long-run variance is constructed based on the quadratic spectral window with the truncation parameter being selected via the Andrew's (1993) plug-in method. (3) The null hypothesis is H_0: $\beta_0 = 0$ and H_0: $\beta_1 = 1$, tested independently with t-statistics; Asterisks (*, **, ***) denote the 10%, 5%, and 1% significance of the hypothesis testing, respectively. (4) The sample starts from May 1991 because we needed information on daily intervention at $t-1$ month in order to compute settlement-based intervention at t month. The sample period ends March 1999. This is because one of the proxies has a discontinuity in the classification.

Table 4: Frequency and magnitude of interventions

FY	Months	Total amount	Amount per month	Yen/Dollar rate	FY	Months	Total amount	Amount per month	Yen/Dollar rate
1971	9	33711	3746	304	1995	7	47672	6810	107
1972	12	22478	1873	266	1996	0	0	0	124
1973	12	30499	2542	275	1997	1	10591	10591	133
1974	10	7945	795	291	1998	3	37033	12344	119
1975	8	10764	1346	300	1999	7	79626	11375	103
1976	6	5957	993	277	2000	1	13854	13854	126
1977	9	30798	3422	222	2001	1	31455	31455	133
1978	8	20376	2547	208	2002	5	62837	12567	118
1979	11	40857	3714	250	2003	11	327865	29806	104
1980	6	16494	2749	211	2004	0	0	0	107
1981	6	8670	1445	247	2005	0	0	0	118
1982	8	19113	2389	239	2006	0	0	0	118
1983	3	3142	1047	225	2007	0	0	0	100
1984	4	3062	766	254	2008	0	0	0	99
1985	3	7046	2349	180	2009	0	0	0	93
1986	7	42083	6012	149	2010	2	28174	14087	83
1987	8	29180	3648	124	2011	3	136046	45349	83
1988	2	4745	2373	133	2012	0	0	0	94
1989	11	47734	4339	159	2013	0	0	0	103
1990	2	2622	1311	138	2014	0	0	0	120
1991	12	1909	159	133	2015	0	0	0	113
1992	4	5664	1416	115	2016	0	0	0	111
1993	7	30917	4417	103	2017	0	0	0	106
1994	10	32990	3299	87					
Sub-total	178	458756	2577		Sub-total	41	775153	18906	

Note: “Fiscal year (FY)” is from April (in year t) to the end of March (in year $t+1$). “Yen/dollar rate” uses the Tokyo close rate on the third to last business day of March before April 1991 as well as the New York close rate at the end of March after April 1991. “Months” denotes the number of months in which the intervention amount exceeds 30 billion yen. Interventions are in units of 100 million yen.

Table 5: Estimating the reaction function for various sample periods

$$IInt_t = \varphi_0 + \varphi_1(s_{t-1} - s_{t-2}) + \varphi_2(s_{t-1} - s_{t-1}^{MA}) + \varphi_3 IInt_{t-1} + v_t$$

	Sample period									
	1971/8-1981/11		1981/12-1995/5		1995/6-2002/12		2003/1-2004/7		2004/8-2018/3	
φ_0	0.118		-0.073	*	0.179	***	0.561	**	0.023	**
	(0.107)		(0.041)		(0.044)		(0.223)		(0.011)	
φ_1	-7.184	***	-1.536		-2.425	*	-1.992		-0.169	
	(2.406)		(1.114)		(1.251)		(3.648)		(0.371)	
φ_2	0.733		-0.389	*	-1.607	***	4.119		-0.275	**
	(0.681)		(0.214)		(0.419)		(2.608)		(0.129)	
φ_3	0.373	***	0.713	***	0.121		0.440	*	0.113	
	(0.097)		(0.063)		(0.127)		(0.250)		(0.181)	
Adjusted R^2	0.291		0.598		0.282		0.194		0.069	

Note: (1) HAC standard errors are presented in brackets; The long-run variance is constructed based on the quadratic spectral window with the truncation parameter being selected via the Andrew's (1993) plug-in method. (2) Asterisks (*, **, ***) denote the 10%, 5%, and 1% significance of the hypothesis testing, respectively.

Table 6: Estimating the reaction function based on the ordered probit model

$$IInt_t = \begin{cases} +1 & if \quad \mu_2 < y_t^* \\ 0 & if \quad \mu_1 < y_t^* < \mu_2 \\ -1 & if \quad y_t^* < \mu_1 \end{cases}$$

where $y_t^* = X_t\beta + \varepsilon_t$ with $\varepsilon_t \sim i.i.d.N(0, \sigma^2)$ and

$$X_t\beta = \beta_1(s_{t-1} - s_{t-2}) + \beta_2(s_{t-1} - s_{t-1}^{MA}) + \beta_3 IInt_{t-1}$$

