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The Influence of Actual and Unrequited Interventions

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The Influence of Actual and Unrequited Interventions

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Abstract

Intervention operations are used by governments to manage their exchange rates but officials rarely confirm their presence in the market, leading inevitably to erroneous reports in the financial press. There are also reports of what we term, unrequited interventions, interventions that the market expects but do not materialize. In this paper we examine the effects of various types of intervention news on intra-day exchange rate behavior. We find that unrequited interventions have a statistically significant influence on returns, volatility and order flow, suggesting that the expectation of intervention, even when governments do not intervene, can affect currency values.

JEL codes: F31, F33, G15

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1. Introduction

This paper examines intra-day foreign exchange market reactions to news of actual and unrequited interventions reported in the financial press. Intervention operations are used by many governments to manage their exchange rates. Research has found that these operations can, under certain circumstances, effectively influence the level and volatility of exchange rates.[1] One of the more puzzling aspects of intervention policy is the fact that some governments keep their intervention operations secret, even ex post.[2] The financial press often reports when a central bank is intervening over the wire services, though governments rarely officially confirm their presence in the market. Because there is often uncertainty in the market about whether a given government is intervening, there are inevitably circumstances when the financial press reports interventions that have not occurred. There are also frequently reports of what we term, unrequited interventions, interventions that the market expects but do not materialize. In this paper we examine the effects of various types of intervention news (reported actual interventions, falsely reported interventions, oral interventions and unrequited interventions) on exchange rate behavior.

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[1] A number of recent papers have examined the influence of intervention operations on daily exchange rate returns and volatility and generally find evidence that interventions influence returns and increase volatility. Dominguez and Frankel (1993a,b), Dominguez (2003b), Humpage (1999), Fatum and Hutchison (2003, 2006), De Grauwe and Grimaldi (2003), and Ito (2003) find that interventions influence daily returns. Bonser-Neal and Tanner (1996), Dominguez (1998), Galati et al. (2005), and Frenkel et al. (2005) find that interventions lead to increases in implied volatilities measured using options data. Chaboud and LeBaron (2001) find a positive correlation between daily (futures) trading volume and Fed interventions. Dominguez (1998) using a GARCH model, Beine et al. (2002) using a FIGARCH model, and Beine and Laurent (2003) using a model that allows for a time-varying jump probability associated with interventions, all find evidence that interventions tend to increase exchange rate volatility. Dominguez (2006) and Beine et al. (2003b) examine the effects of G3 interventions on daily realized volatility using an ARFIMA model. A few papers find evidence that situation-specific interventions lead to decreases in volatility. For example, Beine et al. (2003a) allow for a regime-dependent specification using a Markov switching model and find that when the market is highly volatile concerted interventions decrease volatility. Dominguez (1998) and Taylor (2004) find that interventions in the mid-1980s reduced exchange rate volatility.

[2] Dominguez and Frankel (1993b) discuss the possible reasons that central banks might want to keep their intervention operations secret (the so-called stealth operations). Neely (2000) notes that central banks are moving increasingly toward electronic trading methods, which suggests that they are less interested in keeping operations secret. On this topic also see: Vitale (1999), Bhattacharya and Weller (1997), Chiu (2003), Beine et al. (2004) and Beine and Bernal (*forthcoming*). Although the Japanese government generally does not provide contemporaneous information about their intervention operations, the Ministry of Finance publishes lagged daily intervention data (lagged one month) on their website: http://www.mof.go.jp/english/e1c021.htm.

A number of previous studies have shown that in order to find significant reactions in the foreign exchange market to the news, one needs to measure the precise impact of the news at the intra-day level.[3] Using Reuters' time-stamped newswire reports we are able to match the timing of intervention news to movements in intra-day exchange rates. We also include scheduled macro announcement news reports which have been used in previous studies to allow us to compare the effects of intervention news against these more "traditional" variables.

The intra-day foreign exchange data used in this study are transactions prices and quote spreads in three dollar currency markets: usd-gbp, usd-eur and yen-usd available from the Reuters D2000-2 electronic trading system over the period from December 1999 through July 2000. The data do not include information on traded quantities, but they do indicate whether trades were initiated by a buyer or seller, allowing us to measure order flow as well as returns and volatility. We use a 20 minute sampling frequency and measure order flow as the cumulative number of buyer initiated trades minus the cumulative number of seller initiated trades over the same 20 minutes.

The intra-day intervention news and exchange rate data allow us to test whether interventions have similar impact effects on returns and volatility as compared to (the already heavily studied) scheduled macro announcements. The fact that information regarding interventions most often comes from unofficial sources suggests that there are likely to be differences of opinion among market participants about the implications of the information. In our application, we can distinguish between scheduled (and presumably better-understood) macro announcements and more ambiguous intervention news. We also measure what proportion of the price discovery process in reaction to intervention news occurs via order flow. Previous studies have found evidence that a substantial proportion of the market reaction to macro-announcements occurs via order flow. By examining how intervention news events influence order flow – we can begin to better understand how this measure relates to price and volatility movements in the foreign exchange markets.

[3] See Dominguez and Panthaki (2006) for a more detailed discussion of the intra-day influence of news on exchange rates.

The paper is organized as follows. Section 2 reviews the links between intervention operations and exchange rates in standard models. Section 3 describes the exchange rate and order flow data from Reuters D2000-2 used in our empirical analysis. Section 4 provides results of our event study analysis of the influence of intervention news and macro surprises on exchange rate returns and volatility. Section 5 introduces our order flow information and examines its role in explaining exchange rate movements. Section 6 concludes.

2. Intervention News and Exchange Rates

Theory suggests that foreign exchange market interventions that are sterilized[4] may influence exchange rates through two potential channels: portfolio balance and "information/signaling". In portfolio-balance models of exchange rate determination investors diversify their holdings among domestic and foreign assets as a function of expected returns and the variance of returns. Foreign and domestic assets are assumed to be outside assets (so that Ricardian equivalence does not hold) and imperfect substitutes (so that uncovered interest parity does not hold). Portfolio balance theory predicts that the change in the relative supply of foreign and domestic assets that occurs with a sterilized intervention will require a change in expected relative returns. For example, after a sterilized home-currency supporting intervention, investors will require a higher expected return on foreign assets to hold willingly the larger outstanding stock, leading to a depreciation of the foreign currency relative to the home currency. In the portfolio balance model, traders do not need to observe the intervention operation in order for it to be effective. However, only actual intervention operations, which change the composition of domestic relative to foreign assets in trader's portfolios, can influence exchange rates via this channel. Consequently, unrequited interventions (as well as false

[4] Sterilized interventions are a combination of two transactions. The central bank conducts a non-sterilized intervention, for example, by purchasing (or selling) foreign-currency denominated bonds and increasing (decreasing) the home monetary base. The central bank then sterilizes the operation by selling (or purchasing) a corresponding quantity of home-currency denominated bonds in order to reverse the effects on the monetary base. Countries that adhere to monetary or inflation targets are generally assumed to engage chiefly in sterilized intervention operations. In practice the U.S. and the ECB claim to routinely sterilize their operations.

reports of interventions and oral interventions) should have no influence on exchange rates via the portfolio balance channel.

The second channel whereby intervention operations may influence exchange rates is the information or signaling channel. Intervention operations may provide investors with "information" about the Central Bank's (or Government's) view of the appropriate exchange rate.[5] Intervention operations may also provide a "signal" of future policy intentions (for example, future monetary policy). Moreover, the intervention operation may itself "buy credibility" for future policy intentions. As long as the information signaled through intervention policy is relevant and credible, it can potentially influence the exchange rate.[6] Only those intervention operations that are observed by the market can serve to influence exchange rates via the signaling channel so that non-reported or secret interventions (if they are truly secret) are unlikely to serve as signals.

When traders first learn of an intervention operation over the newswires, they may not know whether the information is substantiated or not. It is therefore possible for all intervention news (whether actual, false or unrequited) to have a short-term impact on exchange rates via the signaling channel. [7] As soon as traders learn that intervention news is false or unrequited then we might expect returns and volatility to revert to their original levels. Alternatively, it may be that in periods when interventions are expected (even if they do not occur) that unrequited interventions reported over the newswires serve to coordinate the markets' view of exchange rate movements.[8]

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[5] It is also possible for governments to communicate this information directly to the market. See, for example, Fratzcher (2004), Jansen and DeHaan (2005) and Sager and Taylor (2004).

[6] See Mussa (1981), Dominguez (1992), Vitale (2003), Sarno and Taylor (2001), D'Souza (2002) and Taylor (2005) for further discussion of the intervention-signaling hypothesis.

[7] Naranjo and Nimalendran (2000) hypothesize that interventions create significant adverse selection problems for dealers. They find evidence in daily data that dealers increase exchange rate spreads around interventions and suggest that in doing so they protect themselves against the greater informational asymmetry around interventions.

[8] Montgomery and Popper (2001) suggest that actual central bank intervention may also serve to aggregate and disseminate traders' information and thereby serve an informational sharing role for a heterogeneously informed market

We use time-stamped Reuters's newswire reports[9] to measure intervention news. Our search criteria retrieved newswire articles under the joint subject area of "foreign exchange" and "intervention". We then coded and grouped[10] news articles according to geographic region (Euro-zone, U.K., U.S. or Japan) and type of intervention news. Table 1 provides a breakdown of the intervention news categories that appeared in newswire reports over the period under study. In the table we distinguish between cases where there was a 'threat' or 'no threat' of intervention from the policymaker. Further distinctions were made between interventions that were 'reported' or 'not reported' in the news (panel a), and interventions that were 'expected' or 'not expected' by the market (panel b).

There were 172 newswire reports that we classified as 'threats'; these included reports of interventions, threats of intervention, and statements that were intended to influence the home currency (sub-classified as oral interventions). Examples of this category of intervention news include:

> "The beleaguered euro got a boost overnight when French Finance Minister Laurent Fabius reminded markets that currency market intervention was a weapon in Europe's arsenal and the currency should rise in the coming weeks" (May 9, 2000).
>
> "Japanese Finance Minister Kiichi Miyazawa said Japan would act in response to rapid moves in the foreign exchange market" (March 14, 2000).

There were 48 newswire reports that we classified as 'No Threat' interventions, defined as news that a central bank did not intend to intervene; examples include:

> "ECB President Wim Duisenberg says the ECB could not and should not do anything directly to influence the euro's exchange rate but said he would not fundamentally rule out intervention. Asked whether there was a floor set at which the ECB would defend the euro at all costs, Duisenberg said, 'If there were such a limit, I wouldn't tell you. But there isn't one. But we know how limited the effect

[9] These data are from the Factiva database and, unfortunately, do not include the headline news that run over the Reuters ticker second by second, but they include the major economic news events that occur over a given day. Chang (2006) finds evidence that newswires and print media are often inaccurate in terms of substance (missing interventions as well as falsely reporting interventions), and Fischer (2006) finds evidence that the timing of newswire reports of SNB interventions often differ substantially from the official timing of interventions. Newswire reports, however flawed, are one of the main sources of information for traders and dealers in the forex market, and are the only source of timed intra-day news available to researchers.

