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Official Japanese Intervention in the JPY/USD Exchange Rate Market: Is It Effective and Through Which Channel Does It Work?

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Abstract

This paper investigates whether official Japanese intervention in the JPY/USD exchange rate over the January 1999 to March 2004 time period is effective. By integrating the official intervention data with a comprehensive set of newswire reports capturing days on which there is a rumor or speculation of intervention, the paper also attempts to shed some light on through which of the two channels, the signaling channel in a broad sense or the portfolio balance channel, effective Japanese intervention works. The results suggest that Japanese intervention is effective during the first 5 years of the sample and ineffective during the last 3 months of the sample, thereby providing an ex-post rationale for why Japan intervened as well as for why the interventions stopped. Moreover, the results suggest that when Japanese intervention is effective, it works through a portfolio-balance channel. The results do not rule out that effective intervention also works through signaling.

Keywords: Exchange Rates; Foreign Exchange Market Intervention; Channels of Transmission
JEL classification: E52, F31, G14

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1. Introduction

The literature on sterilized central bank intervention in the foreign exchange market is rich with conflicting and sample specific results in regards to whether intervention is effective in influencing exchange rates.[1] By contrast, there is little disagreement that if intervention is effective, it is effective through signaling (by carrying out intervention the central bank informs the market about its future policy intentions and/or fundamentals) or through portfolio balance effects (by carrying out intervention the central bank changes the relative demand and supply of imperfectly substitutable foreign and domestic assets).[2] While the literature on effectiveness is extensive, fewer empirical studies investigate the transmission channels of intervention.[3] The aim of this paper is to asses whether the recent 1999 to 2004 Japanese intervention is effective and to gain insight on through which channel effective intervention works.[4]

Specifically, the paper investigates whether Japanese intervention over the January 1, 1999 to March 31, 2004 time period is effective in influencing day-to-day changes in the JPY/USD exchange rate.[5] By integrating the official Japanese intervention data with a comprehensive set of newswire reports capturing days on which there is a rumor or speculation of intervention, the paper sheds some light on through which of the two channels, the signaling channel in a broad sense or the portfolio balance channel, Japanese intervention, if effective, works.[6]

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[1] See Neely (2005) for a detailed overview of several recent intervention studies and their main results.

[2] See, for example, Edison (1993) for a detailed exposition of the signaling and the portfolio balance channels.

[3] See Dominguez and Frankel (1993a) for a study of the portfolio balance channel. See Fatum and Hutchison (1999) and Lewis (1995) for studies of the (monetary policy) signaling channel.

[4] Official daily data on Japanese intervention from April 1991 to present is publicly available. As of January 2009, there has been no intervention in the JPY/USD exchange rate since March 16, 2004. See Fatum and Hutchison (2006a) and Ito (2003) and others for studies of the effects of official Japanese intervention during the 1990s.

[5] Fatum and Hutchison (2005) show that Japanese intervention is sterilized. Ito (2007) provides institutional details of Bank of Japan intervention.

[6] Sarno and Taylor (2001) discuss, and Reitz and Taylor (2008) test, the coordination channel through which intervention works by sending a coordinating signal to the market regarding the "correct" or the equilibrium value of

In order to investigate which transmission channel of intervention is at work, three categories of intervention are defined: Actual intervention of which the market is aware (proxied by official intervention on days when there is a rumor of intervention), actual intervention of which the market is unaware (proxied by official intervention on days when there is no rumor of intervention), and perceived intervention when no actual intervention occurs (proxied by days when there is a rumor of intervention but no official intervention). Testing the hypothesis of effectiveness separately for each category of intervention provides insight on effectiveness as well as on the channel of transmission as follows. The signaling channel can only be at work when the market is aware of or thinks intervention occurs (otherwise a signal about future policy intentions and fundamentals will go unnoticed, in which case it is not possible for the signaling channel to function), thus effectiveness of the first and the third category of intervention is consistent with signaling. The portfolio balance channel can only be at work when an intervention is actually carried out (otherwise the relative demand and supply of foreign and domestic assets do not change, in which case it is not possible for the portfolio balance channel to function), thus effectiveness of the first and the second category is consistent with portfolio effects.

The existing literature combining intervention data with newswire reports of intervention typically uses firm newswire reports of intervention to indicate whether the market is aware of an intervention or whether an intervention is carried out in secrecy.[7] However, a firm report of intervention is typically on the newswire the day after the intervention the report refers to is carried out. For example, a firm report of the January 12, 1999 official Japanese intervention

the exchange rate in the face of persistent exchange rate misalignments caused by non-fundamental influences. The analysis presented in this paper does not distinguish between signaling in a narrow sense (e.g. signaling of the direction of future monetary policy) and signaling of information in a broader sense (e.g. coordination signaling in situations of non-fundamentals based exchange rate misalignments).

[7] See, for example, Dominguez and Frankel (1993b, chapter 7).

operation is reported on the newswire on January 13, 1999. Therefore, whether or not an intervention is reported is generally a matter of "after-the-fact" information that can play no role in the contemporaneous exchange rate response to intervention. By contrast, rumors and speculation of intervention are generally picked up by the newswire the same day they occur. Accordingly, the analysis of this paper uses rumors or speculation of intervention rather than firm reports of intervention to indicate market awareness as well as market perception of intervention.

A premise of this approach is that not all interventions are carried out when a rumor of intervention is reported, and not all rumors of intervention are reported when intervention is carried out. As it turns out, over the full sample period under study, official Japanese intervention occurs on a total of 159 days while a rumor of intervention occurs on a total of 269 days. A total of 92 (of the 159) intervention days are also days on which a rumor occurs. Since not all official intervention days coincide with a rumor, and not all rumor days coincide with an official intervention, the data encompasses three official intervention-rumor of intervention combinations.[8] This facilitates the creation of the aforementioned three types of intervention categories and, in turn, the hypothesis testing of effectiveness separately for each intervention category.

The analysis also assesses the impact of official statements (sometimes referred to as "oral intervention" or "central bank communication") and whether the first day of intervention after a day, or days, of no intervention, and whether the first day of no intervention after a day, or days, of intervention, significantly influence exchange rate movements.

[8] There are four (two times two) official intervention-rumor of intervention combinations. Official intervention on a day when there is a rumor of intervention; official intervention when there is no rumor of intervention; rumor of intervention on a day when there is official intervention; rumor of intervention when there is no official intervention. However, since official intervention on a day when there is a rumor of intervention is equivalent to rumor of intervention on a day when there is official intervention, there are, effectively, only three different combinations.

The empirical approach of the paper builds on the work of Dominguez and Frankel (1993b) and their (OLS) estimations of daily effects of official Bundesbank and Fed intervention on the DEM/USD exchange rate over the 1982 to 1990 time period.[9] Using a standard GARCH time series methodology and a comprehensive list of macro news control variables (measuring the news surprise as the difference between official news announcements and results of surveys of expectations of these announcements conducted by Bloomberg during the days preceding the announcements), the findings of this paper show that for the January 1, 1999 to December 31, 2003 time period, official intervention, whether or not the market is aware of the intervention, exerts a significant same-day influence on the JPY/USD exchange rate. The analysis does not detect a systematic and significant link between days when there is a rumor of intervention, but no intervention occurs, and the JPY/USD exchange rate.[10] For the first quarter of 2004, the analysis shows that neither actual intervention nor rumors of intervention alone have any impact on the JPY/USD exchange rate.