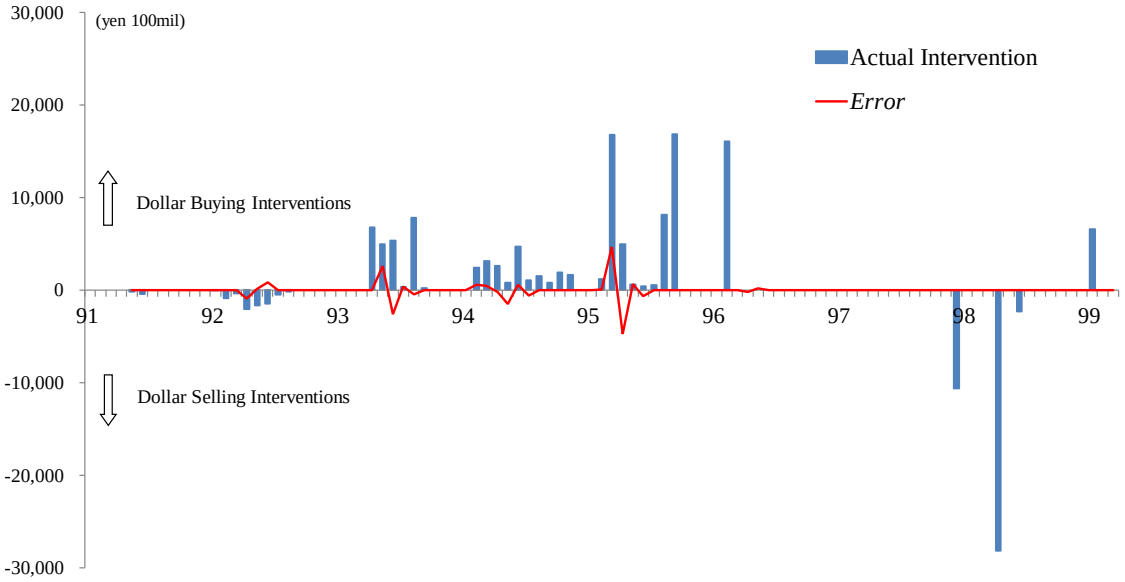
	Sample period									
	1971/8-1981/11		1981/12-1995/5		1995/6-2002/12		2003/1-2004/7		2004/8-2018/3	
β_1^*	-13.928	***	-4.613		-10.773	**	-6.676		10.219	
	(5.334)		(3.492)		(4.505)		(10.781)		(11.962)	
β_2^*	1.059		-1.125	*	-7.335	***	16.562		-33.315	***
	(1.186)		(0.614)		(2.017)		(11.313)		(11.580)	
β_3^*	0.574	***	1.819	***	0.412		1.485	*	-0.251	
	(0.158)		(0.207)		(0.403)		(0.796)		(0.802)	
μ_2^*	0.264		1.448	***	1.110	***	-0.339		8.405	***
	(0.179)		(0.160)		(0.215)		(0.628)		(2.546)	
μ_1^*	-0.622	***	-1.002	***	-2.863	***				
	(0.186)		(0.172)		(0.351)					
pseudo-R^2	0.168		0.417		0.302		0.298		0.517	

Note: (1) Standard errors are in Brackets. (2) Asterisks (*, **, ***) denote the 10%, 5%, and 1% significance of the hypothesis testing, respectively. (3) We can estimate only the normalized parameters $\beta_i^* \equiv \beta_i/\sigma$ and $\mu_i^* \equiv \mu_i/\sigma$, not the parameters β_i and μ_i themselves. (4) In the last two periods, there was no dollar-selling intervention at all and thus, the parameter μ_1^* is not estimated in the regression.

Table 7: From Plaza to Louvre, and beyond

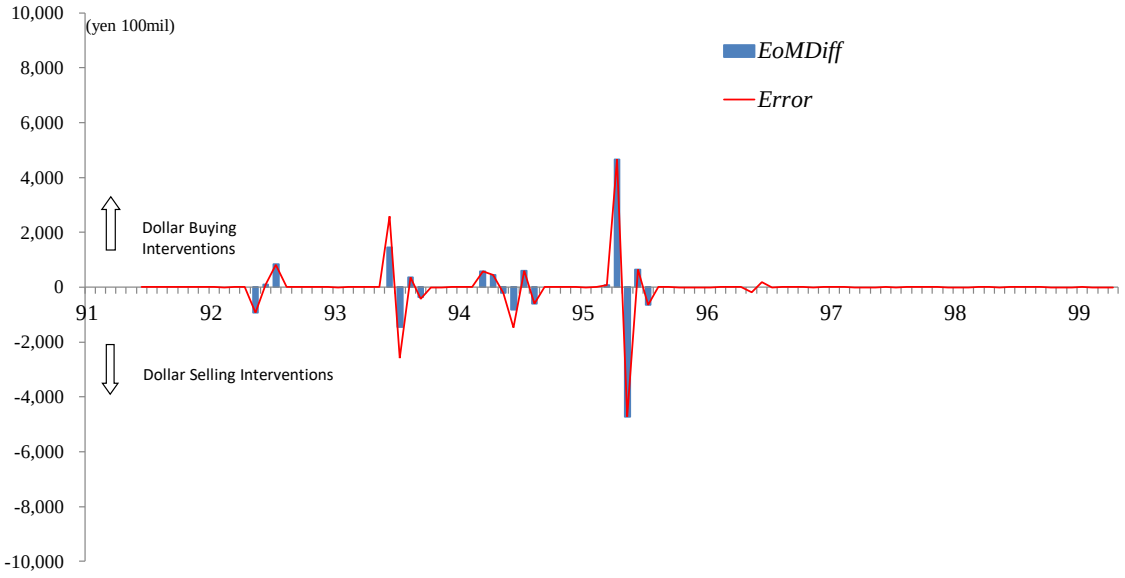
	USD/JPY (End of Month)	Major Events	Japanese Intervention (100 millions of Yen)	U.S. Intervention (1 Million of USD)	Unilateral or Coordinated	Direction of Interventions
Sep-85	222.8	Plaza Agreement	-2839	-224	Policy Coordination	Buy yen, sell dollars
Oct-85	212.9		-3303	-1138	Policy Coordination	Buy yen, sell dollars
Nov-85	200.9		-904	-77	Policy Coordination	Buy yen, sell dollars
Dec-85	202.92		0	0		
Jan-86	194.3		0	0		
Feb-86	181.85		0	0		
Mar-86	180		0	0		
Apr-86	170.2		4743	0	Japan unilateral	Sell yen; buy dollars
May-86	168.9		1914	0	Japan unilateral	Sell yen; buy dollars
Jun-86	166.1		1767	0	Japan unilateral	Sell yen; buy dollars
Jul-86	155.7		6178	0	Japan unilateral	Sell yen; buy dollars
Aug-86	155.25		4680	0	Japan unilateral	Sell yen; buy dollars
Sep-86	154.43		0	0		
Oct-86	159.35		0	0		
Nov-86	162.5		0	0		
Dec-86	159.5		0	0		
Jan-87	151.2		13494	50	Policy Coordination	Sell yen; buy dollars