[10] In theory each "news" report may have a different one-time influence on exchange rates. We group similar news items together in order to examine whether certain "types" of intervention news have a systematic influence on exchange rate behavior.

> of such intervention is. If we take such a step in coordination with the United States and Japan, then that would be a possibility. But we see no reason for it at present'" (February 17, 2000).
>
> "Bundesbank's Welteke says he doesn't believe short-term measures can stabilise euro's exchange rate" (March 6, 2000).

'Detected interventions' refer to cases where newswires correctly reported that a central bank intervened. The one 'false intervention' refers to a newswire that incorrectly stated that the ECB was intervening. The largest category of intervention news, termed 'unrequited interventions', includes 292 newswire reports that indicated that the market expected an intervention that did not occur; examples include:

> "The authorities have to show their hand. They have to stand up and be seen. I think the market will take their lead," Soros said in London (May 5, 2000).
>
> "Actions speak louder than words, and it is all very well saying that you want the currency to be higher but people are actually waiting to see intervention, said Paul Coughlin, chief trader at American Express Bank in London" (May 11, 2000).

The euro officially came into existence in January 1999, and a year later there was broad concern in Europe that the euro had dipped below parity against the dollar. The majority of the unrequited intervention news reports in our data over this period were associated with the absence of ECB operations to support the euro against the dollar. It was not until September 2000 (beyond our sample period) that the ECB actually intervened (in coordination with a number of other central banks including the Fed, the BOJ and the BOE).

The Japanese government, in contrast to the Europeans, sought a depreciation of the yen relative to the dollar in this time period. Figure 1, which shows the yen-usd exchange rate and BOJ interventions from 1990 though 2002, puts Japanese exchange rate objectives into context. After a number of years of yen depreciation relative to the dollar, the yen began to strengthen in August 1998 (on the heels of a number of interventions in support of the yen by the BOJ and the Fed)[11] with a precipitous rise in

[11] Ito (2003) provides a chronological description of Japanese foreign exchange intervention over the period 1991 through 2004. He notes that Japanese intervention strategy changed dramatically in 1995 under

the value of the yen relative to the dollar starting in July 1999 through early 2000. The BOJ intervened to weaken the yen by selling yen and purchasing dollars on 17 days over the period January 1999 (with the yen-usd rate at 108) through April 2000 (with the yen-usd rate at 104). Our eight-month sample period (circled on Figure 1) includes the last 5 of these 17 intervention days.[12] Newswire reports over this period suggest that both the market and the Japanese government considered the yen-usd "100" mark as a critical value not to be crossed (which indeed did not happen). The first BOJ intervention in our sample occurred on December 24, 1999, a day when our Reuters electronic brokerage data (and the Reuters newswire data) suggests there was extremely little trading in advance of the Christmas holiday. The second intervention, on January 4, 2000, also occurred during a period of extremely light trading volume. The yen-usd rate rebounded from the critical "100" level after these interventions for a few weeks and then as the yen began to depreciate in early March, the BOJ again intervened on March 8th, 15th and April 3rd. The yen-usd rate rebounded over the next few months and it was not until after a year's hiatus that the BOJ again began to purchase dollars in September 2001 through June 2002. Along with the actual BOJ interventions that took place during this time, there were numerous unrequited intervention news reports of additional Japanese operations (which did not occur) to weaken the yen.

During our sample period the Bank of England (BOE) did not engage in any actual intervention operations, though newswire reports indicate BOE concern over the strength of the pound (and its impact on the competitiveness of UK exports), as well as statements regarding the costs and benefits of joining the euro-zone. We include the usd-gbp in our analysis in large part because the source of our exchange rate data, the Reuters D2000-2 electronic brokerage trading system, is most dominate in this market.

Eisuke Sakakibara, the Director General of the International Bureau, toward larger sized interventions on fewer occasions. Sakakibara retired in July 1999 but his successor, Mr. Kuroda, who was in charge of Japanese intervention policy during our sample period, followed a similar intervention philosophy of infrequent, large and unpredictable operations. Also see Chaboud and Humpage (2005), Kim (*forthcoming*), Fatum and Hutchison (2006) and Frenkel, Pierdzioch, and Stadtmann (2005) for further analysis of Japanese interventions over this time period.

[12] Newswire reports suggest that the BOJ intervened on multiple occasions on each "intervention day". The Fed, Bundesbank, and ECB also generally follow a strategy of intervening on multiple occasions over the course of a given intervention day. See Dominguez (2003a) for more discussion of intra-day intervention operation strategies.

The empirical approach we take in this paper is based on the assumption that exchange rates are forward looking asset prices that react to changes in the market's expectation of future fundamentals. We further assume that "future fundamentals" may include both standard variables from international macro models (for example, money and income differentials) as well as variables such as actual and unrequited interventions that may provide information about future fundamentals. We use intra-daily exchange rate data to allow a narrow enough window around the times of news announcements to be able to precisely estimate the exchange rate reactions in the spirit of Anderson, Bollerslev, Diebold and Vega (2003)[13].

We examine the intra-daily influence of intervention news on exchange rate movements.[14] We also consider whether intervention news not only impacts exchange rates directly, but also influences exchange rates via order flow (signed trade volume). Like unrequited interventions, order flow plays no role in standard models of exchange rate determination, so a finding that order flow matters will provide evidence in favor of a different modeling strategy for exchange rate determination (at least for very short term movements).[15]

The information that market participants in foreign exchange markets receive can be broadly categorized into two types: "scheduled" and "non-scheduled". Official macro data are typically announced by the relevant government agency on a pre-arranged schedule, so that market participants can plan in advance their reactions to this information. Table 2 describes the scheduled macro news announcements from the UK, the US, the Euro-area and Japan that are included in our "macro surprise" variables. Non-scheduled news is by its nature less likely to be anticipated by the market. It is also likely

[13] The enormous literature measuring the effects of macro news on intra-daily exchange rates includes Hakkio and Pearce (1985), Ito and Roley (1987), Ederington and Lee (1995), DeGennaro and Shrieves (1997), Almeida, Goodhart and Payne (1998), Andersen and Bollerslev (1998), Bauwens et al. (2005), Chaboud, Chernenko, Howorka, Iyer, Liu and Wright (2004), Faust, Rogers, Wang and Wright (2003), Love (2004), Love and Payne (2003), Melvin and Yin (2000), and Ehrmann and Fratzscher (2005).

[14] Bauwens et al. (2005) examine the influence of news, including rumors of intervention, on euro-usd volatility over a six month period in 2001. They find that the most significant pre-announcement increase in volatility is related to rumors of central bank interventions. They also find that once a rumor is refuted, volatility stabilizes or drops. Other intra-day studies of the effects of (actual) intervention operations include: Goodhart and Hesse (1993), Peiers (1997), Chang and Taylor (1998), Beattie and Fillion (1999), Fischer and Zurlinden (1999), Neely (2002), Payne and Vitale (2003), Breedon and Vitale (2004), Panthaki (2005), Pasquariello (2004, *forthcoming)*, and Dominguez (2003a, 2006).

[15] Evans and Lyons (2002) is one of the first studies that found a link between order flow and exchange rate movements. We will be examining these same links though with a very different data set and time period.

that market participants are less able to quickly interpret the implications of non-scheduled news. All our categories of intervention news are non-scheduled, potentially leading to more heterogeneity in trader responses to this sort of news.[16] Further, regardless of whether news is scheduled or not, its influence on exchange rates may be related to the state of the market at the time of the news arrival.[17] News that arrives during periods of high uncertainty may have different effects on the exchange rate, than news that arrives in calmer periods.[18]

3. Exchange Market Data

Our intra-day exchange rate and order flow data cover an eight-month period, from December 1999 through July 2000 for the usd-gbp, the usd-euro, and the yen-usd. The data are from the brokered segment of the inter-dealer exchange rate market as captured by the Reuters D2000-2 electronic trading system. Electronic brokers were first introduced in 1992 and since that time their market share has increased rapidly. In the early 1990s the inter-dealer market was split evenly between direct and voice-broker trading but by the late 1990s (the sample period used in this study) the two top electronic brokerage systems, Reuters and EBS, made up over 50 percent of the market. Reuters has the largest share of the usd-gbp market, while EBS has a much larger share of total trading in the usd-eur and yen-usd markets, potentially leading the Reuters data in these markets to be less representative. Reuters usd-eur and yen-usd order flow data, in particular, may not well capture average trading behavior in these markets. Likewise,

[16] Of course, an increase in market heterogeneity may also occur in reaction to scheduled announcements. Kondor (2005) shows that if traders display confirmatory bias, the release of public information may increase divergence in opinion. The main insight is that sometimes (public) information implies something different when it is coupled with different (private) pieces of existing information. Bacchetta and van Wincoop (2006) also model the influence of higher-order expectations in reaction to news.

[17] For example, Dominguez (2003a) shows that the influence of central bank interventions on exchange rate returns depends on the intra-day timing of intervention operations (whether they occur during heavy trading volume, or are closely timed to scheduled macro announcements) as well as whether the operations are coordinated with another central bank. Dominguez and Panthaki (2006) find that "news" has its greatest influence on intra-day exchange rate returns during periods of high market uncertainty (proxied by high volatility as measured by the absolute value of returns).

[18] Andersen, Bollerslev, Diebold and Vega (2003) find evidence that "bad" news in good times (economic expansions) have greater impacts than good news in good times, suggesting that good news in good times confirms beliefs but bad news in good times comes as more of a surprise. Our short sample period will not allow us to test this hypothesis directly, though in future work we intend to test whether "confirming" versus "surprising" news about interventions has different effects.

spreads in the usd-eur and yen-usd quotes are sometimes quite wide due to the relative lack of liquidity in these markets on the Reuters system.

Inter-dealer brokering systems provide prices that are advertised to all subscribers (though the identity of the quoting dealer is only available once the quote is hit). Dealers can submit a buy or sell quote or "hit" a quote of another dealer. Only the highest bid and lowest ask (the touch) are shown on the Reuters screen. The quantity available at each (best) bid and ask is also shown (which may involve more than one bank), and when a bid or ask is hit the quantities available at that price are adjusted if they dip below $10 million. When multiple banks have entered the same bid or ask price, and the price is hit, offers are met on a first come basis (meaning that the dealer who first input the price gets the deal first and if more quantity is needed, the dealer that next submitted the same price fills the order, and so on). All transactions are made at either the posted bid or ask. While dealers in individual banks will know their own customer order flow – they do not have access to information on customer orders of other banks. One of the reasons that inter-dealer brokerage systems have become so popular is that they provide an important source of real time information on both market quotes and overall market order flow. [19] The Reuters D2000-2 system classifies transactions as buyer-initiated or seller-initiated, providing dealers with a real time proxy of signed trading volume.[20] We measure order flow in this study as the difference between the number of buyer-initiated trades and seller-initiated trades in each 20-minute interval.

