SIZE MATTERS: CENTRAL BANK INTERVENTIONS ON THE YEN/DOLLAR EXCHANGE RATE

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ABSTRACT:
This paper explores the effects of the recent interventions of the Bank of Japan on the level and volatility of the yen/dollar exchange rate. A special attention is devoted to the prominent features affecting the signal conveyed by these interventions. The results show a clear duality: small unilateral interventions are counterproductive while large and isolated ones influence the FX market in the desired directions. It is also found that the perverse effect is avoided through coordinated operations.

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KEYWORDS: Central bank intervention, Signaling channel, Foreign exchange market, Exchange rates.

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INTRODUCTION

Direct purchases and sales of foreign currency have for long been a possible stabilization instrument in the hands of central banks. Sterilization of these interventions ensures that they can be used as an independent tool from usual monetary actions. Current perceived misalignments of the major currencies and the high levels of disagreement between monetary authorities have induced a renewal in the interest of the major central banks for such instruments. While the Federal reserve has been increasingly reluctant to rely on foreign exchange interventions, the Bank of Japan and to a lesser extent the European Central Bank still consider such operations as part of their policy tools. The recent talks between these two central banks about future concerted rounds of interventions illustrate this high degree of interest.

While the ECB intervened several times a couple years ago, the BoJ has nevertheless been the most active in the foreign exchange markets. The BoJ still intervened massively after 1998, at time the Fed decided to withdraw from the exchange rate markets. Given the amounts involved in these central bank operations, an assessment of the efficiency of these interventions is of overwhelming importance.

On the whole, the recent literature on CBI on the foreign exchange (FX) market documents poor effectiveness on the level of exchange rates together with a destabilizing impact in terms of conditional volatility. However, the results are far from uniform across the literature. They depend however on the period and the currency under study, but also on the econometric specification. Quite exhaustive surveys on this matter have been provided by Baillie et al. (2000) and more recently by Humpage (2003). Concerning the yen/dollar exchange rate, a number of authors like Dominguez (1998), Baillie and Osterberg (1997) or Beine et al. (2002) (among others) document a volatility increase at a daily frequency as a result of CBI. Chang and Taylor (1998) confirm this result using high frequency data. They in general found weak impacts on the level of exchange rate returns. The recent work of Nagayasu (2004) that introduces a clear distinction between concerted and unilateral interventions reaches quite the same conclusions.

In this paper, we revisit the issue of the effectiveness of the recent central bank interventions of the Bank of Japan. In contrast to the previous literature, we control for the sizes of these interventions. The amounts involved in the BoJ interventions show a dramatic increase over time. This contrasts with the use of considering different sub-samples based on different perceived intervention regimes (Ito, 2003, Ito and Yabu, 2004). As an alternative to the use of sub-samples, we allow for parameter heterogeneity with respect to the size of the interventions. Referring to the signaling channel which has previously received the most important empirical support, we argue that the nature of information conveyed by these central bank interventions can differ depending on the size of the underlying operations. We find that failure to control for the size might lead to misleading conclusions in terms of effectiveness of the intervention policy (Nagayasu, 2004). Indeed, we find that whereas on average unilateral BoJ interventions are found to be counterproductive, large operations signaling the commitment of the central bank to stabilize the market succeed in moving the exchange rate in the desired direction. Furthermore, the results are found to be robust to the introduction of several features of the BoJ intervention policy such as the clustering behavior of the foreign exchange sales or purchases.
The paper is organized as follows. Section 1 reviews the theoretical literature used to capture the impact of interventions as well as the findings of the empirical studies applied to the BoJ interventions. Section 2 depicts the statistical features of the BoJ interventions. Section 3 provides the details of the econometric framework and reports the results of the empirical analysis.