Feb-87	153.55	Louvre Agreement	0	0		
Mar-87	149		9307	2435	Policy Coordination	Sell yen; buy dollars
Apr-87	138.1		13930	1529	Policy Coordination	Sell yen; buy dollars
May-87	143.15		0	20	US unilateral	Sell yen; buy dollars
Jun-87	145.9		0	103	US unilateral	Sell yen; buy dollars
Jul-87	150.15		0	0		
Aug-87	142.55		653	105	Policy Coordination	Sell yen; buy dollars
Sep-87	144.22		1677	285	Policy Coordination	Sell yen; buy dollars
Oct-87	140.75	Black Monday	336	65	Policy Coordination	Sell yen; buy dollars
Nov-87	134.75		6408	428	Policy Coordination	Sell yen; buy dollars
Dec-87	123.5		3548	1089	Policy Coordination	Sell yen; buy dollars
Jan-88	127.65		2258	235	Policy Coordination	Sell yen; buy dollars
Feb-88	128.8		0	0		
Mar-88	124.37		370	318	Policy Coordination	Sell yen; buy dollars
Apr-88	124.57		1114	260	Policy Coordination	Sell yen; buy dollars
May-88	124.64		0	0		
Jun-88	130.95		0	0		
Jul-88	132.5		0	0		
Aug-88	134.2		0	0		
Sep-88	134.2		0	0		
Oct-88	125.9		0	200	US unilateral	Sell yen; buy dollars
Nov-88	122		3631	1570	Policy Coordination	Sell yen; buy dollars
Dec-88	125.27		0	200	US unilateral	Sell yen; buy dollars
Jan-89	128.65		0	0		
Feb-89	126.29		0	0		
Mar-89	133.25		0	-100	US unilateral	Buy yen, sell dollars
Apr-89	131.47		0	-50	US unilateral	Buy yen, sell dollars
May-89	142.88		-6835	-3185	Policy Coordination	Buy yen, sell dollars
Jun-89	143.55		-10120	-3823	Policy Coordination	Buy yen, sell dollars
Jul-89	139.35		-2145	-230	Policy Coordination	Buy yen, sell dollars
Aug-89	144.15		-1191	-595	Policy Coordination	Buy yen, sell dollars
Sep-89	141.35		-4300	-1594	Policy Coordination	Buy yen, sell dollars
Oct-89	142.75		-3606	-1100	Policy Coordination	Buy yen, sell dollars
Nov-89	143.65		-764	-50	Policy Coordination	Buy yen, sell dollars
Dec-89	142.1	Peak of the Bubble	-665	-100	Policy Coordination	Buy yen, sell dollars
Jan-90	143.22		-4155	-600	Policy Coordination	Buy yen, sell dollars
Feb-90	148.65		-2858	-350	Policy Coordination	Buy yen, sell dollars
Mar-90	158.63		-11095	-1180	Policy Coordination	Buy yen, sell dollars
Apr-90	159.25		-1342	-50	Policy Coordination	Buy yen, sell dollars