The intra-day price series used in this study incorporates information from both transactions prices (actual trades) and (tradeable) bid and ask quotes submitted by dealers (but not hit).[21] We use tradeable quotes in addition to actual transactions prices to create a 20-minute price series for the usd-eur, usd-gbp and yen-usd rates that spans the period over which we have intervention news data.[22] We measure exchange rate returns as the

[19] See Rime (2003) and Lyons (2001, chapter 3) for detailed descriptions of electronic trading systems.
[20] The dealer posting the quote is considered the non-initiating side. Reuters does not provide information on the size of each trade.
[21] Tradeable quotes differ from indicative quotes, which have been used in a number of previous studies, in that they provide "firm" prices. Indicative quotes provide market information for non-dealers.
[22] There are a periods of low liquidity on Reuters D2000-2 due to technical problems (the feed failing), holidays, and during Asian trading hours. Some studies simply drop these time periods from the sample. Our approach is to interpolate a 20 minute time series (using a linear interpolation method) from all available quotes in order to fully span our "news" data set. Reuters does not include weekend data so any news that arrives over a weekend is moved to the first 20-minute interval on the nearest Monday. The

log difference in 20-minute (midpoint) prices. Figure 2 shows average daily usd-eur, usd-gbp and yen-usd returns, order flow and news arrival (measured as the number of newswire articles in a given 20-min interval) over the 24-hour GMT time scale. News arrival and order flow are fairly evenly spread over the day, and there is little evidence of trend in average returns.

We measure exchange rate volatility as the absolute value of the 20-minute returns. Figure 3 shows the average absolute return in each 20-minute interval over the 24-hour GMT time scale for each of the exchange rates (the x-axis for the three currencies starts at midnight, which is approximately 12am GMT for usd-eur and usd-gbp and 3pm GMT for yen-usd). The data confirm the seasonal pattern that is typically found in intra-day exchange rate volatility data which, in turn, largely reflects the opening and closing of the three main trading markets in Tokyo, Europe and New York. In order to take the opening and closings of markets into account we de-seasonalize the volatility series using the Andersen and Bollerslev (1997ab, 1998) flexible fourier form (FFF) regression method which involves decomposing the demeaned *i*-minute exchange rate returns, into a daily volatility factor, a periodic component for the i^{th} intraday interval and an i.i.d. mean zero unit variance innovation term all divided by the square root of the number of uncorrelated intraday return components.[23] This estimated FFF seasonal is shown (together with the average daily volatility) in Figure 3.

Table 3 provides descriptive statistics for our 20-minute exchange rates, returns[24] and volatility as well as order flow, order flow volatility and transaction frequency (measured as the number of transactions in a given 20-min interval). The three exchange rate returns series display little autocorrelation, suggesting that future exchange rate changes cannot be predicted from past changes. Intra-day return volatility, order flow volatility, and transaction frequency for all three currencies shows evidence of strong and persistent autocorrelation. While buy and sell orders are highly autocorrelated, net order-flow (buy orders minus sell orders) does not display significant autocorrelation. Usd-gbp returns are significantly less variable than are usd-eur or yen-usd returns over this time

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average number of newswire reports on Mondays (including weekend news) is 93 compared to 100 for Tuesdays, 123 for Wednesdays, 132 for Thursdays and 81 for Fridays.

[23] See Dominguez (2006) for a detailed description of how this was implemented.

[24] We compute returns (approximately) as the percentage change in the exchange rate multiplied by 100, so the units can be thought of as basis points.

period and yen-usd transaction frequency is significantly lower (at 3 transactions every 20 minutes) than is transaction frequency for usd-eur or usd-gbp (which have closer to 30 transactions every 20 minutes).

Table 4 presents contemporaneous correlations among our key variables: exchange rate returns, exchange rate volatility, order flow, order flow volatility, trading frequency and news arrival.[25] The correlations for all three currencies indicate that there exists a strong contemporaneous association between exchange rate returns and order flow, as well as between exchange rate volatility, order flow volatility and transaction frequency. The correlation between returns and order flow is highest for usd-eur (at .51) and lowest for yen-usd (at .224). Beyond these contemporaneous correlations, we might expect longer-lived correlation between intervention news and the other variables if traders have different views of the implications (and information content) of the news.

4. Effects of Intervention News on Returns and Volatility

The standard approach in the empirical exchange rate literature is to run the following sort of "event study" style regression[26] of the conditional mean of i-minute exchange rate returns on j leads[27] and lags of the actual intervention indicator, each of the k "news" announcements, and on g lags of past returns (to account for any autocorrelation); that is:

$$\Delta s_{ti} = \alpha_0 + \sum_j \alpha_{1,j} I_{ti-j} + \sum_k \sum_j \alpha^k_{2,j} N^k_{ti-j} + \sum_g \alpha_{3,g} \Delta s_{ti-g} + \varepsilon_{ti} \qquad (1)$$

where Δs_{ti} denotes the change in the natural log of the i-minute (spot market) exchange rate on day t, I denotes the intervention indicator, and N denotes intervention news and macro surprises[28]. All news variables are time-stamped to the nearest i-minute. We use the

[25] Evans and Lyons (2003) document strong contemporaneous correlation between news arrival, transaction frequency and order flow volatility. Melvin and Yin (2000) find a positive correlation between trading frequency (using indicative quotes) and the rate of flow of public information.

[26] An alternative approach based on state dependent heteroscedasticity is used by Rigobon and Sack (2004) and Evans and Lyons (2003).

[27] We include leads and lags in order to take into account the possibility that the time-stamp on our news does not match the actual timing of when market participants first learn about the news. We find evidence of both lead and lag effects for our intervention news variables for up to 2 hours before and after the Reuters' time stamp.

[28] The intervention indicator and the intervention news variables are (0,1) dummy variables. Macro surprises are measured as the difference between the specific announcement and the ex-ante expectation of

Schwarz (1978) criteria to fix the lead/lag lengths, and we correct for heteroskedasticity and serial correlation in the error term using the Newey and West (1987) approach. Using this general regression specification it is possible to test for the impact and intra-day effects of different kinds of intervention news and macro surprises on exchange rate returns by examining whether the $\alpha_{1,j}$ s and $\alpha_{2,j}^{k}$ s are individually and jointly statistically significant. The coefficients in this context measure the typical effect of the k[th] news announcement at time i (on day t) on exchange rate returns in the same (narrow) i-minute window. It is worth noting that in order to be able to interpret the coefficients in this way we need to assume that the variables in the regression can be viewed as predetermined regressors over the i-minute period (which is less likely to be realistic for low-frequency data windows). It is also the case that the coefficients will measure the linear combination of exchange rate return effects associated with the market's assessment of both the news *and* how the news will influence the economy.[29]

Our "news" variable (*N*) includes five distinct categories of news: (1) macro surprises, (2) news about intervention policy from policy-makers, (3) news about intervention policy from the market, (4) news about policy-maker-market interactions, and (5) news about unrequited interventions (interventions that the market expected but did not occur).[30] All our categories of intervention news are further broken down by geographic region (Euro-zone, Japan, UK or Joint). Macro surprises are also disaggregated by country so that UK, US, Euro-area and Japanese surprises are included separately.[31]

Table 5 presents results of our regression of intra-day (20-minute) usd-eur, usd-gbp, and yen-usd returns on news. The first, third and fifth columns in table 5 present the results of our benchmark regression, which include the actual Japanese interventions and

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the announcement (based on the median response to a survey conducted by Money Market Services International) divided by the sample standard deviation of each announcement (this serves to normalize the surprises so that comparisons of the relative size of coefficients is feasible).

[29] For a nice discussion of the underlying assumptions in this sort of event study analysis see Faust, Rogers, Wang and Wright (2003) pages 6-9.

[30] We attempted to group news into variables in such a way as to insure that we would not be combining news that would be expected to lead to opposite effects on exchange rates. (This task was made easier for the fact that there were no major shifts in exchange rate objectives by the relevant governments over the 8-month period under study.) The coefficients on these disaggregated news variables are then aggregated into broader groupings of variables in order to keep our tables readable. Regression results with the disaggregated news categories are available upon request.

[31] As robustness checks we also included disaggregated macro surprises (by type and region). Results were qualitatively similar whether surprises are included in aggregated or disaggregated form.

the macro surprises as "news", for each exchange rate. Both leads and lags of the Japanese intervention indicator variable significantly influence yen-usd returns and lagged interventions influence usd-gbp returns. Macro surprises are generally not found to be statistically significant, only Japanese macro surprises significantly influence usd-eur returns. Further, the relatively low regression goodness-of-fit for these benchmark regressions suggests that actual interventions and macro surprises account for a small fraction of the overall variability of returns for all three exchange rates.

The second, fourth and sixth columns in table 5 include our intervention news variables in the lower panel. For each intervention news category the reported coefficient is the sum of six leads and lags, corresponding to two hours before and after the newswire time-stamp. Statistical significance is based on two criteria. The first is an exclusion restriction, where the null hypothesis is that all the leads and lags are zero (under the column labeled F-test). The second is a Wald test of the null hypothesis that the sum of the leads and lags equals zero. This second test provides evidence on mean reversion. For example, if there is an immediate influence of news on returns which is subsequently reversed (within the 4 hour window), the sum of the coefficients would be zero (or close to zero). In many cases individual coefficient leads or lags were found to be statistically significant (leading to a significant F-stat), while the sum of the coefficients over the 4 hour lead/lag window was not always statistically different from zero (leading to an insignificant Wald test).

The coefficient values and statistical (in)significance of the macro surprises in table 5 remain qualitatively unchanged with the inclusion of intervention news. The coefficient on the Japanese intervention indicator variable remains significant especially in the yen-usd regression, suggesting that these interventions led to a depreciation of the dollar relative to the yen (recall that the objective of the Japanese government in this period was to depreciate the yen). Interestingly, the results suggest that all our categories of intervention news seem to have a qualitatively similar influence on returns. For example, news that the ECB would not intervene led to a six-basis-point depreciation of the euro. Recall that, had the ECB intervened (which they did not) in this sample period, their objective would have been to appreciate, not depreciate, the euro. Likewise, market

expectations of Japanese interventions led to a five-basis-point depreciation of the dollar in both the yen-usd and usd-gbp markets

The regression results presented in table 5 indicate that actual interventions, threats of interventions, denials of interventions, and unrequited interventions all had an influence on intra-daily exchange rate returns in the usd-eur and yen-usd markets. However, the relatively low regression goodness-of-fit (for all specifications across all three exchange rates) suggests that intervention news does not go very far in explaining overall exchange rate movements. It is possible that our binary coding of intervention news is partly to blame for our inability to explain a larger fraction of exchange rate variation. It may be that our news variables will be more successful at explaining exchange rates during periods when the market is more uncertain, or that intervention news influences volatility more than returns. It may also be that intervention news do not impact price directly, but that their influence is mediated through order flow. We investigate these possibilities in the next three sets of regressions.