1. THE LITERATURE

1.1. THE SIGNALING CHANNEL

As emphasized by Sarno and Taylor (2001), sterilized interventions\(^1\) can have an impact through various channels. The most well-known theoretical explanations refer to the portfolio channel and the signaling channel (Mussa, 1981). A clear consensus supports however that, when interventions do work, it is mainly through a "signaling channel". The signaling channel states that through these interventions, the central bank conveys some private information to market participants and hence alter their expectations about the future dynamics of the exchange rate. This point is clearly endorsed by the Fed which states that "Because the Fed's purchase or sales of dollars are small compared with the total volume of dollar trading, they do not shift the balance of supply and demand immediately. Instead, intervention affects the present and future behavior of investors. In this regard, U.S. foreign exchange interventions used as a device to signal a desired exchange rate movement."

The determinants of the signaling channel have been further investigated. Dominguez (1998) has pointed out that intervention signals may not always be credible and unambiguous. In particular, ambiguous signals are less effective than those delivered by strong banks. In this context, coordination among central banks may exert a positive influence on the market, regardless the amount involved in the intervention (Catte et al., 1994). Other features associated to FX operations may also alter the information content of CBI. For instance, sustainability of the intervention plays a role in the signaling effect. The size of the intervention may be of some importance, not per se, but rather by indicating to the market the strength of the central bank’s commitment to a specific value of the exchange rate. Using large amounts in the operations also raises the probability that these interventions will be detected (Neely, 2006; Beine et al., 2007), which in turn raises the visibility of the central bank.

1.2. PREVIOUS LITERATURE ON JAPANESE INTERVENTIONS

The release of official interventions by the BoJ took place in 2000. As a result, earlier papers on the relationship between CBI and the yen/dollar rate met the problem of lack of observable interventions. They had to deal with sources of information which are inevitably less reliable than direct CBI data. For instance, Baillie and Osterberg (1997) did not include BoJ interventions in their study while Cai et al. (2001) captured the size of these interventions.\(^2\)

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\(^1\) Over the investigated period, the BoJ was reported to have sterilized most of its interventions.
interventions through estimations\(^2\) published in the Financial Times. Like Bonser-Neal and Tanner (1996), Beine et al. (2002) took advantage of official interventions data provided by the Federal Reserve (Fed) but had to infer the BoJ interventions from the Wall Street Journal and/or the Financial Times reports.

A bulk of empirical studies using the official data has recently emerged (see Humpage, 2003 for a review). Using event study methodologies, Fatum and Hutchinson (2003) and Morel and Teiletche (2003) study the impact of BoJ interventions on the dynamics of the YEN/USD exchange rate. Fatum and Hutchison (2003) find support for effectiveness of Japanese interventions and identify coordination and size in the underlying amounts used in the operations as factors of success. This contrasts with Morel and Teiletche (2003) who find no impact of those operations on the forward rates and negative impact on expected volatility. Relying on a more classical parametric approach, Ito (2003) finds that unilateral operations of the bank of Japan delivered the intended effects, at least after 1995. This contrasts with the evidence provided by Nagayasu (2004) who finds that unilateral interventions were ineffective and furthermore resulted in higher uncertainty in the markets.

Our approach aims at reconciling the former results by accounting for a specific signaling content of large-scale interventions carried out by the BoJ. Ito (2003) introduces interventions expressed in amounts, assuming implicitly that a linear effect of foreign sales and purchases by the central bank is at stake. This tends to contrast with the usual approach adopted in the empirical literature (Humpage, 2003) and with the view that the size of these interventions is low with respect of the market turnover, preventing the emergence of any portfolio effect. Following the traditional modeling approach, Nagayasu (2004) captures the presence of the BoJ in the market through dummy variables but fails to distinct for asymmetric effects between large-scale and small-scale operations. Using a similar sample period (1991-2001), our analysis documents such an asymmetric effect and supports the use of large-scale operations as a stabilization instrument in the hand of central banks.

In contrast to Ito (2003) and Ito and Yabu (2004) who rely on sub-samples and consider different intervention regimes using exogenous break dates, we allow for parameter heterogeneity depending on the size of these interventions. The advantage of this approach is twofold. First, we make use the full sample. This is important given the relative low number of intervention days. Such an approach tends thus to raise the quality of the statistical inference carried out in the empirical analysis. Second, we distinguish between large and low scale operations using non arbitrary statistical criteria regarding the intervention amounts. This ensures that our results are not driven by some data mining procedure and rule out the well known problems created by the use of know break dates.