The results, therefore, suggest that Japanese intervention is effective during the first 5 years of the sample and ineffective during the last 3 months of the sample. This provides an ex-post rationale for why Japan intervened as well as for why the interventions stopped.[11] Moreover, the results suggest that when intervention is effective, it works through a portfolio-balance channel. The results do not rule out that effective intervention also works through signaling.

Official statements in support of more intervention as well as official statements casting doubt on the likelihood of more intervention are both found to be insignificant. Moreover, the analysis finds strong and robust evidence that for the January 1, 1999 to December 31, 2003 time

[9] The empirical analysis of Dominguez and Frankel (1993b) uses news reports of intervention to classify whether an intervention is secret or reported. They do not address through which channel effective intervention works.
[10] See Dominguez and Panthaki (2007) for an intraday study of perceived intervention.
[11] See Taylor (2006) for a discussion of the Japanese intervention "exit strategy".

period the first day of intervention following a no intervention day has a larger than average impact on exchange rates. Some sample specific evidence that the first day after intervention is associated with an adverse exchange rate adjustment is found.

The analysis does not attempt to address the inherent endogeneity problem concerning intervention studies, thus it is likely that the models are affected by simultaneity leading to an underestimation of the coefficient estimates (see, for example, Dominguez and Frankel 1993b and Neely 2005 for a discussion). Therefore, the magnitude of the coefficient estimates is not discussed in this paper.

The rest of the paper is organized as follows. Section 2 details the data. Section 3 presents the empirical approach of the time-series analysis. Section 4 discusses the results of the baseline model estimations as well as several extensions and robustness checks. Section 5 concludes.

2. Data

The official Japanese intervention data consists of daily volumes of intervention operations in the JPY/USD foreign exchange market. During the period under study, January 1999 to March 2004, all official interventions in the JPY/USD market are sales of JPY against purchases of USD.[12]

Table 1 shows intervention data summary statistics. The table shows that Japan intervenes in the JPY/USD exchange rate market on a total of 159 days over the full sample period. On most intervention days the magnitude of intervention is substantial, with purchases of over USD 1,000 million on 113 days and only 20 days with purchases of less than USD 250 million. The table shows that only 30 of the intervention days occur between January 1999 and

[12] The U.S. government did not intervene in the JPY/USD exchange rate market during this period.

December 2002, 82 intervention days occur during 2003, while 47 intervention days occur during the first quarter of 2004.[13]

In order to compare the exchange rate effect of interventions that the market seem aware of to interventions that the market seem unaware of and, in turn, attempt to shed light on through which transmission channel intervention works, rumors of intervention are taken into account.

The analysis distinguishes between a rumor of intervention and a firm report of intervention, and only incorporates the former for the following reason. A rumor of intervention occurs on the same day that the market thinks an intervention takes place, while a firm report of intervention typically occurs the day after the intervention has taken place.[14] Therefore, whether or not an intervention is reported is generally a matter of "after-the-fact" information that can not play a role in the contemporaneous exchange rate response to intervention. By contrast, whether or not an intervention coincides with a rumor seems a better indicator of whether the market is aware of the intervention operation the same day it is carried out. Moreover, whether the market is aware of the intervention operation may affect the same-day market reaction to intervention as well as trigger a same-day market reaction to the rumor itself (whether or not intervention actually occurs.) [15]

The Factiva search engine and a comprehensive combination of various search words (e.g. Bank of Japan, intervention etc.) are used to find the days with a rumor of intervention. The

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[13] Fatum and Hutchison (2006b) show that the described variation in intervention frequencies over the January 1999 to March 2004 time period is consistent with the existence of three different intervention reaction function regimes.

[14] For example, a firm report of the January 12, 1999 official Japanese intervention operation is reported on the newswire on January 13, 1999.

[15] For completeness, Factiva was also gleaned for firm reports of intervention. For the full sample, a total of 31 firm reports of intervention were found. To compare, Chang (2006) finds 27 firm reports of intervention in the Wall Street Journal over the January 2000 to March 2003 time period. While most Bank of Japan interventions are unreported, no false firm reports of intervention were found. By contrast, more than half of the interventions under study coincide with a rumor and, furthermore, several "false" rumors of intervention (i.e. a rumor of intervention when no intervention takes place) were found. This further illustrates the importance of distinguishing between reports of intervention and rumors of intervention.

second row of Table 2 shows that a total of 269 days across the full sample are associated with a rumor of intervention. Row three of Table 2 reports that 92 of the rumor days are also intervention days, i.e. 92 of the 269 rumors are "true". Row four shows that, accordingly, the remaining 67 of the 159 intervention days in the full sample do not coincide with a rumor of intervention. For the full sample, as many as 177 rumor days are, in fact, "false". The numbers of days associated with false rumors are reported in row five. [16]

Some studies suggest that official statements regarding threats of intervention or regarding the desired direction of future exchange rate movements (sometimes referred to as "oral interventions") influence exchange rate. In order to take into account this possibility, the analysis uses the Factiva search engine to find, respectively, newswire reports of official statements in support of intervention and/or a weaker JPY ("positive statements"), and newswire reports of official statements suggesting that further intervention in the JPY/USD rate is not recommended or unlikely ("negative statements"). Rows six and seven of Table 2, respectively, report a total of 108 positive and 17 negative statements for the full sample period.

The analysis follows Ito (2003) and others in using New York close quotes of the daily JPY/USD exchange rate. The exchange rate data are obtained from Global Financial Data (GFD).

Several studies have found unexpected macro news to impact day-to-day exchange rate changes.[17] Therefore, the analysis also incorporates a comprehensive list of macro news control variables. These control variables capture the surprise component of Japanese news regarding CPI, GDP, Industrial Production, Trade Balance, Unemployment and the surprise component of US news regarding CPI, GDP, Industrial Production, Trade Balance, Unemployment, and

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[16] It is not surprising to find a large number of false rumors of intervention. Chang (2006) reports a total of 282 JiJi News (local Japanese newswire) and Wall Street Journal reports of rumors and speculation of Japanese intervention over the January 2000 to March 2003 time period. Moreover, other studies question the accuracy of newswire reports of intervention (see Fischer 2006 and Osterberg and Wetmore Humes 1993).

[17] See, for example, Galati, Melick and Micu (2005) and Fatum and Scholnick (2006).

Monetary Policy. For each of these macro news control variables, the surprise measure is the difference between official announcements and results of surveys of expectations of these announcements conducted by Bloomberg during the days preceding the announcements.

The official value of a news variable is announced once a month, or at a lower frequency. The news control variables capture the associated surprise element on announcement dates, thus these variables are non-zero only on announcement dates and only when the announcement differs from market expectations.

Summary statistics for the JPY/USD exchange rate and the macro news surprises are displayed in Table 3.