In order to examine how intervention news influences traders under different market conditions, we test for two types of interaction effects. First, we ask whether intervention news is more (or less) likely to influence returns during periods of high market uncertainty (proxied by high volatility). We create an indicator variable that takes on the value 1 during 20-minute intervals when volatility (measured as the absolute value of returns) exceeds the sample average by two standard deviations. The first three columns in table 6 present regression results that show that during periods when the market is most uncertain, intervention news (of all types) had a significantly larger influence on returns than was the case when news arrived during normal periods (while we include each intervention news variable separately as well as interacted with our "high volatility" indicator in the regression, we report only the sums of the leads and lags of the coefficients on the interacted terms in the table). Second, we examine if intervention is more (or less) effective when lots of other news is hitting the market. We create an indicator variable that takes on the value 1 during 20-minute intervals when the number of news reports exceeds the sample average by two standard deviations.[32] The

[32] The "news report" variable is based on a broad interpretation of foreign exchange market news. For more information about this variable see Dominguez and Panthaki (2006).

coefficients in the last three columns of table 6 (again we report only the sums of the leads and lags of the coefficients on the intervention news variables interacted with the "high news arrival" indicator variable) indicate that intervention news often had a larger impact on returns when it arrived during heavy news periods. In the usd-eur market, in particular, the Wald tests indicate that intervention news continued to influence returns beyond a four-hour window. These results suggest that intervention news is more likely to influence trader behavior during specific market conditions, especially during times of high uncertainty. However, the regression goodness-of-fit measures remain relatively low indicating that intervention news explains a small fraction of overall variability of returns.

In order to examine whether intervention news helps to explain the absolute value of exchange rate returns, we regress de-seasonalized[33] intra-day volatility, V_{ti}^{s}, on the same set of explanatory variables:

$$V_{ti}^{s} = \lambda_0 + \sum_j \lambda_{1,j} I_{ti-j} + \sum_k \sum_j \lambda_{2,j}^{k} N_{ti-j}^{k} + \sum_g \lambda_{3,g} V_{ti-g}^{s} + \eta_{ti} \qquad (2)$$

Andersen and Bollerslev (1998) find that three factors influence intra-daily exchange rate volatility: calendar effects and volatility dependencies (both of which are captured in the FFF seasonal) and macro surprises, with macro surprises providing the least explanatory power. We augment their specification with our intervention news variables and allow for a longer lag structure to test whether the effects of these (non-scheduled) news reports are longer-lived. We use the Schwarz (1978) criteria to fix the leads and lags in the regression specification and correct for potential heteroskedasticity and serial correlation in the error term using the Newey and West (1987) approach.

Table 7 presents our volatility regression results using the same column format as we did in table 5. We again find that only Japanese macro surprises enter significantly in the usd-eur regression, providing suggestive evidence that scheduled news, perhaps because it is less ambiguous, has extremely short-lived (less than 20 minutes) influence on volatility. The Japanese intervention indicator variable now significantly influences volatility for all three currencies. We also find that all the different types of intervention

[33] It could be that the intra-day seasonal is explained by news arrival. We test for this possibility by including our intervention news variables and macro surprises directly in the FFF regression and find no evidence of correlation between the daily seasonal and our news variables.

news significantly influence volatility across all three currencies (the F-stats are consistently significant for all our news variables).[34] Interestingly intervention news often led to own-market increases in volatility but decreases in volatility in the other currency markets. Very few of the Wald tests are significant in table 7 suggesting little evidence of a long-lived influence of news on volatility.

5. Does Intervention News Influence Order Flow?

In standard models of exchange rate behavior when "positive" news arrives for a currency, demand for that currency rises, causing the relative value (the price) of the currency to rise. In these models there is no reason for order flow to rise in reaction to news because price is assumed to instantaneously reflect the news. Trading volume may rise in reaction to news, but as long as the new price is efficient, there is no reason for these trades to be biased in favor of purchases or sales. So that in standard models the arrival of "news" should be orthogonal to changes in order flow.[35]

We use transaction frequency, *TF*, as a proxy for volume, and first test whether the arrival of intervention news in our sample is positively related to transaction frequency.

$$TF_{ti} = \gamma_0 + \sum_j \gamma_{1,j} I_{ti-j} + \sum_k \sum_j \gamma_{2,j}^k N_{ti-j}^k + \sum_g \gamma_{3,g} TF_{ti-g} + \upsilon_{ti} \qquad (3)$$

Table 8 presents the results of this regression. We find strong evidence of a relationship between transaction frequency and both the Japanese intervention indicator variable and intervention news (but not macro surprises). This suggests that when traders learn of interventions news (regardless of whether the news indicates that an intervention is likely or not) this influences their decision about whether to trade or not. In some cases the coefficient sign on intervention news is negative suggesting transaction frequency fell in reaction to the news, though the signs on intervention news do not indicate any discernable patterns among the different sorts of news. While our measures of regression

[34] It is also worth noting that the regression goodness-of-fit is dramatically higher, due in part to the strong AR component of volatility.

[35] One view of the relationship between order flow and prices is that it is only a temporary phenomenon. Order flow in this context reflects trader "digestion effects" in reaction to news, so that once the news is fully "digested", any order flow induced price effects will revert back. Work by Evans and Lyons (2002) and Danielsson, Payne and Luo (2002), however, shows that order flow continues to explain changes in foreign exchange returns well after 24 hours, suggesting either that digestion is very slow, or more likely, that the influence of order flow on prices is not temporary.

goodness-of-fit in table 8 are quite high, this is largely due to the strong autoregressive nature of transaction frequency.

Under what circumstance might intervention news cause a change not just in volume, but in order flow? One reason that price might not immediately (or fully) react is if the intervention news either is not common knowledge, or if different market participants interpret the news differently. Unrequited intervention operations are likely to be good examples of news that evoke heterogeneous reactions. In this case, order flow might convey this information to the market (rather than price). Further, if underlying demand for currencies is driven not by news per se, but by changes in risk aversion or hedging technologies, again it might be order flow that will convey this information to the market.[36]

A simple linear regression specification that relates foreign exchange returns to order flow is:

$$\Delta s_{ti} = \beta_0 + \sum_j \beta_{1,j} OF_{ti-j} + \sum_g \beta_{2,g} \Delta s_{ti-g} + \mu_{ti} \qquad (4)$$

Table 9 presents results for a regression of returns on contemporaneous and lagged order flow (OF). The first thing to note in the table is that our measure of regression goodness-of-fit differs significantly across the three currencies. Our estimates suggest that order flow explains over 14% of the variation in 20-minute usd-gbp returns, 6% of yen-usd returns, and only 2.8% of usd-eur returns. These differences are likely due in large part to the fact that the Reuters D2000 system dominates in the sterling market but only captures a small fraction of trades in either the euro or yen markets.[37] The coefficient on contemporaneous order flow is statistically significant and positively associated with returns for all three currencies, suggesting that the influence of news is not fully captured in price changes and that order flow may play a role in the price discovery process.

[36] Four recent papers that have studied the link between "news" and order flow include: Love (2004), Love and Payne (2003), Melvin and Yin (2000), Evans and Lyons (2003), and Dominguez and Panthaki (2006). Breedon and Vitale (2004) find that the strong contemporaneous correlation between order flow and exchange rates is mostly due to liquidity (and not information) effects.

[37] The fact that Reuters has incomplete market share in these currencies suggests that Reuters' order flow measures total order flow with error. This in turn suggests that the relationship between order flow and returns is measured with error in the usd-eur and yen-usd regressions, leading coefficients to be biased toward zero. This sort of measurement error is less of a concern in the usd-gbp regression because Reuters is dominant in that market.

Our results so far suggest that intervention news influences exchange rate returns, volatility, and transaction frequency and that order flow influences returns. The next question to ask is what drives order flow? Previous studies have found a link between macro surprises and order flow, which runs counter to standard models that would suggest that common knowledge news, such as macro surprises, should be instantly incorporated in price. We test whether this result also holds for our data sample, and whether intervention news is also linked to order flow, *OF*.

$$OF_{ti} = \varphi_0 + \sum_j \varphi_{1,j} I_{ti-j} + \sum_k \sum_j \varphi^k_{2,j} N^k_{ti-j} + \sum_g \varphi_{3,g} OF_{ti-g} + \xi_{ti} \qquad (5)$$

Table 10 presents results for the regression of order flow on the Japanese intervention indicator, macro surprises, intervention news, and past order flow. The first, third and fifth columns provide results for our benchmark specification which only includes the Japanese intervention indicator and macro surprises. Again, only the Japanese macro surprises are statistically significant in the usd-eur regression, while actual Japanese interventions enter statistically significantly in all three currency markets. The results in the second, fourth, and sixth columns of table 10 indicate that the intervention indicator variable is no longer significant when we include the other intervention news variables in the regression specification. Interestingly it is in the yen-usd market, where Reuters' has limited market share, that we find the intervention news variables have the most influence. However, the regression goodness of fit never rises above .026 suggesting that order flow is largely not being driven by these variables.[38] The coefficient signs on intervention news in these regressions are generally consistent with what we found earlier in the returns regressions. Coefficient signs on Japanese intervention news are generally negative suggesting that this news led buy orders for dollars to fall relative to sell orders. Likewise, the coefficient signs on ECB intervention news are generally positive suggesting that this news led buy orders for dollars to rise relative to sell orders.

[38] This result is at odds with results in Evans and Lyons (2004) which find a strong connection between disaggregated order flow and news. It is possible that the difference in results is due to the fact that our order flow information is only reflecting inter-dealer trades.

6. Conclusions

In this paper we examine whether actual and unrequited intervention news influences exchange rates. Previous studies have found that scheduled macro announcements, when measured in surprise form, help to explain intra-daily exchange rate behavior. Likewise, official interventions by governments in the foreign exchange market have been found to influence intra-day (and daily) returns and volatility. Results in this paper indicate that unrequited intervention news (and even news of "no intervention") has a statistically significant influence on both intra-day exchange rate returns and volatility, suggesting that the expectation of intervention, even when governments do not intervene, can affect currency values. These results provide strong evidence in favor of the hypothesis that interventions influence exchange rates via the information/signaling channel.