Figure 1: Actual intervention and estimated error



Notes: The intervention amounts are in units of 100 million yen. $Error_t$ is defined as $Int_t - Proxy_t$ where $Proxy_t$ is Adjusted MOF FEEF.

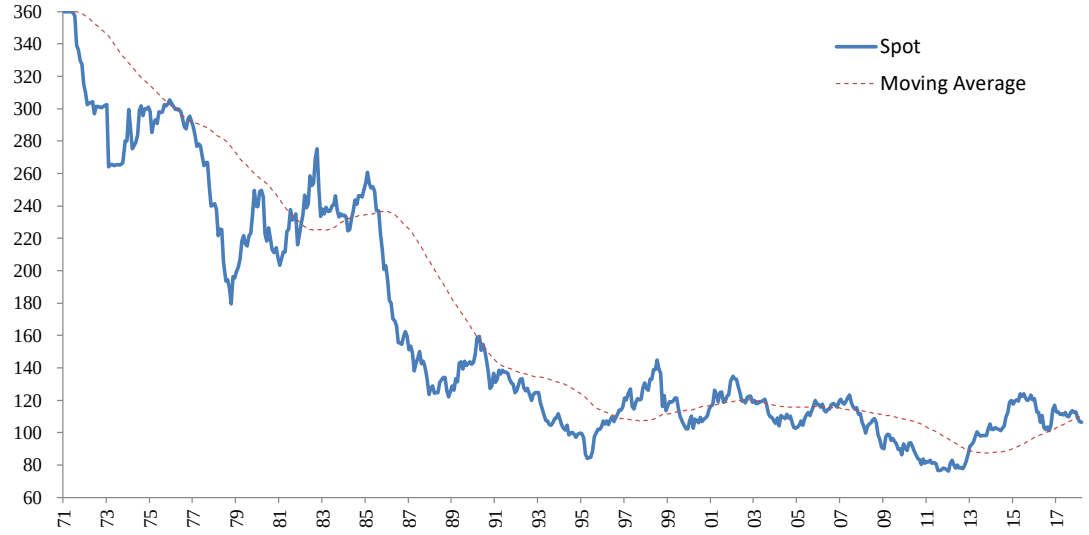
Figure 2: Estimated error and EoMDiff



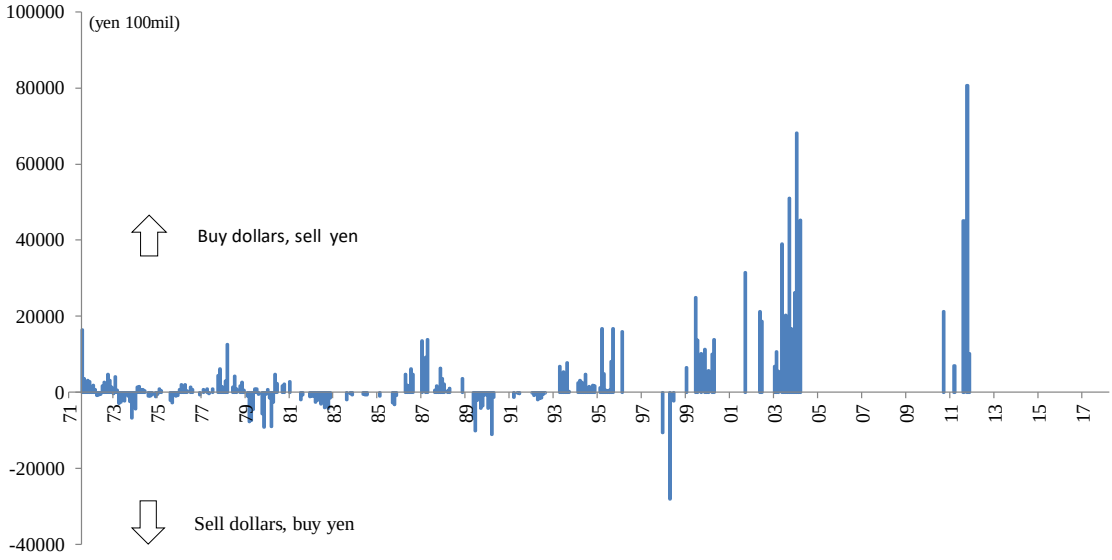
Notes: $Error_t$ is defined as $Int_t - Proxy_t$ where $Proxy_t$ is Adjusted MOF FEEF. $EoMDiff_t$ is defined as $Int_t^{End} - Int_{t-1}^{End}$ where Int_t^{End} is interventions conducted in the last two business days of the month t.

Figure 3: The yen/dollar rate and magnitude of interventions from August 1971 to March 2018

(a) Yen/dollar exchange rate



(b) Magnitude of Japanese interventions



Note: The monthly yen/dollar rate uses the Tokyo close rate on the third-to-last business day for the period before April 1991, since the proxy is for settlement-based interventions. After April 1991, we use the end-of-month New York close rate for the monthly yen/dollar rate. Intervention amounts below 30 billion yen for the period from August 1971 to March 1991 are assumed to be 0, as intervention amounts for the period are estimated with the proxy and the proxy is likely to contain a certain degree of estimation error. The intervention amounts are in units of 100 million yen.

Figure 4: The yen/dollar exchange rate, last selling rate, and last buying rate

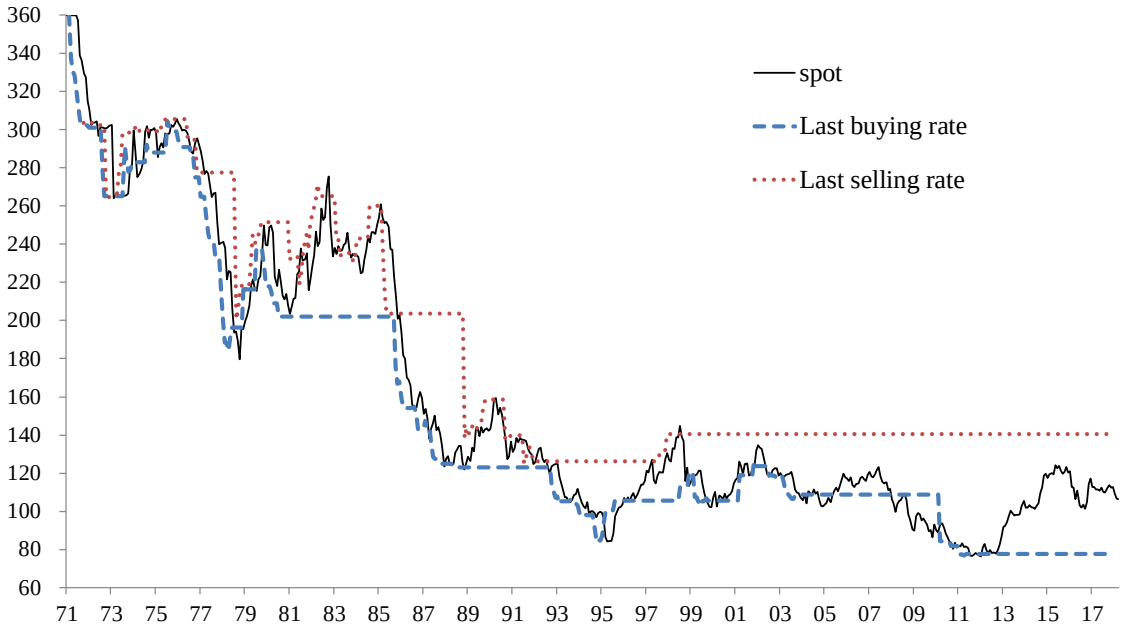
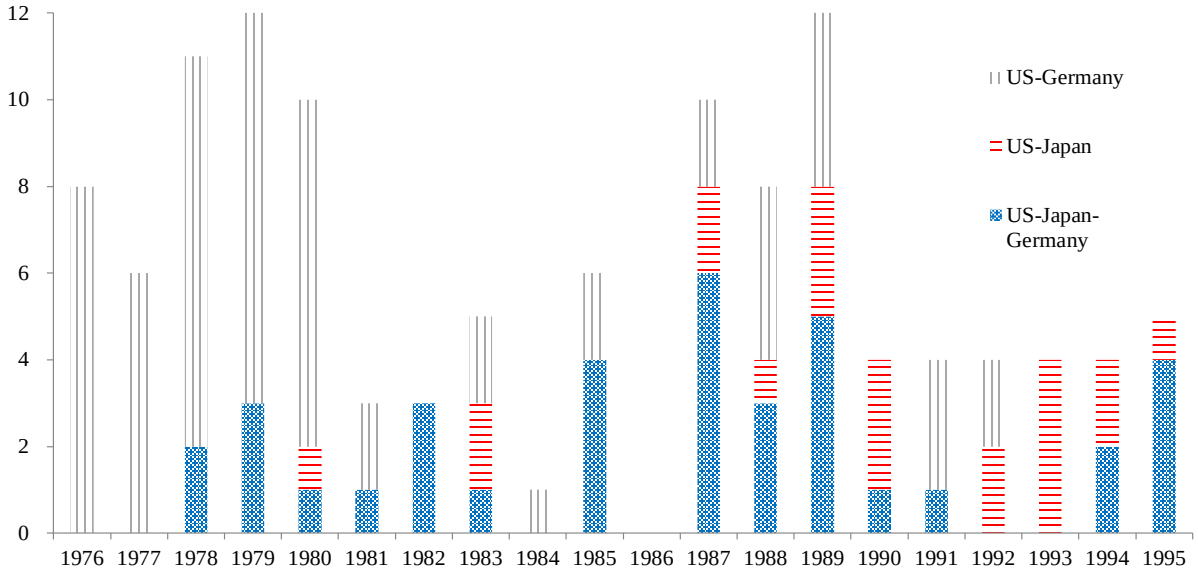