\(^2\) The estimated values of the interventions in 1998 reported in this paper are: $5 billions on April, 10 and $2 billions on June, 17. Our data base indicates that the dates are correct but these two coordinated interventions have the following respective sizes: $20.32 billions and $1.68 billions. It seems that the undervaluation of the April, 10 intervention comes from the fact that it was thought to be a unilateral Japanese intervention.
2. Features of Interventions in the Yen-USD Market

We work with first quality data including the precise dates and amount of official CBI on the yen/dollar exchange rate, covering the period April 1991-October 2000. The data have been provided directly by the BoJ and the Fed. Figure 1 displays the Japanese interventions over time. While there are clearly much more purchases of dollars carried by the BoJ, a massive purchase of yens took place on the 10th of April, 1998, amounting to 2,620 billions of yens, i.e., more than 20 billions of USD. This is by far an historical record of direct central bank intervention in the foreign exchange market.

The absolute size of BoJ interventions is growing with time much faster than inflation, which was relatively low during the period under consideration. By the end of 1994, the BoJ often relied on massive interventions. Nevertheless, it kept carrying out small interventions like, for instance, in November 1997. Therefore, the data seem compatible with a progressive change in strategy rather than with a clear cut-off between two subperiods. Like other types of FX operations, Japanese CBI exhibit clear patterns of grouped interventions. Indeed, periods of frequent interventions (mid-1992, mid-1993, end-1994, 1995, second half of 1999 and first quarter of 2000) alternate with inactive periods (first quarter of 1993, from second quarter of 1996 until the November 1997, from mid-2000 until the end of the sample period). Besides, isolated interventions are also observed.

Successive CBI may be seen as a signaling strategy. Indeed, a central bank might decide to split its planned intervention across time in order to influence the market during a longer period. Also, successive interventions allow the bank to react on a daily basis to market movements. However, interventions are generally costly. Therefore in practice, while a clustering strategy is easier to conduct, small amounts may lead to less credibility. There might be therefore a potential trade-off between size and clustering of CBI. In a signalling perspective, the distinction between initial and subsequent operations stems from the fact that initial trades might have a higher information content than subsequent one. This distinction will be therefore explicitly accounted for in the econometric analysis.

The choice of the sample period is induced by the willingness of using comparable periods as the ones used by Ito (2003) and Nagayasu (2004).
Figure 2 presents the evolution of the Fed's interventions. Note that, due to the magnitude of the data, the scale is different from the one adopted in Figure 1. The Fed's interventions are concentrated in the first half of the sample period, suggesting that the Fed has dramatically changed its policy regarding FX interventions. After 1995, the only US intervention occurred on the 18th of June, 1998. It was a sale of 883 millions of USD coordinated with the BoJ.

Since only 21 interventions are observed during the period, it is quite difficult to draw conclusions on the size and grouping regularities of the Fed interventions. The small number of occurrences clearly indicates the Fed's reluctance to intervene on the yen/dollar market. Compared to Japan, the US obviously intervened with smaller and less variable amounts.

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4 Humpage (1997) points out the "reluctance to intervene" of US monetary authorities in the nineties.
The signaling effect of coordination will also be a main focus in the next section. Therefore, at this stage, we adopt a classification of unilateral vs. coordinated CBI, rather than a classification by country. There are several reasons for this choice. First, coordination is indeed a main feature in recent CBI. The central banks themselves confirm that they often coordinate their actions on the FX market. Second, the literature has already emphasized the fact that coordination matters (Catte et al. (1994)). Lastly, this classification will reduce the potential multicollinearity problem in the estimations. Actually, during the last decade, only two types of CBI are observed on the yen/dollar rate: coordinated CBI and unilateral BoJ interventions. There is no occurrence of unilateral Fed intervention on the YEN/USD over our investigation period.