3. Empirical Analysis

Studies of financial market time series in general and exchange rate time series in particular often find evidence of time-dependent variance in the residuals. Specifically, large and small errors tend to come in clusters and the size of the current error term seems dependent on the size of the previous error (see, for example, Engle 1982 and Bollerslev 1986). In order to address this issue of autoregressive conditional heteroskedasticity (ARCH), the analysis of this paper follows Baillie and Bollerslev (1989) in estimating a regression equation with residuals modeled as a GARCH process. The basic empirical relationship of the analysis is given by the GARCH(p,q) specification:

(1) $$\begin{aligned}\Delta s_t &= a + b_1 INT_t^{RUMOR} + b_2 INT_t^{NoRUMOR} + b_3 RUMOR_t^{NoINT} \\ &+ b_4 PSTAT_t + b_5 NSTAT_t + CZ_t + \varepsilon_t\end{aligned}$$

(2) $$\varepsilon_t \sim N(0, h_t)$$

(3) $$h_t = \alpha_0 + \sum_{j=1}^{q} \alpha_j \varepsilon^2_{t-j} + \sum_{j=1}^{p} \beta_j h_{t-j}$$

where Δs_t is the first-difference in the log of the spot JPY/USD exchange rate; INT^{RUMOR} is actual intervention (volume) that occurs on a day when there is a rumor of intervention (i.e. the variable INT^{RUMOR} contains actual interventions of which the market is aware); $INT^{NoRUMOR}$ is actual intervention (volume) that occurs on a day when there is no rumor of intervention (i.e. $INT^{NoRUMOR}$ contains actual interventions of which the market is unaware); $RUMOR^{NoINT}$ is an indicator variable that takes on the value one when a rumor of intervention is reported but no actual intervention took place, and zero otherwise (i.e. $RUMOR^{NoINT}$ captures days on which the market suspects an intervention takes place but no actual intervention occurs); PSTAT is an indicator variable that takes on the value one on a day when there is an official statement in support of intervention and/or a weaker JPY, and zero otherwise; NSTAT is an indicator variable that takes on the value one on a day when there is an official statement suggesting that further intervention in the JPY/USD rate is not recommended or unlikely, and zero otherwise; C is the coefficient vector associated with the control variables contained in Z_t. The control variable matrix Z_t contains the unexpected component of Japanese news regarding CPI (JPCPI), GDP (JPGDP), Industrial Production (JPIP), Trade Balance (JPTB), Unemployment (JPUNEMP) and the surprise component of US news regarding CPI (USCPI), GDP (USGDP), Industrial Production (USIP), Trade Balance (USTB), Unemployment (USUNEMP), and Monetary Policy (USFOMC).

Equation (2) states that the error term is normally distributed with zero mean and time-dependant (conditional) variance h_t. Equation (3) shows that the variance depends on the squared error of the past q periods (the ARCH terms) and the conditional variance of the past p periods.

Simultaneous estimations of equations (1) through (3) are carried out for the full sample and, to ensure that the results are robust, also for two truncated samples (Sub-Sample 1: January 1, 1999 to December 31, 2002; Sub-Sample 2: January 1, 1999 to December 31, 2003). In addition, estimations are carried out separately across the January 1, 2004 to March 31, 2004 period during which the intervention frequency is unusually high (Sub-Sample 3). For each of the exchange rate regressions, the most parsimonious GARCH specification possible that still allows for acceptance of the null hypothesis of no ARCH in the standardized residuals is selected. As it turns out, GARCH(1,1) models give the better fit in all cases.[18,19]

4. Results

Table 4 shows the GARCH(1,1) estimation results from regressing changes in the JPY/USD exchange rate on intervention of which the market is aware (INT^{RUMOR}), intervention of which the market is unaware ($INT^{NoRUMOR}$), and the indicator variable capturing rumors of intervention on days when no intervention occurs ($RUMOR^{NoINT}$). The models also include as explanatory variables the two indicator variables capturing intervention statements (PSTAT and NSTAT) as well as the 11 control variables containing various Japanese and US macro surprises.

The first column of Table 4 displays the results pertaining to the full sample (January 1999 to March 2004). Both INT^{RUMOR} and $INT^{NoRUMOR}$ are highly significant (at the 99 percent

[18] Fatum and Scholnick (2006) also find that GARCH(1,1) specifications give the better fit when estimating models of the JPY/USD exchange rate. They find GARCH(2,1) models to perform better when estimating models of the DEM/USD and the GBP/USD exchange rates.

[19] None of the GARCH specifications fit the Sub-Sample 3 data particularly well. Therefore, for Sub-Sample 3, only the baseline model is estimated using the GARCH approach. While extensions of the baseline model are estimated using GARCH(1,1) specifications for the full sample and for Sub-Samples 1 and 2, Sub-Sample 3 extensions are based on OLS estimations with Newey-West heteroskedasticity- and serial-correlation consistent (HAC) standard errors (see Newey and West, 1987).

level) and of the correct (positive) sign, thereby providing evidence that actual intervention (i.e. JPY sales), whether the market is aware of the intervention or not, is, on average, associated with an exchange rate movement in the intended direction (i.e. JPY depreciation). By contrast, $RUMOR^{NoINT}$ is highly insignificant, implying that, on average, a rumor of intervention is not in itself sufficient to elicit a detectable exchange rate movement.

As discussed earlier, evidence of effectiveness of intervention of which the market is aware is consistent with a portfolio-balance transmission channel as well as an information signaling transmission channel. Evidence of effectiveness of intervention of which the market is unaware is attributed to the former channel, while evidence of effectiveness of rumors of intervention on days when no intervention occurs is attributed to the latter channel.

The significance and sign of both INT^{RUMOR} and $INT^{NoRUMOR}$ suggest that intervention works through the portfolio-balance channel yet, at the same time, it is not possible to rule out that intervention may also work through the signaling channel. The insignificance of $RUMOR^{NoINT}$ shows that no evidence of an information signaling channel is found. Taken together, a cautious characterization of the full sample baseline results is that the importance of the portfolio-balance channel is confirmed while no evidence of an information signaling channel is found.

Turning to the possibility that official statements (“oral intervention”) impact the exchange rate, the highly insignificant PSTAT and NSTAT variables clearly suggest that this is not the case. This is an interesting and, in light of existing studies such as Beine, Janssen and Lecourt (2004) and Fratzscher (2004, 2005) who find “central bank communication” to influence exchange rate markets, at a first glance a surprising result. However, considering the time period under study, the rejection of an influence of either “positive” or “negative” statements is perhaps less surprising. During the period under study, all interventions are unilateral, all interventions are carried out in the same direction (i.e. JPY sales), and the intervention frequency is remarkably high, especially during the latter part of the sample period. Therefore, it seems plausible that during the period under study there is very little uncertainty in the market about the desire of the intervening authority to depreciate the JPY and, accordingly, "positive" statements repeating or confirming this desire do not contain a sufficient degree of news to affect the market. Similarly, the insignificance of the "negative" statements may be due to the fact that they appear at odds with the actual intervention operations and, therefore, are disregarded by the market.[20]

The first column of Table 4 also shows that for the full sample some significant effects of Japanese macro surprises are detected, while none of the US macro surprise variables are significant.

The conditional variance equation estimates confirm the presence of ARCH effects in the exchange rate time series. The ARCH-F and Q^2 tests indicate that the full sample model is free of any ARCH effects left in the standardized residuals. Moreover, the standard F-test cannot reject the model specifications. This also holds true for the full sample model specifications reported in Tables 5 through 7 and for the Sub-Sample 1 and Sub-Sample 2 based models reported in Tables 4 through 7.

The second and third columns of Table 4 report the results pertaining to the truncated samples. As the columns show, the Sub-Sample 1 and Sub-Sample 2 findings regarding the

[20] Beine, Janssen and Lecourt (2004) analyze the impact of statements over the 1991 to 2003 period and Fratzscher (2004, 2005) analyzes the impact of statements over the 1990 to 2003 period. Their samples contain unilateral as well as coordinated interventions, intervention in opposite directions, and substantial variation in intervention frequencies. Both find that official statements impact the JPY/USD exchange rate. Fatum and Hutchison (2002) and, subsequently, Jansen and de Haan (2005) and others find some evidence that official statements influence the EUR/USD exchange rate.

effects of intervention, rumor, and statement variables are identical to the previously described full sample. Overall, the results are robust across the full sample and Sub-Samples 1 and 2.