Figure 5: Structural break test

Note: The sample period is from August 1971 to May 1995. The trimming parameter is set to 0.15. Therefore, break candidates are the middle 70% of the sample.

Figure 6: Coordinated interventions



Data Appendix

Table: Japanese Interventions and yen/dollar rates

	Japanese Interventions (100mil Yen)		Yen/Dollar Rate		Japanese Interventions (100mil Yen)		Yen/Dollar Rate
	Actual	Estimated			Actual	Estimated	
Jan-71				Jan-76	NA	795	303.6
Feb-71				Feb-76	NA	2081	301.8
Mar-71				Mar-76	NA	572	299.7
Apr-71				Apr-76	NA	2000	299.8
May-71				May-76	NA	433	299.7
Jun-71				Jun-76	NA	285	297.9
Jul-71				Jul-76	NA	1306	293.6
Aug-71	NA	16434	339.0	Aug-76	NA	770	288.6
Sep-71	NA	3568	336.4	Sep-76	NA	270	287.7
Oct-71	NA	2015	329.5	Oct-76	NA	-16	293.5
Nov-71	NA	3202	327.6	Nov-76	NA	-41	295.5
Dec-71	NA	2750	315.2	Dec-76	NA	-721	292.1
Jan-72	NA	1184	310.1	Jan-77	NA	227	288.6
Feb-72	NA	1822	302.5	Feb-77	NA	727	283.4
Mar-72	NA	810	303.8	Mar-77	NA	289	276.7
Apr-72	NA	-849	303.8	Apr-77	NA	853	278.5
May-72	NA	-646	304.4	May-77	NA	-358	277.2
Jun-72	NA	-476	296.7	Jun-77	NA	237	270.8
Jul-72	NA	1758	301.2	Jul-77	NA	877	264.7
Aug-72	NA	2631	301.2	Aug-77	NA	183	266.7
Sep-72	NA	1855	301.0	Sep-77	NA	35	266.9
Oct-72	NA	4795	300.5	Oct-77	NA	4436	251.7
Nov-72	NA	3198	301.2	Nov-77	NA	6157	240.0
Dec-72	NA	1314	302.0	Dec-77	NA	1490	240.7
Jan-73	NA	-333	302.6	Jan-78	NA	1021	241.3
Feb-73	NA	4071	264.1	Feb-78	NA	2937	238.0
Mar-73	NA	552	265.8	Mar-78	NA	12669	221.6
Apr-73	NA	-2926	265.5	Apr-78	NA	6	225.9
May-73	NA	-2552	265.0	May-78	NA	-24	225.5
Jun-73	NA	-2074	265.2	Jun-78	NA	1387	205.4
Jul-73	NA	-2267	265.6	Jul-78	NA	4263	193.5
Aug-73	NA	-404	265.4	Aug-78	NA	981	194.3
Sep-73	NA	-1079	265.6	Sep-78	NA	54	189.4
Oct-73	NA	-2421	266.7	Oct-78	NA	1678	179.6
Nov-73	NA	-6804	280.0	Nov-78	NA	2724	196.3
Dec-73	NA	-2603	280.0	Dec-78	NA	551	195.6
Jan-74	NA	-4460	299.7	Jan-79	NA	-97	199.8
Feb-74	NA	1421	287.9	Feb-79	NA	-1070	202.1
Mar-74	NA	1488	275.2	Mar-79	NA	-7722	207.6
Apr-74	NA	783	277.0	Apr-79	NA	-7404	218.4
May-74	NA	778	279.6	May-79	NA	-4617	221.5
Jun-74	NA	359	283.9	Jun-79	NA	843	216.4
Jul-74	NA	113	299.0	Jul-79	NA	884	215.5
Aug-74	NA	-1070	301.9	Aug-79	NA	-466	221.5
Sep-74	NA	-1059	295.7	Sep-79	NA	-281	223.0
Oct-74	NA	-724	299.9	Oct-79	NA	-5654	234.8
Nov-74	NA	-187	300.0	Nov-79	NA	-9213	249.7
Dec-74	NA	-1227	301.0	Dec-79	NA	-486	239.7
Jan-75	NA	-567	298.5	Jan-80	NA	783	239.4
Feb-75	NA	981	285.5	Feb-80	NA	-1461	248.8
Mar-75	NA	397	291.0	Mar-80	NA	-9046	249.7
Apr-75	NA	102	293.1	Apr-80	NA	-2621	245.9
May-75	NA	152	290.9	May-80	NA	4776	222.9
Jun-75	NA	-86	298.0	Jun-80	NA	2353	218.2
Jul-75	NA	60	297.7	Jul-80	NA	-104	226.6
Aug-75	NA	-2106	298.0	Aug-80	NA	0	220.3
Sep-75	NA	-2718	302.6	Sep-80	NA	1677	212.9
Oct-75	NA	-689	301.7	Oct-80	NA	2213	211.0
Nov-75	NA	-965	303.0	Nov-80	NA	0	214.0
Dec-75	NA	-838	305.6	Dec-80	NA	210	207.9

Table: Japanese Interventions and yen/dollar rates (continued)