We also examine the role of order flow in exchange rate determination. In standard models there is no reason for order flow to rise in reaction to news because price is assumed to instantaneously adjust. Trading volume may rise in reaction to news, but as long as the new price is efficient, there is no reason for trades to be biased in favor of purchases or sales. We find evidence that order flow has some explanatory power suggesting that prices are, at the very least, slow to adjust. At the same time, we find that actual interventions and our various categories of intervention news explain a very small fraction of the variation in order flow. Overall, our results indicate that along with actual interventions, other kinds of intervention news (including denials of intervention and unrequited interventions) and order flow matter. We do not find evidence that macro surprises have much influence on intra-day returns, volatility or order flow over our sample period. These results suggest that future models of exchange rate determination ought include a broader conception of price relevant "news".

References

Almeida, A., Goodhart, C., Payne, R., 1998. The effects of macroeconomic news on high frequency exchange rate behavior. Journal of Financial and Quantitative Analysis 33 (3), 383-408.

Andersen, T., Bollerslev, T., 1997a. Intraday periodicity and volatility persistence in financial markets. Journal of Empirical Finance 4, 115-158.

Andersen, T., Bollerslev, T., 1997b. Heterogeneous information arrivals and return volatility dynamics: uncovering the long-run in high frequency returns. Journal of Finance 52 (3), 975-1005.

Andersen, T., and T. Bollerslev, 1998. Deutsche mark-dollar volatility: Intraday activity patterns, macroeconomic announcements, and longer run dependencies, Journal of Finance, 53: 219-265.

Andersen, T., T. Bollerslev, F. Diebold, C. Vega, 2003. Micro effects of macro announcements: Real-time price discovery in foreign exchange, American Economic Review, 93: 38-62.

Bacchetta, P., van Wincoop, E., 2006. Can information heterogeneity explain the exchange rate determination puzzle? American Economic Review, 96, 3: 552-576.

Bauwens, L., Ben Omrane, W., Giot, P., 2005. News announcements, market activity and volatility in the euro/dollar foreign exchange market. Journal of International Money and Finance, 24, 7, 1108-1125.

Beattie, N., Fillion, J., 1999. An intraday analysis of the effectiveness of foreign exchange intervention. Bank of Canada Working Paper 99-4.

Beine, M., Bernal, O., *forthcoming*. Why do central banks intervene secretly? Journal of International Financial Markets, Institutions, and Money.

Beine, M., Benassy-Quere, A., Lecourt, C., 2002. The impact of foreign exchange interventions: new evidence from figarch estimations. Journal of International Money and Finance 21, 115-144.

Beine, M., Janssen, G., Lecourt, C., 2004. Should Central Bankers Talk to the Foreign Exchange Markets? Mimeo, CORE.

Beine, M., Laurent, S., 2003. Central bank interventions and jumps in double long memory models of daily exchange rates. Journal of Empirical Finance 10, 641-660.

Beine, M., Laurent, S., Lecourt, C., 2003a. Official central bank interventions and exchange rate volatility: evidence from a regime-switching analysis. European Economic Review 47, 891-911.

Beine, M., Laurent, S., Palm, F., 2003b. Central bank forex intervention assessed using realized moments. Mimeo, CORE.

Bhattacharya, U., Weller, P., 1997. The advantage of hiding one's hand: speculation and central bank intervention in the foreign exchange market, Journal of Monetary Economics, 39, 251-277.

Bonser-Neal, C., Tanner, G., 1996. Central bank intervention and the volatility of foreign exchange rates: evidence from the options market. Journal of International Money and Finance 15 (6), 853-878.

Breedon, F. and P. Vitale, 2004. An empirical study of liquidity and information effects of order flow on exchange rates. Tanaka Business School Discussion Paper TBS/DP04/23.

Chaboud, A., LeBaron, B., 2001. Foreign exchange market trading volume and Federal Reserve intervention. Journal of Futures Markets 21, 851-860.

Chaboud, A., Chernenko, S., Howorka, E., Iyer, R., Liu, D., Wright, J., 2004. The high-frequency effects of U.S. macroeconomic data releases on prices and trading activity in the global interdealer foreign exchange market. Board of Governors of the Federal Reserve System, IFDP No. 823.

Chaboud, A., Humpage, O., 2005. An Assessment of the Impact of Japanese Foreign Exchange Intervention: 1991-2004. Board of Governors of the Federal Reserve System, IFDP No. 824.

Chang, Y., 2006. The accuracy of reports of foreign exchange intervention by the Bank of Japan: does Tokyo know more? Journal of International Money and Financy 25, 1241-1256.

Chang, Y., Taylor, S., 1998. Intraday effects of foreign exchange intervention by the Bank of Japan. Journal of International Money and Finance 18, 191-210.

Chiu, P., 2003. Transparency versus constructive ambiguity in foreign exchange intervention. BIS Working Paper No.144.

Danielsson, J., Payne, R., and J. Luo, 2002. Exchange rate determination and inter-market order flow effects, FMG mimeo, London School of Economics.

DeGennaro, R., and R. Shrieves, 1997. Public information releases, private information arrival, and volatility in the foreign exchange market, Journal of Empirical Finance, 4: 295-315.

De Grauwe, P., Grimaldi, M., 2003. Intervention in the foreign exchange market in a model with noise traders. Mimeo, University of Leuven.

Dominguez, K., 1992. The Informational Role of Official Foreign Exchange Intervention Operations: The Signalling Hypothesis, in: Dominguez, K., Exchange Rate Efficiency and the Behavior of International Asset Markets, chapter 2, Garland Publishing Company, N.Y., pp. 41-80.

Dominguez, K., 1998. Central bank intervention and exchange rate volatility. Journal of International Money and Finance 17, 161-190.

Dominguez, K., 2003a. The market microstructure of central bank intervention. Journal of International Economics 59, 25-45.

Dominguez, K., 2003b. Foreign exchange intervention: did it work in the 1990s? In: Bergsten, C.F., Williamson, J. (Eds.), Dollar Overvaluation and the World Economy. Institute for International Economics, Special Report 16, Washington, D.C., pp.217-245.

Dominguez, K., 2006, "When Do Central Bank Interventions Influence Intra-Daily and Longer-Term Exchange Rate Movements? Journal of International Money and Finance 25, 1051-1071.

Dominguez, K., Frankel, F., 1993a. Does foreign exchange intervention matter? The portfolio effect. American Economic Review 83, 1356-69.

Dominguez, K., Frankel, F., 1993b. Does Foreign Exchange Intervention Work? Institute for International Economics, Washington, D.C.

Dominguez, K., Panthaki, F., 2006. What Defines 'News' in Foreign Exchange Markets?, Journal of International Money and Finance, 25, 168-198.

D'Souza, Chris, 2002. A Market Microstructure Analysis of Foreign Exchange Intervention in Canada. Bank of Canada working paper 2002-16.

Ederington, L., and J. Lee, 1995. The short-run dynamics of price adjustment to new information, Journal of Financial and Quantitative Analysis, 30: 117-134.

Ehrmann, M., and M. Fratzscher, 2005. Exchange rates and fundamentals: new evidence from real-time data, Journal of International Money and Finance, 24, 317-341.

Evans, M., and R. Lyons, 2002. Order flow and exchange rate dynamics, Journal of Political Economy, 110: 170-180.

Evans, M., and R. Lyons, 2003. How is macro news transmitted to exchange rates?, NBER Working paper 9433.

Evans, M., and R. Lyons, 2004. Exchange rate fundamentals and order flow, mimeo, Georgetown University.

Fatum, R. and M. Hutchison, 2003. Is sterilized foreign exchange intervention effective after all? An event study approach, Economic Journal, 113, 487, 390-411.

Fatum, R. and M. Hutchison, 2006. Effectiveness of Official Daily Foreign Exchange Market Intervention Operations in Japan, Journal of International Money and Finance, 25, 199-219.

Faust, J., Rogers, J., Wang, S., Wright, J., 2003. The high-frequency response of exchange rates and interest rates to macroeconomics announcements, Board of Governors of the Federal Reserve System, IFDP No. 784, October.

Fischer, A.M., 2006. On the inadequacy of newswire reports for empirical research on foreign exchange interventions. Journal of International Money and Finance, 25, 1226-1240.

Fischer, A.M., Zurlinden, M., 1999. Exchange rate effects of central bank interventions: an analysis of transaction prices. Economic Journal 109, 662-676.

Fratzscher, M., 2004. Communication and exchange rate policy. ECB working paper 363, May.

Frenkel, M., Pierdzioch, C., Stadtmann, G., 2005. The effects of Japanese foreign exchange market interventions on the yen/us dollar exchange rate volatility. International Review of Economics and Finance, 14, 27-39.

Galati, G., Melick, W., Micu, M., 2005. Foreign exchange market intervention and expectations: an empirical study of the dollar/yen exchange rate. Journal of International Money and Finance, v.24, 6, 982-1011.

Goodhart, C., Hesse, T., 1993. Central bank forex intervention assessed in continuous time. Journal of International Money and Finance 12, 368-389.

Hakkio, C., and D.K. Pearce, 1985. The reaction of exchange rates to economic news. Economic Inquiry, 23, 4, 621-636.

Humpage, O., 1999. U.S. intervention: assessing the probability of success. Journal of Money, Credit and Banking 31 (4), 731-747.

Ito, T., 2003. Is foreign exchange intervention effective? The Japanese experiences in the 1990s. In: Mizen, P. (Ed.), Monetary History, Exchange Rates and Financial Markets, Essays in Honor of C. Goodhart. Cheltenham U.K.; Edward Elgar, pp.126-153.

Ito, T., and V. Roley, 1987. News from the US and Japan: which moves the yen/dollar exchange rate?, Journal of Monetary Economics, 19, 2, 255-277.

Jansen, D-J., and J. De Haan, 2005. Talking heads: the effects of ECB statements on the euro-dollar exchange rate, Journal of international Money and Finance, 24, 343-361.

Kim, Suk-Joong, *forthcoming*. Intraday evidence of efficacy of 1991-2004 Yen Intervention by the Bank of Japan. Journal of International Financial Markets, Institutions and Money.

Kondor, P., 2004. The More We Know, the Less We Agree: Public Announcements and Higher-order Expectations, FMG Discussion paper No. 532, London School of Economics.

Love, R., 2004. First and second moment effects of macro news in high frequency foreign exchange data, mimeo FMG, London School of Economics.

Love, R., and R. Payne, 2003. Macroeconomic news, order flows, and exchange rates, Discussion Paper 475, FMG, London School of Economics.

Lyons, R., 2001. The Microstructure Approach to Exchange Rates, MIT Press.

Melvin, M., and X. Yin, 2000. Public information arrival, exchange rate volatility, and quote frequency, Economic Journal, 110: 644-661.

Montgomery, J., Popper, H., 2001. Information Sharing and Central Bank Intervention in the Foreign Exchange Market. Journal of International Economics (55) 2, 295-316.

Mussa, M., 1981. The Role of Official Intervention. Group of Thirty, New York, N.Y.

Naranjo, A., Nimalendran, M., 2000, Government Intervention and Adverse Selection Costs in Foreign Exchange Markets. Review of Financial Studies 13, 453-477.