Figures 4 and 5 provide the absolute size of the interventions, respectively unilateral from the BoJ and coordinated operations. Coordinated CBI are obtained by summing up US and Japanese interventions occurring the same day and in the same direction. Coordinated interventions are defined as occurring on the same calendar day, irrespectively of the time discrepancy between Japan and the US. Figure 3 shows the opening hours of the Japanese, European and US markets, expressed in Tokyo local time as our exchange rate quotation refers to the opening price on the Tokyo market. In contrast with European and American markets, there is no overlap between the Japanese and the US markets opening. The New-
York market opens up at 10.00 p.m. Tokyo time, five hours after the Tokyo market closure. Central Banks typically intervene during their domestic business hours (Dominguez, 2003). This is consistent with the reported average times of interventions inferred from Reuters timestamp. On average, the Fed is reported to intervene at GMT 02.57 p.m., while the BoJ intervenes at GMT 03.56 a.m., i.e., around the Japanese lunchtime.

**Figure 3. Exchange Rate Markets and Opening Hours (Tokyo Local Time)**

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Day t</td>
<td>Day t+1</td>
<td></td>
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<tr>
<td>9.00</td>
<td>17.00</td>
<td>22.00</td>
</tr>
<tr>
<td>1.00</td>
<td></td>
<td>6.00</td>
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<tr>
<td>Tokyo local time</td>
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**Figure 4. BoJ Interventions (Absolute Amounts), Billions of USD**
At first sight (Fig. 4 and 5), coordinated interventions seem larger on average. However, a formal test of equal mean between the unilateral interventions of the BoJ and the BoJ interventions involved in coordinated interventions is not rejected: the test statistics is equal to 0.107 leading to a p-value of 0.54.\(^6\) This suggests that there is no link between the amount of the intervention and the fact that this intervention is coordinated or not. Table 1 provides descriptive statistics on different kinds of CBI.

**Table 1. Descriptive statistics of central bank interventions (Billions of USD)**

<table>
<thead>
<tr>
<th></th>
<th>BoJ</th>
<th>Fed</th>
<th>Coordinated</th>
<th>Unilateral BoJ</th>
<th>Coordinated BoJ</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number</strong></td>
<td>195</td>
<td>20</td>
<td>20</td>
<td>175</td>
<td>20</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td>0.81</td>
<td>0.305</td>
<td>1.138</td>
<td>0.762</td>
<td>0.893</td>
</tr>
<tr>
<td><strong>Mean (absolute amount)</strong></td>
<td>1.204</td>
<td>0.409</td>
<td>1.479</td>
<td>1.176</td>
<td>1.154</td>
</tr>
<tr>
<td><strong>Standard deviation</strong></td>
<td>2.546</td>
<td>0.376</td>
<td>1.91</td>
<td>2.609</td>
<td>1.747</td>
</tr>
</tbody>
</table>

**Notes:** number gives the number of interventions of each type. Mean refers to the average size taking into account the direction of the operations. By convention, positive amounts refer to USD purchases. Mean (absolute amount) refers to the sample average of the operation, irrespective of their direction. Standard deviation is obtained by calculating the standard deviation of the absolute amounts involved in the operations.

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\(^6\) The test statistics follows a standard normal distribution under the null hypothesis of equal mean.
3. The Econometric Analysis

For the sake of capturing the impact of central bank interventions, we use the GARCH(1,1) model which has been by far the benchmark model used in the empirical literature (see Humpage, 2003 on this point). For instance, Dominguez (1998) uses a GARCH (1,1) model of dollar/mark and dollar/yen exchange rates in which interventions are captured through four dummy variables. Beine et al. (2002) extend this analysis by allowing the dynamics of the conditional variance to follow a fractionally integrated GARCH (FIGARCH) specification. Kim et al. (2000) include dummies for the sustainability and for the size of interventions to study the dynamics in the Australian dollar.