	Japanese Interventions (100mil Yen)		Yen/Dollar Rate		Japanese Interventions (100mil Yen)		Yen/Dollar Rate
	Actual	Estimated			Actual	Estimated	
Jan-81	NA	2854	203.4	Jan-86	NA	0	194.3
Feb-81	NA	0	207.4	Feb-86	NA	0	181.9
Mar-81	NA	0	211.4	Mar-86	NA	87	180.0
Apr-81	NA	72	211.6	Apr-86	NA	4743	170.2
May-81	NA	-100	224.2	May-86	NA	1914	168.9
Jun-81	NA	-69	225.8	Jun-86	NA	1767	166.1
Jul-81	NA	-1936	237.8	Jul-86	NA	6178	155.7
Aug-81	NA	-719	231.4	Aug-86	NA	4680	155.3
Sep-81	NA	-69	232.0	Sep-86	NA	77	154.4
Oct-81	NA	-183	235.1	Oct-86	NA	0	159.4
Nov-81	NA	0	215.9	Nov-86	NA	0	162.5
Dec-81	NA	-1181	222.0	Dec-86	NA	0	159.5
Jan-82	NA	-1083	228.6	Jan-87	NA	13494	151.2
Feb-82	NA	-1052	234.3	Feb-87	NA	0	153.6
Mar-82	NA	-2699	246.7	Mar-87	NA	9307	149.0
Apr-82	NA	-2128	238.9	Apr-87	NA	13930	138.1
May-82	NA	-1724	241.3	May-87	NA	0	143.2
Jun-82	NA	-3153	258.7	Jun-87	NA	115	145.9
Jul-82	NA	-584	252.6	Jul-87	NA	0	150.2
Aug-82	NA	-4077	254.2	Aug-87	NA	653	142.6
Sep-82	NA	-1797	269.5	Sep-87	NA	1677	144.2
Oct-82	NA	-4146	275.4	Oct-87	NA	336	140.8
Nov-82	NA	-1504	250.2	Nov-87	NA	6408	134.8
Dec-82	NA	-202	233.7	Dec-87	NA	3548	123.5
Jan-83	NA	-24	238.0	Jan-88	NA	2258	127.7
Feb-83	NA	-53	235.0	Feb-88	NA	9	128.8
Mar-83	NA	0	239.1	Mar-88	NA	370	124.4
Apr-83	NA	1	236.4	Apr-88	NA	1114	124.6
May-83	NA	0	236.9	May-88	NA	0	124.6
Jun-83	NA	0	239.8	Jun-88	NA	0	131.0
Jul-83	NA	0	240.7	Jul-88	NA	0	132.5
Aug-83	NA	-1979	246.1	Aug-88	NA	0	134.2
Sep-83	NA	0	237.3	Sep-88	NA	0	134.2
Oct-83	NA	-413	233.0	Oct-88	NA	13	125.9
Nov-83	NA	-750	234.9	Nov-88	NA	3631	122.0
Dec-83	NA	-24	233.8	Dec-88	NA	123	125.3
Jan-84	NA	0	234.3	Jan-89	NA	0	128.7
Feb-84	NA	0	233.4	Feb-89	NA	0	126.3
Mar-84	NA	0	224.6	Mar-89	NA	0	133.3
Apr-84	NA	0	225.4	Apr-89	NA	-39	131.5
May-84	NA	-601	232.0	May-89	NA	-6835	142.9
Jun-84	NA	-626	236.9	Jun-89	NA	-10120	143.6
Jul-84	NA	-743	243.8	Jul-89	NA	-2145	139.4
Aug-84	NA	-12	241.1	Aug-89	NA	-1191	144.2
Sep-84	NA	-37	246.4	Sep-89	NA	-4300	141.4
Oct-84	NA	-75	246.3	Oct-89	NA	-3606	142.8
Nov-84	NA	0	245.3	Nov-89	NA	-764	143.7
Dec-84	NA	0	250.0	Dec-89	NA	-665	142.1
Jan-85	NA	-80	254.0	Jan-90	NA	-4155	143.2
Feb-85	NA	-1092	260.9	Feb-90	NA	-2858	148.7
Mar-85	NA	-253	254.0	Mar-90	NA	-11095	158.6
Apr-85	NA	0	251.1	Apr-90	NA	-1342	159.3
May-85	NA	0	251.7	May-90	NA	0	150.7
Jun-85	NA	0	249.2	Jun-90	NA	0	154.4
Jul-85	NA	0	237.5	Jul-90	NA	0	150.8
Aug-85	NA	0	237.0	Aug-90	NA	0	144.4
Sep-85	NA	-2839	222.8	Sep-90	NA	0	137.4
Oct-85	NA	-3303	212.9	Oct-90	NA	0	127.4
Nov-85	NA	-904	200.9	Nov-90	NA	0	128.9
Dec-85	NA	0	202.9	Dec-90	NA	0	136.7

Table: Japanese Interventions and yen/dollar rates (continued)