Neely, C., 2000. The practice of central bank intervention: looking under the hood. Central Banking 11 (2), 24-37.

Neely, C., 2002. The temporal pattern of trading rule returns and central bank intervention: intervention does not generate technical trading rule profits. Journal of International Economics 58, 211-232.

Newey, W., and K. West, 1987. A simple, positive semidefinite, heteroskedasticity and autocorrelation consistent covariance matrix, Econometrica, 55, 703-708.

Panthaki, F., 2005. Exchange rate volatility and central bank interventions, FMG Discussion Paper No. 550, London School of Economics.

Pasquariello, P., 2004. Central bank intervention and the intraday process of price formation in the currency markets. Mimeo, University of Michigan Business School.

Pasquariello, P., *forthcoming*. Informative trading or just noise? An analysis of currency returns, market liquidity, and transaction costs in proximity of central bank interventions. Journal of Financial Markets.

Payne, R., Vitale, P., 2003. A transaction level study of the effects of central bank intervention on exchange rates. Journal of International Economics 61 (2), 331-352.

Peiers, B., 1997. Informed traders, intervention and price leadership: a deeper view of the microstructure of the foreign exchange market. Journal of Finance 52 (4), 1589-1614.

Rigobon, R. and B. Sack, 2004. The impact of monetary policy on asset prices, Journal of Monetary Economics, 51, 8, 1553-71.

Rime, D., 2003. New electronic trading systems in foreign exchange markets, in D.C. Jones (ed.), New Economy Handbook, Academic Press: Elsevier Science, USA, 469-504.

Sager, M., and M.P. Taylor, 2004. The impact of European central bank governing council announcements on the foreign exchange market: a microstructural analysis, Journal of International Money and Finance, 23, 1043-1051.

Sarno, L., and M.P. Taylor, 2001. Official intervention in the foreign exchange market: is it effective and, if so, how does it work? Journal of Economic Literature 39, 839-868.

Schwarz, G., 1978. Estimating the dimension of a model. Annals of Statistics 6, 461-464.

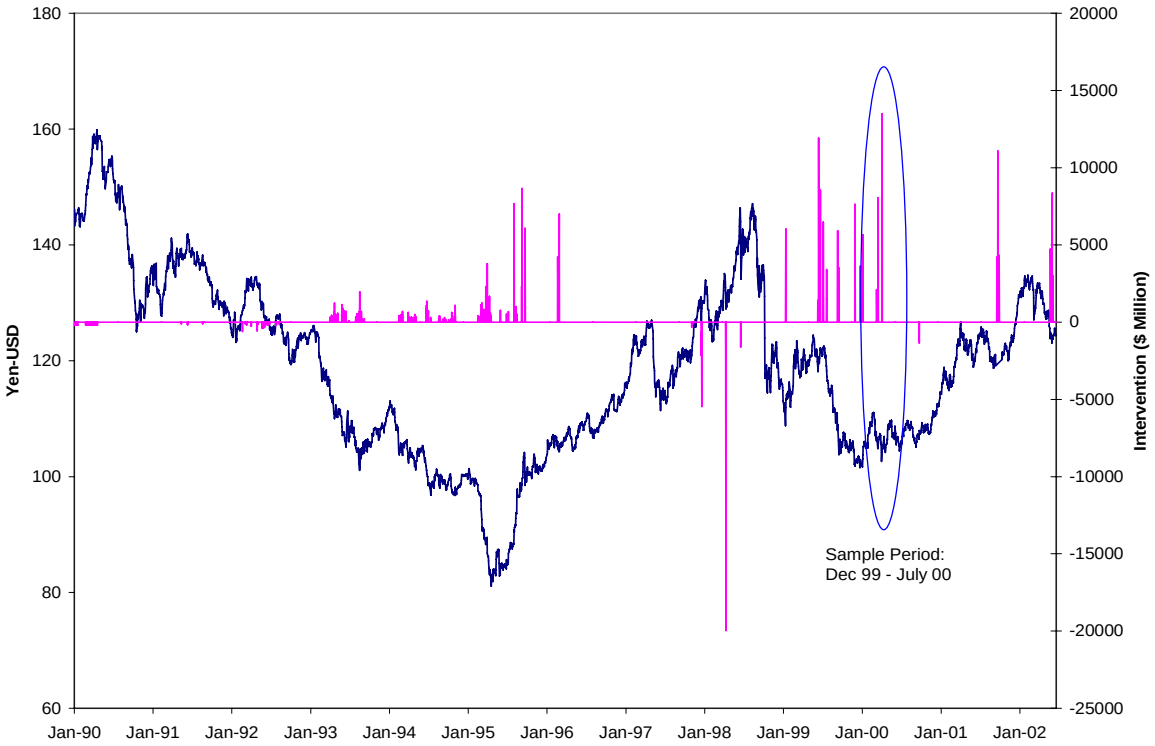
Taylor, M.P., 2004. Is official exchange rate intervention effective? Economica, 71, 1-12.

Taylor, M.P., 2005. Official foreign exchange intervention as a coordinating signal in the dollar-yen market. Pacific Economic Review, 10, 1 73-82.

Vitale, P., 2003. Foreign exchange intervention: how to signal policy objectives and stabilize the economy. Journal of Monetary Economics 50, 841-87.

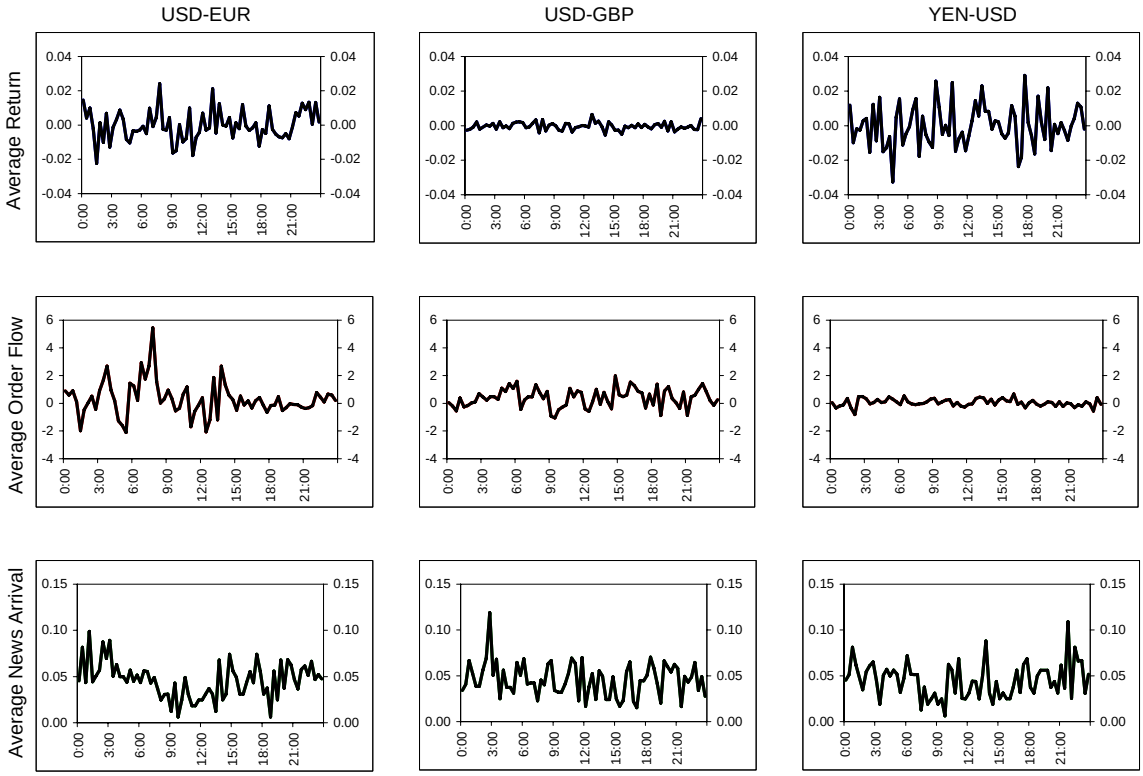
Vitale, P., 1999. Sterilized central bank intervention in the foreign exchange market, Journal of International Economics, 49, 245-267.

Figure 1 Japanese Interventions and the yen-usd rate, 1990-2002



Notes: Left-hand scale shows the daily yen-usd exchange rate and right-hand scale shows daily Japanese interventions (in millions of dollars) from 1990-2002. Daily Japanese intervention data is available at: http://www.mof.go.jp/english/e1c021.htm. Our eight month sample period (circled in the figure) includes five Japanese intervention days.

Figure 2: Average Daily Returns, Order Flow and News Arrival

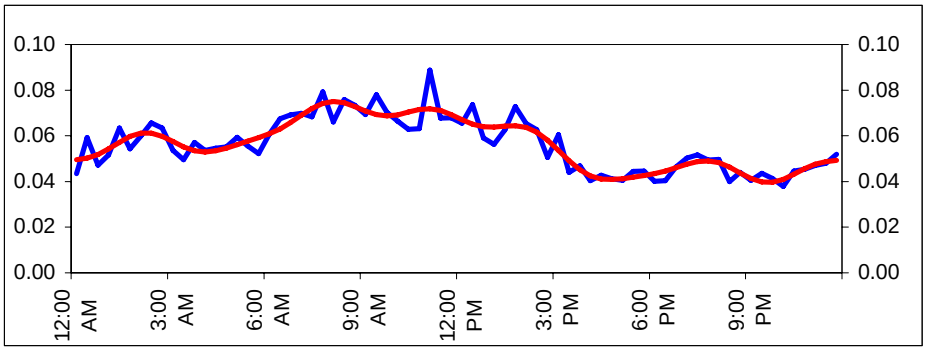


Notes: The data cover the eight month period from 01 Dec 1999 to 24 July 2000 and are sampled at 20-minute frequency. Currencies are defined as the number of dollars per foreign currency for the euro and sterling, and number of foreign currency per dollar for the yen. The figures plot the average intra-daily pattern of returns, order flow and news arrival over a 24-hour period. Returns are calculated as 100 times the log difference of the mid quote where the mid quote is calculated as the average of the bid and ask quotes. Order flow is the net of the total buys and total sells, where a buy (sell) refers to a trade in which the initiator is a purchaser (seller) of the denominator currency (euro for USD-EUR, sterling for USD-GBP and US dollar for YEN-USD). News Arrival is an indicator variable for the number of Reuters news articles in each 20 minute period.