The fourth column of Table 4, however, reveals drastically different results. For Sub-Sample 3, none of the intervention variables are significant and, furthermore, the standard F-test rejects the model specification altogether. In other words, while it appears that intervention of which the market is aware as well as intervention of which the market is unaware both influence the JPY/USD exchange rate over the 1999 to 2003 period, neither categories of intervention have any impact whatsoever on the JPY/USD during the first quarter of 2004.[21] As before, rumors of intervention on days with no intervention as well as intervention statements are insignificant.[22]

4.1 Delayed Effects

The baseline model estimations address whether the various intervention and statement variables are systematically associated with contemporaneous exchange rate changes, but not whether these variables are associated with delayed exchange rate effects. Exchange rate markets are generally perceived to be highly efficient and characterized by same-day processing of news. Therefore, any impact of intervention should be reflected in the exchange rate almost instantaneously rather than subsequently. However, intervention of which the market is (initially) unaware may be associated with delayed as well as contemporaneous exchange rate effects in case the market subsequently becomes aware of the intervention (e.g. when the newswire reports the intervention the day after it occurs) and the intervention magnitude. If the market only

[21] Although the empirical method of Fatum and Hutchison (2006b), who introduce the matching methodology to the intervention literature, is different from the time-series analysis of this study, they also find a complete absence of effectiveness of official Japanese intervention during the first quarter of 2004. They conjecture that the lack of effectiveness during the first quarter of 2004 is related to the unusually high intervention frequency of this period.
[22] Sub-Sample 3 consists of only 64 observations and, therefore, results pertaining to this particular sample are interpreted with caution.

subsequently learns about the magnitude of an intervention operation, the exchange rate may exhibit contemporaneous as well as delayed effects.

In order to account for the possibility of delayed exchange rate effects, Equation (1) of the baseline model is augmented to include five lags of the explanatory intervention and statement variables:

$$\Delta s_t = a + \sum_{i=0}^{5} b_{1,i} INT_{t-i}{}^{RUMOR} + \sum_{i=0}^{5} b_{2,i} INT_{t-i}{}^{NoRUMOR} + \sum_{i=0}^{5} b_{3,i} RUMOR_{t-i}{}^{NoINT} + \sum_{i=0}^{5} b_{4,i} PSTAT_{t-i} + \sum_{i=0}^{5} b_{5,i} NSTAT_{t-i} + CZ_t + \varepsilon_t \tag{4}$$

Table 5 shows the results of simultaneous estimations of Equations (2) through (4). As the table shows, the baseline results regarding contemporaneous effects are completely robust to the inclusion of lags. While there is no evidence of any delayed exchange rate adjustment effects associated with neither intervention of which the market is aware nor rumors of intervention on days with no intervention (all lags of $\text{INT}^{\text{RUMOR}}$ and $\text{RUMOR}^{\text{NoINT}}$ are insignificant), the coefficient estimate associated with the first lag of intervention of which the market is unaware ($\text{INT}^{\text{NoRUMOR}}$) is significant and of the opposite sign (and of a smaller magnitude than the coefficient estimate associated with the same-day effect) when estimating the model across the full sample and across Sub-Sample 1. This is consistent with the notion that the market subsequently learns about intervention of which it is initially unaware and, accordingly, adjusts with a one-day delay.[23] This finding, however, is not robust across all samples and only marginally significant in the full sample.[24]

4.2 First Day of Intervention and First Day After Intervention Effects

The first intervention operation following an intervention lull may contain relatively more new information than intervention operations carried out on subsequent intervention days (i.e. the first day of intervention following a day, or days, of no intervention is more likely to surprise the market compared to subsequent intervention days when the market is more likely to assign a higher probability to the possibility of another intervention operation being carried out).[25] If this is the case, the first day of intervention following a no intervention day should have a larger than average impact on exchange rates. A natural extension of the baseline analysis, therefore, is to test the hypothesis that an intervention day succeeding a day of no intervention is particularly influential. In order to do so, Equation (1) of the baseline model is replaced by the following expression:

$$(5) \qquad \Delta s_t = a + b_1 INT_t^{RUMOR,NoFDI} + b_2 INT_t^{NoRUMOR,NoFDI} + b_3 FDINT_t + CZ_t + \varepsilon_t$$

where $\text{INT}^{\text{RUMOR,NoFDI}}$ and $\text{INT}^{\text{NoRUMOR,NoFDI}}$, respectively, are identical to $\text{INT}^{\text{RUMOR}}$ and $\text{INT}^{\text{NoRUMOR}}$, respectively, except that the two former variables are set to zero on an intervention

[23] For both the full sample and Sub-Sample 1, Wald-tests of the sum of the contemporaneous and the first lag coefficients confirm that the cumulated exchange rate effect is significant and of the correct sign.
[24] All lags of the statement variables are insignificant. For ease of exposition, neither the lags of the statement variables nor the macro surprises are reported in Table 5.
[25] See Dominguez and Frankel (1993b), Fatum and Hutchison (2006b), and Humpage (1988) for related work and support for the hypothesis that the first day of intervention has a greater effect than subsequent intervention days.

day immediately succeeding a day with no intervention; FDINT is actual intervention (volume) that occurs on a day following a day with no intervention.[26]

Table 6 shows the results of simultaneous estimations of equations (2), (3) and (5). The full sample results (first column) show that the coefficient estimate associated with the first day of intervention is highly significant, of the correct sign, and substantially larger than either of the other two intervention variables. Clearly, this lends strong support to the claim that the first day of intervention following a no intervention day has a larger than average impact on exchange rates. The estimations based on Sub-Samples 2 and 3 repeat this finding (columns two and three).

The fourth column of Table 6 shows the estimation results based on Sub-Sample 3 (the first quarter of 2004). The Sub-Sample 3 results are, once again, drastically different. Intervention is generally ineffective, whether or not the market seems aware of the intervention or not (consistent with the baseline model estimation of Sub-Sample 3), and the coefficient associated with the first day of intervention is marginally significant and of the wrong sign. As before, the standard F-test rejects the model altogether, implying that, in contrast with the 1999 to 2003 period, intervention does not influence the exchange rate during the first quarter of 2004.

As noted earlier, intervention tends to come in clusters. Not surprisingly, therefore, studies of what prompts central banks to intervene generally find past intervention to be an important predictor of future intervention (see Ito and Yabu 2007 for a recent study of Japanese intervention reaction functions). Specifically, the one-day lag of intervention is often the most important and consistently significant explanatory variable when estimating central bank intervention reaction functions (see, for example, Fatum and Hutchison 2006b). However, the

[26] The baseline analysis as well as the augmented delayed effects model found the indicator variables regarding rumors of intervention on no intervention days and statements to be insignificant. Therefore, these variables are excluded from the rest of the analysis. The macro surprise control variables found to be significant in the baseline analysis are included in all estimations but, for ease of exposition, not displayed in subsequent tables.

details of the Japanese intervention reaction function are unannounced, thus it is impossible for the market to know ex-ante with certainty when a cluster of intervention days will end. The exchange rate market is forward-looking, i.e. current expectations of future events are already reflected in today's exchange rate.[27] Therefore, if intervention today induces the market to expect intervention tomorrow, but no intervention tomorrow is carried out, the first day of no intervention will "disappoint" the market and, accordingly, the market will adjust to "price out" what was incorrectly "priced in". In other words, the first day of no intervention following a day of intervention may be systematically associated with an exchange rate movement in the opposite direction of what is intended with the preceding intervention operation (e.g. the first day after an intervention sale of JPY is associated with a JPY appreciation).