We estimate the following AR(1)-GARCH(1,1) model:

\[ r_t = b' x_{t-1} + \varepsilon_t \]  
\[ \sigma_t^2 = \omega + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \gamma' |x_{t-1}| \]

where \( r_t \) is the current exchange rate return, defined as \( 100 * \ln(s_t) - \ln(s_{t-1}) \). The database includes three daily series: dollar/yen exchange rate, Japanese and US interventions on the yen/dollar market during the period ranging from April 1, 1991 to October 20, 2001. The model is estimated on the daily returns of the yen/usd over the period ranging from April 1, 1991 to October 20, 2001. All models are estimated through maximum likelihood, using Gauss 3.6. The conditions for a positive conditional variance are checked in all cases. Standard diagnostics are investigated but not reported here in order to save space. The estimation results are reported in Table 2. They include the estimated coefficients with their standard deviations and levels of significance indicated by stars as well as the log likelihoods and the Box-Pierce Q(20)-statistics on residuals and squared residuals in order to check for remaining autocorrelation and heteroskedasticity.

In order to capture the different features of the signaling content of the interventions, we consider four different definitions for \( x_{t-1} \). The interventions variables are one-day lagged in order to prevent problems of reverse causality. For each type of specification, we estimate a full model in which all variables are included both in the conditional mean (equation (1)) and in the conditional variance (equation (2)). We also estimate a parsimonious model in which insignificant variables (using the 5% significance level) are excluded from the regression. I should be clear that dummies introduced in the conditional mean are signed, i.e. take into account the differences between purchases and sales of foreign currency. Given

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7 All models presented below pass the diagnoses tests for remaining autocorrelation and heteroskedasticity based on the Box-Pierce statistics on residuals and squared residuals computed at the conventional number of lags (20, 50 and 100). Depending on the models, the standardized residuals display some excess of skewness and kurtosis. The complete results are of course available upon request.
the definition of the Yen-USD exchange rate and the convention of sign for the central bank operations, the impact of interventions should be positive. Dummies introduced in the conditional variance equations are of course taken with absolute values.

The first specification (columns denoted (1) and (2) in Table 2) includes unilateral interventions of the BoJ captured by dummy variables. We account for different impact for the concerted interventions between the Fed and the BoJ. In the second specification (columns denoted (3) and (4) in Table 2), we capture the potential different signal conveyed by large interventions of the Bank of Japan. This is done through the inclusion of an additional dummy capturing whether the size of the intervention is above the average absolute value over the investigation period.

While size is obviously one of the most pregnant features allowing to alter expectations of market participants, the fact that the intervention is the initial trade of a round of operations or not is potentially an important feature. To account for such a different signal, we introduce additional dummies in the specifications. The third specification takes into account whether the investigated intervention is following an initial trade of the BoJ or not. More precisely, we capture successive BoJ interventions by introducing a dummy taking the value of 1, respectively -1, if intervention at time t is positive, respectively negative, (the BoJ buys, respectively sells, USD) and preceded by at least one intervention of any bank in a n-days period. Otherwise, the variable takes a zero value. Thus, zero values correspond either to days for which no intervention is observed, or to days of interventions following a period of n trading days without any intervention. The results reported in Table 2 (columns (5) and (6)) are obtained using a value for n equal to 10 but setting n equal to 5, 15 and 20 delivered quite similar results. They are not reported here to save place. Finally, we also accounted for isolated interventions. To this aim, we introduce a dummy variable taking the value of 1, respectively -1, if there is a positive, respectively negative, unilateral BoJ intervention at time t which is preceded by no intervention of any bank in a 10-days period. Otherwise, the variable takes a zero value. Once more, the choice of n=10 turns out to be without loss of generality.