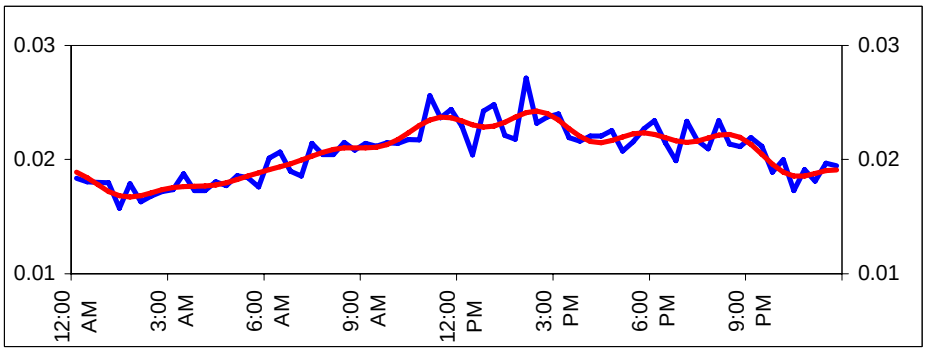
Figure 3: Average Daily Volatility and FFF Seasonal

(in basis points)

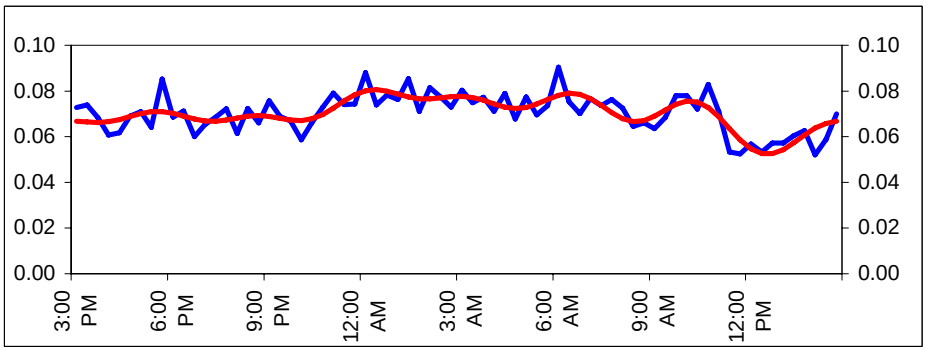
3a. USD-EUR



3b. USD-GBP



3c. YEN-USD



Notes: The data cover the eight month period from 01 Dec 1999 to 24 July 2000 and are sampled at 20-minute frequency. Currencies are defined as the number of dollars per foreign currency for the euro and sterling, and number of foreign currency per dollar for the yen. The figures plot the average intra-daily pattern of volatility (jagged line) and the Flexible Fourier Form seasonal (smooth line) over a 24-hour period. Each 24-hour day starts at midnight, which is 12am GMT for USD-EUR and USD-GBP and 3pm GMT for YEN-USD. Volatility is defined as the absolute return, where returns are calculated as 100 times the log difference of the mid quote. The mid quote is calculated as the average of the bid and ask quotes.

Table 1. Broad Categories of Intervention News

(a) Intervention and News

		News	
		Reported	Not Reported
Policymaker	Threat of Actual or Oral Intervention[1]	Intervention detected[2]	Intervention missed
	No Threat of Actual or Oral Intervention[3]	False intervention[4]	

(b) Interventions and Market Expectations

		Market	
		Expecting	Not Expecting
Policymaker	Threat of Actual or Oral Intervention[1]		Surprise Intervention
	No Threat of Actual or Oral Intervention[3]	Unrequited intervention[5]	

Notes: The data cover the eight month period from 01 Dec 1999 to 24 July 2000. (1) 38 for the Euro-zone, 134 for Japan, 6 joint; (2) the Japanese conducted interventions on 5 days in support of the dollar, all were reported by Reuters; (3) 26 for the Euro-zone, 1 for Japan, I for UK, and 20 joint; (4) there was one false (ECB) intervention; (5) 215 unrequited actual interventions ((Euro-zone: 76, Japan: 91, joint: 48) and 77 unrequited oral interventions (Euro-zone: 8, joint: 69).

Table 2: Summary Statistics of Macro News Announcements

Announcement	Reported as	Local time
UK Announcements (total = 80)		
RPIX	Y/Y % change	08:30 GMT
Retail Sales	M/M % change	08:30 GMT
Global trade	GBP (billion)	08:30 GMT
Provisional M4	M/M % change	08:30 GMT
PPI	M/M % change NSA	08:30 GMT
Industrial Production	M/M % change	08:30 GMT
Unemployment	thousands	08:30 GMT
Current Account	GBP (billion)	08:30 GMT
US Announcements (total = 80)		
PPI	M/M % change	08:30 ET
CPI	M/M % change	08:30 ET
Industrial Production	M/M % change	09:15 ET
Monthly M3	change $ Bln	16:30 ET
Goods & Services Trade Balance	USD (billion)	08:30 ET
Civilian Unemployment Rate	percent	08:30 ET
Nonfarm Payrolls	thousands	08:30 ET
Retail Sales	M/M % change	08:30 ET
Euro Area Announcements (total = 58)		
PPI	M/M % change	11:00 GMT
Harmonised CPI	M/M % change	11:00 GMT
Ind Production	3M/3M % change	11:00 GMT
M3	Y/Y % change	09:00 GMT
Trade ex-EMU prel. EUR	EUR (billion)	11:00 GMT
Unemployment rate	percent	11:00 GMT
Japanese Announcements (total = 122)		
Current Account	billions of Yen	23:50 GMT
Adjusted Merchandise Trade Balance	billions of Yen	23:50 GMT
CPI	M/M % change	23:00 GMT
CPI Tokyo	M/M % change	23:00 GMT
Crude Oil Imports	Y/Y % change	23:30 GMT
Domestic Wholesale Price Index		23:50 GMT
GDP	Q/Q % change	23:50 GMT
Housing Starts	Y/Y % change	05:00 GMT
Job-to-Applicant Ratio		23:00 GMT
Large Scale Retail Sales	Y/Y % change	23:50 GMT
Machine Orders	M/M % change	05:00 GMT
Merchandise Trade Balance Total	billions of Yen	23:50 GMT
Money Supply	Y/Y % change	23:50 GMT
Preliminary Industrial Production	M/M % change	23:50 GMT
Tankan Survey Manufacturing		23:50 GMT
Tertiary Industry Index	M/M % change	23:50 GMT
Unemployment Rate		23:00 GMT
Vehicle Sales	Y/Y % change	00:00 GMT
Workers' Household Spending	Y/Y % change	04:30 GMT

Notes: The data cover the eight month period from 01 Dec 1999 to 24 July 2000. M/M% change refers to month-on-month percentage change. 3M/3M% change is three month-on-three month percentage change. Q/Q% change refers to quarter-on-quarter percentage change. Y/Y% change is year-on-year percentage change. NSA refers to non-seasonally adjusted. 22 GMT is 7am in Japan.

Table 3: Summary Statistics for Returns, Volatility, Order Flow and Transaction Frequency

a. USD-EUR

	Mid Quote	Return	Volatility	Net Order Flow	Order Flow Volatility	Transaction Frequency
Mean	0.97	0.00	5.55	0.27	1.14	30.36
Variance	0.04	9.99	8.30	13.04	1.73	52.13
Skewness	0.10	-0.13	2.93	0.53	2.04	2.30
Kurtosis	2.87	12.07	14.56	17.62	11.62	11.27
Autocorrelation lags						
1	0.99	0.13	0.47	0.04	0.86	0.85
5	0.98	0.05	0.30	0.02	0.61	0.56
10	0.98	0.01	0.19	-0.01	0.38	0.32
20	0.97	-0.02	0.06	0.00	-0.03	-0.04

b. USD-GBP

	Mid Quote	Return	Volatility	Net Order Flow	Order Flow Volatility	Transaction Frequency
Mean	1.57	-0.03	2.06	0.42	1.07	28.02
Variance	0.05	2.88	2.01	7.88	1.17	41.51
Skewness	-0.32	0.00	1.40	0.38	1.39	2.24
Kurtosis	1.83	5.01	7.92	11.40	5.09	9.37
Autocorrelation lags						
1	1.00	0.01	0.36	0.04	0.80	0.79
5	1.00	0.02	0.26	0.02	0.56	0.49
10	1.00	0.00	0.19	0.00	0.35	0.27
20	1.00	0.01	0.12	0.00	0.00	-0.11

c. YEN-USD

	Mid Quote	Return	Volatility	Net Order Flow	Order Flow Volatility	Transaction Frequency
Mean	106.29	0.01	7.01	0.06	0.26	2.83
Variance	2.28	14.06	12.19	2.98	0.36	4.96
Skewness	-0.19	0.17	4.23	0.18	1.91	3.30
Kurtosis	3.15	21.82	26.83	20.46	8.45	20.50
Autocorrelation lags						
1	0.98	0.07	0.49	0.15	0.66	0.66
5	0.95	0.04	0.17	0.04	0.47	0.43
10	0.93	0.03	0.11	0.02	0.32	0.27
20	0.91	0.01	0.04	-0.01	0.11	0.11

Notes: The data cover the eight month period from 01 Dec 1999 to 24 July 2000 and are sampled at 20-minute frequency. Currencies are defined as the number of dollars per foreign currency for the euro and sterling, and number of foreign currency per dollar for the yen. The mid quote is calculated as the average of the bid and ask quotes. Returns are defined as 100 times the log difference of the mid quote. Volatility is defined as the absolute return. Order flow is the net of the total buys and total sells, where a buy (sell) refers to a trade in which the initiator is a purchaser (seller) of the denominator currency (euro for USD-EUR, sterling for USD-GBP and the US dollar for the YEN-USD). Order flow volatility is the standard deviation of order flow and transaction frequency is the number of actual trades in each 20-minute period.