To test the hypothesis that the first day without intervention following a day with intervention plays a special role in the context of Japanese intervention and movements in the JPY/USD exchange rate, Equation (1) of the baseline model is replaced by the following expression:

$$(6) \qquad \Delta s_t = a + b_1 INT_t^{RUMOR} + b_2 INT_t^{NoRUMOR} + b_3 FDAINT_t + CZ_t + \varepsilon_t$$

where FDAINT is an indicator variable that takes on the value one on the first day of no intervention immediately succeeding an intervention day.

The results of the simultaneous estimations of equations (2), (3) and (6) are reported in Table 7. For the full sample, the FDAINT coefficient estimate shown in column 1 is positive (thus inconsistent with the hypothesized adverse exchange rate adjustment) and insignificant.

[27] See, for example, Engel and West (2005) who state that "exchange rates and fundamentals are linked in a way that is broadly consistent with asset pricing models of the exchange rate".

Clearly, the estimations based on the full sample reject the hypothesis. However, the Sub-Sample 1 results shown in column 2 support the opposite conclusion. For Sub-Sample 1, the FDAINT coefficient estimate is significant (at the 95% level) and negative, implying that, on average, the first day of no intervention following a day with intervention sales of JPY is associated with a JPY appreciation. Nevertheless, the Sub-Sample 2 results shown in column 3 repeat the full sample findings and, again, reject that the first day after intervention influences the exchange rate. For Sub-Sample 3, none of the explanatory variables are significant and the F-test rejects the model. In sum, while there is some sample specific evidence that the first day after intervention is associated with an adverse exchange rate adjustment, overall the results are mixed and invite further research rather than warrant any strong conclusions.

4.3 Additional Robustness Checks

In order to test the robustness of the results, the analysis is also carried out using different model specifications, different first day of intervention definitions, and different first day after intervention definitions.

First, all estimations are also carried out using OLS estimation techniques with robust heteroskedasticity- and serial-correlation consistent (HAC) standard errors. The results pertaining to the baseline model described in Equation (1) are reported in Table 8. As the table shows, all the previously described results regarding the intervention and the statement variables are completely unchanged across all four samples. In addition, the augmented delayed effects model as well as the models addressing first day of intervention and first day after intervention effects are re-estimated using OLS and HAC standard errors, yielding identical results to those reported in Tables 5 through 6.[28]

Second, the analysis tests for the possibility that the conditional variance enters into the mean equations (Equations 1, 4, 5, and 6) but find no support for the GARCH-in-mean (GARCH-M) specification.

Third, the definition of a first day of intervention is altered to take into account the stylized fact that intervention often comes in clusters. This is done by replacing the FDINT variable in Equation (5) with the variable FDINTCL, where FDINTCL is defined as actual intervention (volume) that occurs on a day following two or more consecutive days with no intervention. Simultaneous estimations of Equations (2), (3), and FDINTCL-(5) completely repeat the results reported in Table 6. As an additional robustness test of first day of intervention effects, FDINTCL is replaced by FDINTE, where FDINTE is defined as actual intervention (volume) that occurs on the first day of an intervention event.[29] The results using FDINTE in place of FDINT in Equation (5) are unchanged.

Fourth, similar to the robustness check regarding the first day of intervention, the definition of a first day after intervention is altered. Replacing the FDAINT variable in Equation (6) with the variable FDAINTCL, where FDAINTCL is an indicator variable that takes on the value one on the first day of no intervention immediately succeeding two or more consecutive days of intervention. Simultaneous estimations of Equations (2), (3), and FDAINTCL-(6) completely repeat the results reported in Table 7 (i.e. the FDAINTCL coefficient estimate is only negative and significant for Sub-Sample 2).

[28] These as well as the subsequently described robustness results are not reported for brevity but available from the author upon request.
[29] The event definition follows Fatum and Hutchison (2003).

Given the oft-reported sensitivity of GARCH models to even slight specification changes, the discussed robustness checks suggest that the findings of the paper are highly robust.

5. Conclusion

This paper analyzes whether official Japanese intervention in the JPY/USD exchange rate over the January 1, 1999 to March 31, 2004 time period is effective. By distinguishing between intervention of which the market is aware and intervention of which the market is unaware, the paper also attempts to shed some light on through which of the two channels, the signaling or the portfolio balance channel, Japanese intervention, if effective, works. Intervention on days when a rumor of intervention is reported on the newswire is used as a proxy for intervention of which the market is aware, and intervention on days without a rumor of intervention on the newswire is used as a proxy for intervention of which the market is unaware. The analysis also assesses the impact of official statements ("oral intervention" or "central bank communication") and whether the first day of intervention after a day, or days, of no intervention, and whether the first day of no intervention after a day, or days, of intervention, constitute days of particular interest in the context of intervention and exchange rate movements.

Using primarily a standard GARCH time series methodology, the results of the analysis show that for the January 1, 1999 to December 31, 2004 time period, actual intervention, whether or not the market is aware of the intervention, exerts a significant same-day influence on the JPY/USD exchange rate. The analysis does not detect a systematic and significant link between days when there is a rumor of intervention, but no intervention occurs, and the JPY/USD exchange rate. For the first quarter of 2004, the analysis shows that neither actual intervention nor rumors of intervention on no intervention days have any impact on the JPY/USD exchange rate.

The evidence of effectiveness of intervention of which the market is aware can be ascribed to the workings of the portfolio-balance channel as well as the information signaling channel. The evidence of effectiveness of intervention of which the market is unaware points to the former channel being at work. The analysis fails to find any evidence of effectiveness of rumors of intervention on days when no intervention occurs, thus no evidence directly supports that the latter channel is at work. The paper, therefore, cautiously concludes that the importance of the portfolio-balance channel is supported by the data while no direct evidence of the information signaling channel is found.

Official statements in support of more intervention as well as official statements casting doubt on the likelihood of more intervention are both found to be insignificant across all model specifications and samples. Clearly, this is in contrast with studies that find a significant exchange rate impact of official statements. However, the influence of official statements is likely sample specific, and since the sample under study contains nothing but frequent and unilateral JPY intervention sales it is unlikely that there is much uncertainty in the market regarding the desire of the intervening authority to depreciate the JPY. Accordingly, official statements made during the period under study do not contain enough new information to significantly affect the exchange rate market.

With respect to the first day of intervention, the analysis finds strong and robust evidence that for the January 1999 to December 2004 time period the first day of intervention following a no intervention day has a larger than average impact on exchange rates. Some sample specific evidence that the first day after intervention is associated with an adverse exchange rate adjustment is found.

Reaction function studies of Japanese intervention are generally at least modestly successful in modeling current intervention using explanatory variables such as lagged intervention and lagged exchange rate movements. It follows that intervention on any given day, whether or not the market is aware of the intervention operation, contains an expected as well as an unexpected component. A limitation of this and most other intervention studies is that no attempt is made to distinguish between expected and unexpected intervention.[30] A natural extension of the present study is to disentangle the unexpected component of official Japanese intervention and, in turn, reassess the effectiveness of unexpected Japanese intervention and the channels through which it works.

[30] Exceptions include Fatum and Pedersen (2007), Galati, Higgins, Humpage and Melick (2007), Galati, Melick and Micu (2005), Humpage (1999) and Naranjo and Nimalendran (2000).