The results obtained for the successive specifications provide interesting insights about the process by which BoJ operations impact the dynamics of the exchange rate. The first specification shows that on average unilateral operations of the BoJ were counterproductive i.e. moved the yen in the wrong direction. In contrast, coordinated interventions, were found to be ineffective. This confirms that the signalling content of coordinated operations differ from the one conveyed by unilateral interventions and is in line with the findings of Catte et al. (1994). In this respect, these first results are consistent with those of Nagayasu (2004) documenting the ineffectiveness of BoJ unilateral operations as opposed to concerted operations. The results also confirm that concerted operation result in increased exchange rate volatility, which is fully in line with the previous empirical analyses (Dominguez, 1998; Beine et al., 2002).
The previous picture dramatically changes when one accounts for size of the operations as a signalling device. Results obtained with specifications (3) and (4) suggest that large-scale operations convey quite a different message from the other unilateral operations. Indeed, large-scale operations are fond to be effective in moving the exchange rate in the intended direction. Given that the distribution of sizes of the unilateral operations is highly left-skewed (more small amounts than large daily trades), large-scale operations represent roughly 27 percent of the investigated operations. These operations also tend to result in moderate increase of exchange rate volatility. Our results suggest that the policy shift in favour of large interventions observed for the BoJ significantly increased the effectiveness of such an instrument. Failure to account for such this shift might lead to misleading conclusions about the usefulness of these operations. This is also confirmed
by the dramatic increase of the quality of adjustment of this model compared to the benchmark specification. Likelihood ratio tests highly support the inclusion of a dummy variable capturing the different effect of large-scale operations.

Specifications with successive and isolated interventions introduced as separate variables suggest that the other components of the signal are much less important to explain the effectiveness of BoJ unilateral operations. We do not find strong support for a different impact between successive and initial interventions (specifications (5) and (6)), concerning either the levels of the exchange rate returns or the volatility. This is in line with other findings of the literature (Beine, Laurent and Palm, 2004). Nevertheless, the negative sign associated to successive intervention in the conditional mean equations, though insignificant, suggests that successive interventions are less effective and that first trades are much informative for market participants. Regressions accounting for a particular effect associated to isolated operations confirm this interpretation: while very low, we found a weakly significant positive impact of isolated unilateral operations of the BoJ.

On the whole, the econometric findings of the analysis suggest that depending on the nature of the BoJ interventions, the signaling content and hence the effectiveness of these operations can be quite different. We find that on average, unilateral operations exert some counterproductive impact. In this respect coordination prevents the emergence of a wrong signal and is found to be quite neutral for the dynamics of the level of the exchange rate. It nevertheless increases volatility. Isolated operations are also found to mitigate the counterproductive impact of unilateral operations. In the absence of coordination, the choice of high amounts tends to signal the commitment of the central bank to alter the dynamics of the exchange rate. These large-scale interventions are found to move the exchange rate in the intended direction. To the extent that objectives in terms of level have been considered in the case of the BoJ as primary goals of these operations (Ito, 2003; Ito and Yabu, 2004), large-scale operations might be considered as effective policy instruments in the hand of the BoJ.

Our findings turn out to reconcile the apparent contradiction between the results of Ito (2003) and those of Nagayasu (2004). Like Ito (2003), we show that size matters but not in a linear way. Operations involving above-the-mean sales or purchases provide an additional signal to market participants, thereby altering their expectations. In this sense, this goes through a signaling channel rather than a pure portfolio effects. Failure to account for that can leads to misleading conclusions about the usefulness of such operations.
CONCLUSION

This paper investigates the effectiveness of the Bank of Japan interventions in the FX markets over the recent period. A special attention has been devoted to the prominent features of those interventions and to their associated signaling content. It is found that, in line with previous evidence, unilateral operations are in general either ineffective or even counter-productive. In the absence of coordination with another major central bank, namely the Fed, which characterizes the current regime, the results indicate that isolated large-scale interventions can produce the desired effects in terms of the exchange rate level. To the extent that influencing the level of the Yen against the major currencies is by far the most important objective of the Japanese foreign exchange interventions, it might be concluded that large-scale operations should be favoured by the Bank of Japan.

At a more general level, our results show that size of the central bank interventions provide a specific signal to the exchange rate market participants. While the previous literature has been inclined to use pure dummies or in contrast the amounts, we show that size exert some virtuous impact on the dynamics of the exchange rate in a non linear way. Failure to disentangle the signaling content associated to large and small-scale operations can result in misleading conclusions about the effectiveness of FX operations. The integration of this aspect in the empirical identification of the effects is especially important when the underlying amounts of the operations display much variability over time, like in the case of the BoJ interventions.
REFERENCES