	Japanese Interventions (100mil Yen)		Yen/Dollar Rate		Japanese Interventions (100mil Yen)		Yen/Dollar Rate
	Actual	Estimated			Actual	Estimated	
Jan-91	NA	0	131.2	Jan-96	0	0	107.1
Feb-91	NA	0	133.1	Feb-96	16037	16037	105.2
Mar-91	NA	-1280	138.4	Mar-96	0	0	107.3
Apr-91	0	-489	136.1	Apr-96	0	186	105.1
May-91	-139	-139	138.5	May-96	0	-182	108.1
Jun-91	-424	-424	137.5	Jun-96	0	1	109.7
Jul-91	0	0	137.4	Jul-96	0	0	106.9
Aug-91	0	0	136.8	Aug-96	0	0	109.0
Sep-91	0	0	133.0	Sep-96	0	0	111.4
Oct-91	0	0	130.8	Oct-96	0	1	114.1
Nov-91	0	0	130.0	Nov-96	0	-1	113.9
Dec-91	0	0	124.8	Dec-96	0	-1	115.9
Jan-92	-63	-62	125.8	Jan-97	0	0	121.4
Feb-92	-896	-896	129.5	Feb-97	0	1	120.4
Mar-92	-387	-387	132.8	Mar-97	0	1	123.8
Apr-92	-2036	-1104	133.3	Apr-97	0	1	127.1
May-92	-1673	-1775	127.6	May-97	0	0	116.3
Jun-92	-1477	-2305	125.7	Jun-97	0	1	114.7
Jul-92	-478	-478	127.2	Jul-97	0	0	118.8
Aug-92	-160	-160	123.2	Aug-97	0	0	120.8
Sep-92	0	0	119.9	Sep-97	0	0	120.4
Oct-92	0	0	123.5	Oct-97	0	0	120.5
Nov-92	0	0	124.6	Nov-97	0	7	127.8
Dec-92	0	1	124.9	Dec-97	-10591	-10585	130.6
Jan-93	0	0	124.7	Jan-98	0	1	127.2
Feb-93	0	0	118.3	Feb-98	0	0	126.1
Mar-93	0	0	114.8	Mar-98	0	0	133.0
Apr-93	6756	6756	111.1	Apr-98	-28158	-28157	132.9
May-93	4971	2384	107.5	May-98	0	0	138.8
Jun-93	5386	7974	107.3	Jun-98	-2312	-2312	138.8
Jul-93	366	0	104.9	Jul-98	0	0	144.7
Aug-93	7835	8262	104.8	Aug-98	0	0	139.2
Sep-93	218	219	106.2	Sep-98	0	2	136.7
Oct-93	0	1	108.6	Oct-98	0	1	116.0
Nov-93	0	0	109.1	Nov-98	0	2	123.0
Dec-93	0	0	111.8	Dec-98	0	0	113.5
Jan-94	0	0	108.5	Jan-99	6563	6564	116.4
Feb-94	2445	1869	104.5	Feb-99	0	1	119.2
Mar-94	3158	2714	102.7	Mar-99	0	1	118.9
Apr-94	2637	2845	101.7	Apr-99	0	NA	119.5
May-94	824	2298	104.8	May-99	0	NA	121.4
Jun-94	4678	4083	98.5	Jun-99	24996	NA	121.2
Jul-94	1056	1652	99.9	Jul-99	13681	NA	114.6
Aug-94	1494	1494	100.2	Aug-99	0	NA	109.8
Sep-94	789	789	99.2	Sep-99	10195	NA	106.4
Oct-94	1913	1913	97.0	Oct-99	0	NA	104.1
Nov-94	1645	1644	99.0	Nov-99	11328	NA	102.2
Dec-94	0	1	99.8	Dec-99	3704	NA	102.3
Jan-95	0	0	99.6	Jan-00	5753	NA	107.4
Feb-95	1183	1115	96.7	Feb-00	0	NA	110.2
Mar-95	16771	12116	86.6	Mar-00	9969	NA	102.7
Apr-95	4986	9710	84.3	Apr-00	13854	NA	108.2
May-95	635	0	84.6	May-00	0	NA	107.7
Jun-95	430	1064	84.7	Jun-00	0	NA	106.2
Jul-95	579	579	88.4	Jul-00	0	NA	109.4
Aug-95	8174	8174	97.5	Aug-00	0	NA	106.7
Sep-95	16831	16840	99.7	Sep-00	0	NA	108.2
Oct-95	0	3	102.0	Oct-00	0	NA	109.0
Nov-95	0	2	102.2	Nov-00	0	NA	110.4
Dec-95	0	3	103.4	Dec-00	0	NA	114.5

Table: Japanese Interventions and yen/dollar rates (continued)

	Japanese Interventions (100mil Yen)		Yen/Dollar Rate		Japanese Interventions (100mil Yen)		Yen/Dollar Rate
	Actual	Estimated			Actual	Estimated	
Jan-01	0	NA	116.5	Jan-06	0	NA	117.2
Feb-01	0	NA	117.4	Feb-06	0	NA	115.8
Mar-01	0	NA	126.2	Mar-06	0	NA	117.8
Apr-01	0	NA	123.6	Apr-06	0	NA	113.8
May-01	0	NA	119.3	May-06	0	NA	112.6
Jun-01	0	NA	124.7	Jun-06	0	NA	114.4
Jul-01	0	NA	125.1	Jul-06	0	NA	114.7
Aug-01	0	NA	118.9	Aug-06	0	NA	117.4
Sep-01	31455	NA	119.5	Sep-06	0	NA	118.1
Oct-01	0	NA	122.5	Oct-06	0	NA	116.9
Nov-01	0	NA	123.5	Nov-06	0	NA	115.8
Dec-01	0	NA	131.7	Dec-06	0	NA	119.1
Jan-02	0	NA	134.6	Jan-07	0	NA	120.7
Feb-02	0	NA	133.4	Feb-07	0	NA	118.5
Mar-02	0	NA	132.8	Mar-07	0	NA	117.8
Apr-02	0	NA	128.6	Apr-07	0	NA	119.5
May-02	21174	NA	124.3	May-07	0	NA	121.7
Jun-02	18750	NA	119.5	Jun-07	0	NA	123.2
Jul-02	0	NA	119.9	Jul-07	0	NA	118.6
Aug-02	0	NA	118.4	Aug-07	0	NA	115.8
Sep-02	0	NA	121.7	Sep-07	0	NA	114.8
Oct-02	0	NA	122.6	Oct-07	0	NA	115.4
Nov-02	0	NA	122.5	Nov-07	0	NA	111.2
Dec-02	0	NA	118.8	Dec-07	0	NA	111.7
Jan-03	6781	NA	119.9	Jan-08	0	NA	106.5
Feb-03	10614	NA	118.1	Feb-08	0	NA	103.7
Mar-03	5518	NA	118.1	Mar-08	0	NA	99.7
Apr-03	0	NA	119.0	Apr-08	0	NA	103.9
May-03	38997	NA	119.3	May-08	0	NA	105.5
Jun-03	6289	NA	119.8	Jun-08	0	NA	106.2
Jul-03	20271	NA	120.6	Jul-08	0	NA	107.9
Aug-03	4124	NA	117.0	Aug-08	0	NA	108.8
Sep-03	51116	NA	111.5	Sep-08	0	NA	106.1
Oct-03	16687	NA	110.0	Oct-08	0	NA	98.5
Nov-03	15872	NA	109.6	Nov-08	0	NA	95.5
Dec-03	26196	NA	107.3	Dec-08	0	NA	90.7
Jan-04	68215	NA	105.8	Jan-09	0	NA	89.9
Feb-04	34766	NA	109.2	Feb-09	0	NA	97.6
Mar-04	45332	NA	104.3	Mar-09	0	NA	99.0
Apr-04	0	NA	110.5	Apr-09	0	NA	98.6
May-04	0	NA	109.6	May-09	0	NA	95.4
Jun-04	0	NA	108.8	Jun-09	0	NA	96.4
Jul-04	0	NA	111.4	Jul-09	0	NA	94.7
Aug-04	0	NA	109.2	Aug-09	0	NA	93.2
Sep-04	0	NA	110.1	Sep-09	0	NA	89.7
Oct-04	0	NA	106.0	Oct-09	0	NA	90.1
Nov-04	0	NA	103.1	Nov-09	0	NA	86.4
Dec-04	0	NA	102.7	Dec-09	0	NA	93.0
Jan-05	0	NA	103.7	Jan-10	0	NA	90.3
Feb-05	0	NA	104.6	Feb-10	0	NA	88.9
Mar-05	0	NA	107.2	Mar-10	0	NA	93.5
Apr-05	0	NA	104.8	Apr-10	0	NA	93.9
May-05	0	NA	108.6	May-10	0	NA	91.5
Jun-05	0	NA	111.0	Jun-10	0	NA	88.5
Jul-05	0	NA	112.5	Jul-10	0	NA	86.5
Aug-05	0	NA	110.6	Aug-10	0	NA	84.2
Sep-05	0	NA	113.5	Sep-10	21249	NA	83.5
Oct-05	0	NA	116.4	Oct-10	0	NA	80.4
Nov-05	0	NA	119.8	Nov-10	0	NA	83.7
Dec-05	0	NA	117.8	Dec-10	0	NA	81.2