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Table 1 **Official Japanese Intervention January 1, 1999 – March 31, 2004**

Full sample: January 1, 1999 – March 31, 2004

Purchases of USD (million USD)	Number of Days	Cumulated Amount
> 1000	113	443,796
> 500	21	16,613
> 250	5	1,694
> 0	20	2,148
Total	159	464,251

January 1, 1999 – December 31, 2002

Purchases of USD (million USD)	Number of Days	Cumulated Amount
> 1000	28	147,629
> 500	2	1,799
> 250	0	0
> 0	0	0
Total	30	149,428

January 1, 2003 – December 31, 2003

Purchases of USD (million USD)	Number of Days	Cumulated Amount
> 1000	52	165,101
> 500	11	8,864
> 250	4	1,465
> 0	15	1,671
Total	82	177,101

January 1, 2004 – March 31, 2004

Purchases of USD (million USD)	Number of Days	Cumulated Amount
> 1000	33	131,066
> 500	8	5,950
> 250	1	229
> 0	5	477
Total	47	137,722

NOTES:
(a) This table is Table 1 in Fatum and Hutchison (2006b).
(b) Daily Bank of Japan intervention data obtained from the Japanese Ministry of Finance data bank.
(c) Daily intervention operations of USD 1000 million or greater: >1000; daily intervention operations of USD 500 million or greater, but less than USD 1000 million: >500; daily intervention operations of USD 250 million or greater, but less than USD 500 million: >250; daily intervention operations of less than USD 250 million: >0.

Table 2	Summary Statistics: Days with Intervention, Rumors, and Statements			
	Jan 1999 to Mar 2004	Jan 1999 to Dec 2002	Jan to Dec 2003	Jan to Mar 2004
Intervention (INT)	159	30	82	47
Rumors of intervention (RUMOR)	269	136	99	34
Intervention on days with a rumor of intervention (INT^{RUMOR})	92	11	55	26
Intervention on days with no rumor of intervention ($INT^{NoRUMOR}$)	67	19	27	21
Rumor of intervention on days with no intervention ($RUMOR^{NoINT}$)	177	125	44	8
Positive statements (POSSTAT)	108	70	30	8
Negative statements (NEGSTAT)	17	17	0	0

NOTES:
(a) INT is official intervention; RUMOR is a rumor of intervention; INT^{RUMOR} is intervention on days with a rumor of intervention; $INT^{NoRUMOR}$ is intervention on days with no rumor of intervention; $RUMOR^{NoINT}$ is a rumor of intervention when no intervention occurs; POSSTAT is an official statement in support of intervention and/or a weaker JPY; NEGSTAT is an official statement suggesting that further intervention in the JPY/USD rate is not recommended or unlikely.

TABLE 3 **Summary Statistics: The JPY/USD Exchange Rate and the Macro News Surprises**

	Mean	**Std. Dev.**	**Maximum**	**Minimum**	**Non-Zero Observations**
JPY/USD	116.3350	7.81857	134.73	101.56	1364
JP CPI	0.00394	0.001456	0.003	-0.002	33
JP GDP	0.001148	0.005362	0.018	-0.009	27
JP Industrial Production	-0.002318	0.007961	0.015	-0.017	44
JP Trade Balance	-6.6374	171.3451	367.10	-363.40	46
JP Unemployment Rate	-0.0004	0.00161	0.002	-0.004	30
US CPI	-0.00004	0.001536	0.003	-0.003	26
US GDP	0.00175	0.006151	0.0120	-0.0110	12
US Industrial Production	-0.000056	0.002936	0.0070	-0.0050	54
US Trade Balance	-0.4917	2.3448	3.1000	-5.5000	24
US Non-Farm Payroll Employment	-38.9032	101.6827	178.0000	-318.0000	62
US FOMC	-0.00083	0.002887	0.0025	-0.0025	3

NOTES:

(a) All data series run from January 1, 1999 to March 31, 2004. All data are five days a week (Monday to Friday).
(b) Data Sources: The Exchange Rate Series is from Global Financial Data (New York close quotes). The Macro News Surprises are from Bloomberg (difference between actual announcement and median survey value).

TABLE 4 **JPY/USD Exchange Rate Responses to Intervention and Macro Surprises**				
GARCH Models Daily Data: January 1999 to March 2004 (Full Sample)				
	Full Sample	Sub-Sample 1	Sub-Sample 2	Sub-Sample 3
Constant	-0.000272 (0.000194)	-0.000090 (0.000232)	-0.0000244 (0.000198)	-0.001190* (0.000711)
INT^{RUMOR}	0.00000047*** (0.00000012)	0.0000011*** (0.0000002)	0.0000007*** (0.0000002)	-0.0000001 (0.0000003)
$INT^{NoRUMOR}$	0.00000088*** (0.00000023)	0.0000014*** (0.0000004)	0.0000012*** (0.0000003)	0.0000006 (0.0000005)
$RUMOR^{NoINT}$	-0.000281 (0.000508)	-0.000346 (0.000628)	-0.000319 (0.000511)	0.001218 (0.002073)
POSSTAT	0.000117 (0.000679)	0.000219 (0.000865)	0.000015 (0.000691)	0.000641 (0.002475)
NEGSTAT	-0.000110 (0.001347)	-0.000660 (0.001386)	-0.000297 (0.001323)	
JPCPI	-0.051831 (0.596622)	0.315903 (0.747825)	0.009254 (0.593413)	-1.144150 (2721.741)
JPGDP	-0.176648 (0.196971)	-0.407708* (0.229112)	-0.336270 (0.223679)	2.113589 (20.47788)
JPIP	0.083073 (0.124952)	0.104285 (0.225094)	0.102367 (0.125584)	-0.348449 (424.3838)
JPTB	-0.0000121** (0.0000057)	-0.000008 (0.000007)	-0.000012** (0.000006)	-0.000015 (0.000035)
JPUNEMP	-1.069043* (0.546671)	-1.406101** (0.562175)	-0.933932* (0.552203)	0.894603 (1714.594)
USCPI	0.521807 (0.937674)	0.467984 (0.937330)	0.510502 (0.930277)	
USGDP	0.467185 (0.779831)	0.491639 (0.680577)	0.487163 (0.741791)	
USIP	0.027055 (0.278429)	0.252035 (0.294350)	0.128779 (0.285289)	-1.444549 (3.555143)
USTB	-0.000486 (0.278429)	-0.000540 (0.000670)	-0.000487 (0.000641)	0.000734 (0.005980)
USNFPR	0.0000039 (0.0000115)	-0.000003 (0.000015)	0.000004 (0.000012)	-0.000068* (0.000036)
USFOMC	0.236683 (2.821726)	0.179670 (3.077802)	0.260994 (2.826522)	
Variance Equation				
Constant	0.0000006*** (0.0000002)	0.0000011*** (0.0000004)	0.0000006*** (0.0000002)	0.000008** (0.000004)
ARCH(1)	0.0170*** (0.0056)	0.014068** (0.006740)	0.017827*** (0.005755)	-0.077490*** (0.012243)
GARCH(1)	0.9658*** (0.0087)	0.958524*** (0.013249)	0.964923*** (0.008792)	0.729041*** (0.165253)
Observations	1364	1040	1300	64
R-squared	0.032	0.046	0.041	0.164
S.E. of regression	0.006	0.007	0.006	0.006
Durbin-Watson	2.037	2.006	2.030	1.758
ARCH-F (Q^2)	0.53[0.47]	0.89[0.35]	0.64[0.42]	0.03[0.87]
Q^2 (2)	0.58[0.75]	0.92[0.63]	0.64[0.73]	0.00[0.99]
F-Stat	2.37***[0.00]	2.58***[0.00]	2.87***[0.00]	0.63[0.84]