Table: Japanese Interventions and yen/dollar rates (continued)

	Japanese Interventions (100mil Yen)		Yen/Dollar Rate		Japanese Interventions (100mil Yen)		Yen/Dollar Rate
	Actual	Estimated			Actual	Estimated	
Jan-11	0	NA	82.1	Jan-15	0	NA	117.5
Feb-11	0	NA	81.8	Feb-15	0	NA	119.6
Mar-11	6925	NA	83.2	Mar-15	0	NA	120.1
Apr-11	0	NA	81.2	Apr-15	0	NA	119.4
May-11	0	NA	81.5	May-15	0	NA	124.2
Jun-11	0	NA	80.6	Jun-15	0	NA	122.5
Jul-11	0	NA	76.8	Jul-15	0	NA	124.0
Aug-11	45129	NA	76.7	Aug-15	0	NA	121.3
Sep-11	0	NA	77.1	Sep-15	0	NA	119.9
Oct-11	80722	NA	78.2	Oct-15	0	NA	120.6
Nov-11	10195	NA	77.6	Nov-15	0	NA	123.1
Dec-11	0	NA	76.9	Dec-15	0	NA	120.3
Jan-12	0	NA	76.3	Jan-16	0	NA	121.1
Feb-12	0	NA	81.2	Feb-16	0	NA	112.7
Mar-12	0	NA	82.9	Mar-16	0	NA	112.6
Apr-12	0	NA	79.8	Apr-16	0	NA	106.4
May-12	0	NA	78.3	May-16	0	NA	110.7
Jun-12	0	NA	79.8	Jun-16	0	NA	103.2
Jul-12	0	NA	78.1	Jul-16	0	NA	102.1
Aug-12	0	NA	78.4	Aug-16	0	NA	103.5
Sep-12	0	NA	77.9	Sep-16	0	NA	101.4
Oct-12	0	NA	79.8	Oct-16	0	NA	104.8
Nov-12	0	NA	82.5	Nov-16	0	NA	114.5
Dec-12	0	NA	86.8	Dec-16	0	NA	117.1
Jan-13	0	NA	91.7	Jan-17	0	NA	112.8
Feb-13	0	NA	92.6	Feb-17	0	NA	112.8
Mar-13	0	NA	94.2	Mar-17	0	NA	111.4
Apr-13	0	NA	97.5	Apr-17	0	NA	111.6
May-13	0	NA	100.5	May-17	0	NA	110.8
Jun-13	0	NA	99.2	Jun-17	0	NA	112.4
Jul-13	0	NA	97.9	Jul-17	0	NA	110.3
Aug-13	0	NA	98.2	Aug-17	0	NA	110.0
Sep-13	0	NA	98.2	Sep-17	0	NA	112.5
Oct-13	0	NA	98.4	Oct-17	0	NA	113.7
Nov-13	0	NA	102.5	Nov-17	0	NA	112.6
Dec-13	0	NA	105.3	Dec-17	0	NA	112.7
Jan-14	0	NA	102.1	Jan-18	0	NA	109.2
Feb-14	0	NA	101.8	Feb-18	0	NA	106.7
Mar-14	0	NA	103.3	Mar-18	0	NA	106.3
Apr-14	0	NA	102.3	Apr-18			
May-14	0	NA	101.8	May-18			
Jun-14	0	NA	101.4	Jun-18			
Jul-14	0	NA	102.8	Jul-18			
Aug-14	0	NA	104.1	Aug-18			
Sep-14	0	NA	109.7	Sep-18			
Oct-14	0	NA	112.4	Oct-18			
Nov-14	0	NA	118.7	Nov-18			
Dec-14	0	NA	119.7	Dec-18			

Note: The intervention amounts are in units of 100 million yen. The monthly yen/dollar rate is the Tokyo close rate on the third to last business day for the period before April 1991, since the proxy is for settlement-based interventions. After April 1991, we use the end-of-month New York close rate for the monthly yen/dollar rate.