NOTES:

(a) * Denotes significance at 90%, ** Denotes significance at 95%, *** Denotes significance at 99%.
(b) Standard Errors (S.E.) in ( ) below the point estimates; p values in [ ]; lags in ( ) in Variable Names.
(c) GARCH estimations are defined in Equations (1) (2) and (3) in the text.
(d) The dependent variable is the first difference of the log of the daily DEM/USD spot exchange rate (mean= -6.02E-05) for the full sample).
(e) The independent variable INT^{RUMOR} is the intervention volume on days with a rumor of intervention; the independent variable $INT^{NoRUMOR}$ is the intervention volume on days with no rumor of intervention; the independent variable $RUMOR^{NoINT}$ is an indicator variable that takes on the value 1 on days when there is a rumor of intervention but no intervention occurs, and 0 otherwise; POSSTAT is an indicator variable that takes on the value 1 on days when there is an official statement in support of intervention

and/or a weaker JPY, and 0 otherwise; NEGSTAT is an indicator variable that takes on the value 1 on days when there is an official statement suggesting that further intervention in the JPY/USD rate is unlikely or not recommended, and 0 otherwise.
(f) Control Variables are measuring macro news surprises (difference between actual announcement and survey expectations extracted from Bloomberg) regarding Japanese CPI (JPCPI), GDP (JPGDP), Industrial Production (JPIP), Trade Balance (JPTB), and Unemployment (JPUNEMP), and US CPI (USCPI), GDP (USGDP), Industrial Production (USIP), Trade Balance (USTB), Non-Farm Payroll Employment (USNFPR), and Interest Rate Changes (USFOMC).
(g) Full Sample: January 1, 1999 to March 31, 2004; Sub-Sample 1: January 1, 1999 to December 31, 2002; Sub-Sample 2: January 1, 1999 to December 31, 2003; Sub-Sample 3: January 1, 2004 to March 31, 2004.

TABLE 5 **JPY/USD Exchange Rate Responses to Lags of Intervention**				
Daily Data: January 1999 to March 2004 (Full Sample)				
	Full Sample	Sub-Sample 1	Sub-Sample 2	Sub-Sample 3
Constant	-0.000014 (0.000217)	0.000059 (0.000247)	-0.000054 (0.000218)	0.001343 (0.001219)
INT^{RUMOR}	0.0000006*** (0.0000001)	0.0000011*** (0.0000002)	0.0000009*** (0.0000002)	-0.0000002 (0.0000004)
$INT^{NoRUMOR}$	0.0000010*** (0.0000002)	0.0000014*** (0.0000005)	0.0000012*** (0.0000004)	0.0000000 (0.0000006)
$RUMOR^{NoINT}$	-0.000126 (0.000521)	-0.000337 (0.000677)	-0.000284 (0.000530)	0.000706 (0.001558)
$INT^{RUMOR}(-1)$	-0.0000003 (0.0000002)	-0.0000000 (0.0000004)	-0.0000003 (0.0000002)	-0.0000004 (0.0000004)
$INT^{NoRUMOR}(-1)$	-0.0000004* (0.0000003)	-0.0000006** (0.0000003)	-0.0000004 (0.0000003)	-0.0000005 (0.0000006)
$RUMOR^{NoINT}(-1)$	-0.000770 (0.000577)	-0.000351 (0.000772)	-0.000702 (0.000595)	-0.004332 (0.003116)
$INT^{RUMOR}(-2)$	-0.0000000 (0.0000002)	0.0000002 (0.0000004)	-0.0000001 (0.0000002)	-0.0000001 (0.0000004)
$INT^{NoRUMOR}(-2)$	-0.0000000 (0.0000003)	-0.0000000 (0.0000004)	0.0000000 (0.0000004)	-0.0000000 (0.0000006)
$RUMOR^{NoINT}(-2)$	-0.000426 (0.000523)	-0.000045 (0.000687)	-0.000194 (0.000537)	-0.004448* (0.002261)
$INT^{RUMOR}(-3)$	-0.0000000 (0.0000002)	-0.0000003 (0.0000005)	-0.0000000 (0.0000003)	-0.0000002 (0.0000002)
$INT^{NoRUMOR}(-3)$	-0.0000000 (0.0000004)	-0.0000000 (0.0000005)	0.0000000 (0.0000005)	0.0000009 (0.0000008)
$RUMOR^{NoINT}(-3)$	0.000010 (0.000538)	-0.000896 (0.000743)	-0.000064 (0.000559)	0.000783 (0.002684)
$INT^{RUMOR}(-4)$	-0.0000000 (0.0000002)	0.0000004 (0.0000003)	-0.0000000 (0.0000002)	-0.0000002 (0.0000002)
$INT^{NoRUMOR}(-4)$	0.0000001 (0.0000004)	0.0000000 (0.0000004)	0.0000001 (0.0000005)	0.0000006 (0.0000004)
$RUMOR^{NoINT}(-4)$	-0.000519 (0.000522)	-0.000267 (0.000649)	-0.000486 (0.000533)	-0.004479 (0.003268)
$INT^{RUMOR}(-5)$	-0.0000000 (0.0000002)	0.0000003 (0.0000004)	-0.0000001 (0.0000002)	0.0000001 (0.0000002)
$INT^{NoRUMOR}(-5$	0.0000004 (0.0000003)	0.0000005 (0.0000004)	0.0000005 (0.0000004)	0.0000005 (0.0000010)
$RUMOR^{NoINT}(-5)$	0.000237 (0.000514)	-0.000087 (0.000650)	0.000206 (0.000525)	-0.001017 (0.002875)
Variance Equation				
Constant	0.000001*** (0.000000)	0.000002*** (0.000000)	0.000001*** (0.000000)	
ARCH(1)	0.022680*** (0.007794)	0.014723* (0.008657)	0.024742*** (0.008293)	
GARCH(1)	0.941623*** (0.013079)	0.937025*** (0.016021)	0.941887*** (0.013251)	
Observations	1359	1035	1295	59
R-squared	0.033	0.045	0.039	0.236
S.E. of regression	0.006	0.007	0.006	0.006
Durbin-Watson	2.02	1.994	2.009	2.011
ARCH-F (Q^2)	0.70[0.40]	0.94[0.33]	0.91[0.34]	0.72[0.40]
Q^2 (2)	0.72[0.70]	1.05[0.59]	0.98[0.61]	1.21[0.54]
F-Stat	2.21***[0.00]	2.30***[0.00]	2.45***[0.00]	0.77[0.72]

NOTES:

(a) The dependent variable is the first difference of the log of the JPY/USD spot exchange rate.
(b) Sub-Sample 3 model estimated using HAC S.E. and Covariances. All other models estimated using GARCH.
(c) For all other NOTES refer to Table 4.

TABLE 6 **JPY/USD Exchange Rate Responses to First Day of Intervention**				
Daily Data: January 1999 to March 2004 (Full Sample)				
	Full Sample	Sub-Sample 1	Sub-Sample 2	Sub-Sample 3
Constant	-0.000297* (0.000175)	-0.000011 (0.000210)	-0.000286 (0.000179)	-0.000836 (0.001037)
INT^{RUMOR}	0.0000003** (0.0000002)	0.0000012 (0.0000008)	0.0000006** (0.0000003)	0.0000002 (0.0000002)
$INT^{NoRUMOR}$	0.0000006* (0.0000003)	0.0000015** (0.0000007)	0.0000010** (0.0000004)	0.0000005 (0.0000005)
FDINT	0.0000014*** (0.0000003)	0.000003*** (0.000000)	0.0000018*** (0.0000004)	-0.0000015* (0.0000008)
Variance Equation				
Constant	0.0000007*** (0.0000002)	0.0000011*** (0.0000004)	0.0000006*** (0.0000002)	
ARCH(1)	0.0180290*** (0.005583)	0.013849** (0.006359)	0.017981*** (0.005608)	
GARCH(1)	0.962955*** (0.009037)	0.959851*** (0.012230)	0.964480*** (0.008515)	
Observations	1364	1040	1300	64
R-squared	0.029	0.036	0.033	0.053
S.E. of regression	0.006	0.007	0.006	0.006
Durbin-Watson	2.028	2.010	2.028	1.831
ARCH-F (Q^2)	0.54[0.46]	0.77[0.38]	0.53[0.46]	0.06[0.81]
Q^2 (2)	0.55[0.76]	0.77[0.68]	0.53[0.77]	3.24[0.20]
F-Stat	6.64***[0.00]	6.46***0.00]	7.30***[0.00]	1.12[0.35]

NOTES:

(a) The dependent variable is the first difference of the log of the JPY/USD spot exchange rate.

(b) The independent variable FDINT is the intervention volume on days succeeding a day with no intervention.

(c) For the purpose of the estimations displayed in Table 6, the independent variables INT^{RUMOR} and $INT^{NoRUMOR}$ are set to 0 on days when FDINT is positive.

(b) Sub-Sample 3 model estimated using HAC S.E. and Covariances. All other models estimated using GARCH.

(c) For all other NOTES refer to Table 4.

TABLE 7 **JPY/USD Exchange Rate Responses to First Day After Intervention**				
Daily Data: January 1999 to March 2004 (Full Sample)				
	Full Sample	Sub-Sample 1	Sub-Sample 2	Sub-Sample 3
Constant	-0.000337* (0.000179)	-0.000049 (0.000212)	-0.000313 (0.000182)	-0.001356 (0.001040)
INT^{RUMOR}	0.0000005*** (0.0000001)	0.0000011*** (0.0000002)	0.0000007*** (0.0000002)	0.0000003 (0.0000002)
$INT^{NoRUMOR}$	0.0000009*** (0.0000002)	0.0000014*** (0.0000004)	0.0000012*** (0.0000003)	0.0000004 (0.0000005)
FDAINT	0.000702 (0.000873)	-0.002897** (0.001459)	0.000478 (0.000911)	-0.003192 (0.001927)
Variance Equation				
Constant	0.0000006*** (0.0000002)	0.0000011*** (0.0000004)	0.0000006*** (0.0000002)	
ARCH(1)	0.017195*** (0.005425)	0.012901** (0.006344)	0.018021*** (0.005645)	
GARCH(1)	0.966314*** (0.008162)	0.960274*** (0.012228)	0.965454*** (0.008243)	
Observations	1364	1040	1300	64
R-squared	0.023	0.040	0.031	0.04
S.E. of regression	0.006	0.007	0.006	0.006
Durbin-Watson	2.041	2.008	2.032	1.705
ARCH-F (Q^2)	0.27[0.60]	0.75[0.39]	0.49[0.48]	0.01[0.92]
Q^2 (2)	0.33[0.85]	0.87[0.65]	0.50[0.78]	4.02[0.13]
F-Stat	5.42***[0.00]	7.25***[0.00]	6.97***[0.00]	0.80[0.50]

NOTES:

(a) The dependent variable is the first difference of the log of the JPY/USD spot exchange rate.

(b) The independent variable FDAINT is an indicator variable that takes on the value 1 on days without intervention immediately succeeding a day with intervention.

(b) Sub-Sample 3 model estimated using HAC S.E. and Covariances. All other models estimated using GARCH.

(c) For all other NOTES refer to Table 4.

TABLE 8 **JPY/USD Exchange Rate Responses to Intervention and Macro Surprises: HAC Models**				
Daily Data: January 1999 to March 2004 (Full Sample)				
	Full Sample	Sub-Sample 1	Sub-Sample 2	Sub-Sample 3
Constant	-0.000314 (0.000207)	-0.000170 (0.000238)	-0.000284 (0.000210)	-0.001262 (0.001494)
INT^{RUMOR}	0.00000054*** (0.00000018)	0.0000011*** (0.0000004)	0.0000008*** (0.0000002)	-0.0000001 (0.0000003)
$INT^{NoRUMOR}$	0.00000115*** (0.00000034)	0.0000016*** (0.0000004)	0.0000014*** (0.0000004	0.0000005 (0.0000006)
$RUMOR^{NoINT}$	-0.000154 (0.000512)	-0.000174 (0.000658)	-0.000196 (0.000537)	0.001291 (0.001589)
POSSTAT	0.000312 (0.000576)	0.000478 (0.000786)	0.000233 (0.000616)	0.001449 (0.001546)
NEGSTAT	-0.000232 (0.001649)	-0.000649 (0.001741)	-0.000371 (0.001676)	
JPCPI	-0.105734 (0.865868)	0.257784 (1.217663)	0.006251 (0.964927)	-1.146263 (0.912060)
JPGDP	-0.237534 (0.252885)	-0.406993 (0.303838)	-0.349636 (0.253554)	2.108249*** (0.170912)
JPIP	0.086012 (0.098433)	0.093010 (0.165092)	0.108708 (0.100043)	-0.352684 (0.158270)
JPTB	-0.0000126*** (0.0000046)	-0.000009 (0.000006)	-0.000012** (0.000005)	-0.000011 (0.000007)
JPUNEMP	-1.156192 (0.986515)	-1.407104 (1.316768)	-1.083784 (1.024058)	0.893199 (1.167478)
USCPI	0.298613 (0.816436)	0.315862 (0.820060)	0.291518 (0.814383)	
USGDP	0.363932** (0.177146)	0.356963** (0.180514)	0.361874 (0.177523)	
USIP	0.150441 (0.344190)	0.335503 (0.428974)	0.255815 (0.355092)	-1.444410*** (0.422553)
USTB	-0.000438 (0.000413)	-0.000467 (0.000417)	-0.000439 (0.000413)	0.000098 (0.000858)
USNFPR	0.0000031 (0.0000047)	0.0000002 (0.0000054)	0.000003 (0.000048)	-0.000052 (0.000037)
USFOMC	0.132074 (0.773172)	0.151236 (0.745088)	0.136115 (0.767182)	
Observations	1364	1040	1300	64
R-squared	0.034	0.047	0.030	0.172
S.E. of regression	0.006	0.007	0.006	0.006
Durbin-Watson	2.017	1.994	2.015	1.715
ARCH-F (Q^2)	2.67[0.10]	1.04[0.31]	2.32[0.13]	0.04[0.84]
Q^2 (2)	3.96[0.14]	1.38[0.50]	3.34[0.19]	0.01[0.99]
F-Stat	2.95*** [0.00]	3.14*** [0.00]	3.51*** [0.00]	0.88 [0.57]

NOTES:

(a) The dependent variable is the first difference of the log of the JPY/USD spot exchange rate.
(b) All models estimated using HAC S.E. and Covariances.
(c) For all other NOTES refer to Table 4.