Table 4: Contemporaneous Correlations

a. USD-EUR

	Return	Volatility	Total Buy Orders	Total Sell Orders	Order Flow	Order Flow Volatility	Transaction Frequency	Reuters News
Return	1	…	…	…	…	…	…	…
Volatility	-0.011	1	…	…	…	…	…	…
Total Buy Orders	0.108	0.321	1	…	…	…	…	…
Total Sell Orders	-0.141	0.324	0.882	1	…	…	…	…
Order Flow	0.511	0.011	0.292	-0.193	1	…	…	…
Order Flow Volatility	-0.023	0.317	0.921	0.934	0.022	1	…	…
Transaction Frequency	-0.015	0.333	0.971	0.969	0.054	0.956	1	…
Reuters News	0.005	0.018	-0.007	-0.007	-0.001	-0.008	-0.007	1

b. USD-GBP

	Return	Volatility	Total Buy Orders	Total Sell Orders	Order Flow	Order Flow Volatility	Transaction Frequency	Reuters News
Return	1	…	…	…	…	…	…	…
Volatility	-0.033	1	…	…	…	…	…	…
Total Buy Orders	0.050	0.397	1	…	…	…	…	…
Total Sell Orders	-0.091	0.397	0.930	1	…	…	…	…
Order Flow	0.376	0.013	0.222	-0.151	1	…	…	…
Order Flow Volatility	-0.025	0.452	0.909	0.908	0.037	1	…	…
Transaction Frequency	-0.020	0.404	0.983	0.982	0.038	0.925	1	…
Reuters News	-0.001	-0.008	-0.023	-0.017	-0.016	-0.023	-0.022	1

c. YEN-USD

	Return	Volatility	Total Buy Orders	Total Sell Orders	Order Flow	Order Flow Volatility	Transaction Frequency	Reuters News
Return	1	…	…	…	…	…	…	…
Volatility	0.014	1	…	…	…	…	…	…
Total Buy Orders	0.120	0.180	1	…	…	…	…	…
Total Sell Orders	-0.111	0.168	0.469	1	…	…	…	…
Order Flow	0.224	0.016	0.533	-0.497	1	…	…	…
Order Flow Volatility	0.010	0.226	0.799	0.782	0.036	1	…	…
Transaction Frequency	0.007	0.203	0.861	0.853	0.028	0.922	1	…
Reuters News	-0.003	-0.008	-0.011	0.010	-0.020	0.003	-0.001	1

Notes: The data cover the eight month period from 01 Dec 1999 to 24 July 2000 and are sampled at 20-minute frequency. Currencies are defined as the number of dollars per foreign currency for the euro and sterling, and number of foreign currency per dollar for the yen. Returns are defined as 100 times the log difference of the mid quote where the mid quote is calculated as the average of the bid and ask quotes. Volatility is defined as the absolute return. Order flow is the net of the total buys and total sells, where a buy (sell) refers to a trade in which the initiator is a purchaser (seller) of the denominator currency (euro for USD-EUR, sterling for USD-GBP and the US dollar for the YEN-USD). Order flow volatility is the standard deviation of order flow and transaction frequency is the number of actual trades in each 20-minute period. Reuters News is the number of intervention news reports in each 20 minute period.

Table 5: The Influence of Intervention News on Returns

	USD-EUR					USD-GBP					YEN-USD				
Independent Variables	Benchmark		Benchmark + Reuters News			Benchmark		Benchmark + Reuters News			Benchmark		Benchmark + Reuters News		
Constant	0.0000		-0.0003			-0.0004		-0.0003			0.0003		0.0007		
Japanese Intervention Indicator															
leads 2-6	0.0026		0.0021			-0.0031		-0.0038			-0.0001		-0.0213		
lead 1	-0.0030		0.0010			-0.0041		-0.0068			-0.0615	**	-0.0938	**	
lag 0	-0.0014		-0.0245			0.0226		0.0191			-0.0394	*	-0.0600	**	
lag 1	0.0005		0.0034			-0.0075	*	-0.0097	**		-0.0344		-0.0450	*	
lags 2-6	0.0002		0.0008			0.0017		0.0011			-0.0368	*	-0.0459	**	
Lagged Dependent variable															
lag 1	0.1205	***	0.1116	***		0.0147		0.0125			0.0626		0.0577		
lag 2	0.1014	***	0.0946	***		0.0084		0.0074			0.1217	***	0.1172	***	
Macro Surprises															
UK	0.0083		0.0072			0.0053		0.0049			0.0005		0.0000		
US	-0.0117		-0.0115			0.0024		0.0024			-0.0067		-0.0065		
Euro-zone	0.0181		0.0160			0.0027		0.0026			-0.0162		-0.0177		
Japan	0.0241	**	0.0236	**		0.0038		0.0034			-0.0057		-0.0056		
				F-test	Wald Test				F-test	Wald Test				F-test	Wald Test
News from Policymakers															
Euro-zone															
Oral Policy			0.0285	***				0.0056					0.0992	***	
Intervention			0.0625	***	**			0.0053					0.0041	***	
No intervenion			-0.0676	***	*			-0.0172					0.0076	***	
Japan															
Oral Policy			-0.2142	***	***			-0.0207					0.0846	***	
Intervention			0.0064	***				0.0077					0.0355	***	
No intervenion			-0.5935	***	***			-0.0514					0.0795	***	
UK															
Oral Policy			-0.1032	***				0.0269					-0.0804	***	
Intervention			0.0403	***				-0.0599					-0.0273	***	
No intervenion			-0.2720	***				…					-0.3854	***	
Joint															
Intervention			0.0513	***	***			-0.0039					0.1313	***	*
No intervenion			-0.0391	***				-0.0001					-0.0360	***	
News about Market's Expectations															
Euro-zone															
Intervention			0.0239	***				-0.0574					0.0495	***	
No intervenion			-0.0649	***				0.0079					-0.0955	***	
Japan															
Intervention			0.1148	***				0.0569		*			-0.5120	***	**
Joint															
Intervention			0.0800	***				0.0145					0.0885	***	
No intervenion			-0.0832	***	***			0.0016					0.0260	***	
News about Policymaker-Market Interactions															
Euro-zone intervention denied			0.0021	***				…					-0.5978	***	**
Market detects Japan intervention			0.0054	***				-0.0010					0.0054	***	
News about Unrequited Interventions															
Euro-zone															
Unrequited actual intervention			-0.0008	***				0.0069		**			-0.0035	***	
Unrequited oral intervention			-0.0611	***				-0.0317					0.0651	***	
Japan															
Unrequited actual intervention			0.0335	***				-0.0031					-0.0099	***	
Joint															
Unrequited actual intervention			-0.0266	***				-0.0027					-0.0336	***	
Unrequited oral intervention			0.0067	***				0.0020					-0.0781	***	**
Rbar-squared	0.0275		0.0317			-0.0001		0.0002			0.0194		0.0178		
F-test (all regressors)	35.91	***	4.23	***		0.97		1.03			25.06	***	2.76	***	

Notes: Returns are calculated at 20 minute frequency and are defined as 100 times the log difference of the mid quote where the mid quote is calculated as the average of the bid and ask quotes. *, ** and *** represent significance at 10, 5 and 1 percent respectively. Significance for the upper panel of the table is based on the t-statistic. Coefficients for each "news" regressor (in the lower panel of the table) represent the sum of all coefficients from lead 6 to lag 6. The individual F-tests are exclusion restrictions for the six leads and lags of each regressor. The Wald tests are for the null hypothesis that the sum of the six leads and lags is equal to zero.

Table 6: The Influence of Intervention News on Returns in "High Volatility" and "High News Arrival" Periods

	"High volatility"								"High news arrival"							
Independent Varia$Bles	USD-EUR			USD-G$BP			YEN-USD		USD-EUR			USD-G$BP			YEN-USD	
Constant	-0.0008			-0.0003			0.0010		-0.0004			-0.0003			0.0007	
Japanese Intervention																
leads 2-6	-0.0054			-0.0028			-0.0049		-0.0014			-0.0018			-0.0234	
lead 1	-0.0030			-0.0045			-0.0701	**	-0.0028			-0.0068			-0.0942	**
lag 0	-0.0084			-0.0004			-0.0357		-0.0206			0.0192			-0.0595	**
lag 1	0.0021			-0.0083	*		-0.0441	*	0.0049			-0.0094	**		-0.0475	**
lags 2-6	0.0029			0.0027			-0.0441	**	-0.0009			0.0012			-0.0455	**
Lagged Dependent variable																
lag 1	0.0730	***		0.0163			0.0491		0.1052	***		0.0154			0.0555	
lag 2	0.0723	***		0.0054			0.1082	***	0.0879	***		0.0057			0.1167	***
Macro Surprises																
UK	0.0068			0.0059			0.0024		0.0068			0.0052			0.0002	
US	-0.0103			0.0022			0.0090		-0.0108			0.0025			-0.0063	
Euro-zone	-0.0006			0.0017			-0.0162		0.0148			0.0027			-0.0166	
Japan	0.0228	**		0.0035			-0.0056		0.0232	**		0.0033			-0.0050	
Interaction Terms		F-test	Wald Test		F-test	Wald Test		F-test	Wald Test		F-test	Wald Test		F-test	Wald Test		F-test	Wald Test
News from Policymakers																		
Euro-zone																		
Oral Policy	-0.2796	***	**	-0.0171	***		1.5151	***	0.0131	***	***	0.0017			-0.0358	***		
Intervention	1.0991	***		-0.2042	***		0.2584	***	-0.0763	***	***	-0.0360			0.0106	***		
No intervenion	-0.8976	***	***	0.0222	***		0.2747	***	0.0765	***	***	0.0035			0.1191	***		
Japan																		
Oral Policy	-2.5053	***	***	0.0049	***		-0.6283	***	0.0350	***	***	-0.0028			-0.1048	***		
Intervention	0.1362	***		0.0588	***		0.4517	***	-0.0363	***	***	-0.0117			-0.0558	***		
No intervenion	…			…			…		-0.0314	***	***	-0.0371			-0.0373	***		
UK																		
Intervention	0.1290	***		0.0566	***		-0.7862	***	-0.2598	***	***	-0.0609			0.2572	***		
Joint																		
Intervention	0.1564	***		-0.0214	***		0.5202	***	0.3233	***	***	-0.0413			-0.0507	***		
No intervenion	-0.3180	***	***	-0.0036	***		-0.9098	***	-0.2488	***	***	-0.0441			0.0804	***		
News about Market's Expectations																		
Euro-zone																		
Intervention	-0.3286	***		0.0250	***		1.8344	***	-4.0615	***	***	-8.5049			-19.7749	***		
No intervenion	-0.7514	***		0.0811	***		0.3384	***	***	33.8263	***	***	8.9223			-6.1190	***	
Japan																		
Intervention	0.0242	***		0.0477	***		0.6929	***	-0.0202	***	***	0.0035			-0.0209	***		
Joint																		
Intervention	2.6037	***		-0.1261	***		1.6604	***	0.2984	***	***	0.0025			-0.2385	***		
No intervenion	-0.7002	***		0.0035	***		-0.3037	***	***	-0.1168	***	***	-0.0125			0.0000	***	
News about Policymaker-Market Interactions																		
Euro-zone intervention denied	…			…			-1.0636	***	-0.0997	***	***	…			0.0525	***		
Market detects Japan intervention	0.5193	***	***	0.0233	***		1.4374	***	-0.0407	***	***	-0.0151			0.1471	***		
News about Unrequited Interventions																		
Euro-zone																		
Unrequited actual intervention	-0.0046	***	**	0.0106	***	***	0.0394	***	0.0063	***	***	0.0090			-0.0136	***		
Unrequited oral intervention	…			…			-0.1560	***	-0.0384	***	***	-0.0116			-0.0563	***		
Japan																		
Unrequited actual intervention	0.1892	***		-0.0914	***		-0.8888	***	0.0887	***	***	0.0318			-0.0321	***		
Joint																		
Unrequited actual intervention	-0.1281	***		0.1267	***		0.9163	***	-0.2688	***	***	0.0766			0.1690	***		
Unrequited oral intervention	-0.2781	***		-0.1580	***		-0.7987	***	0.2649	***	***	0.0016			-0.1750	***		
Rbar-squared	0.1083			0.0235			0.0611		0.0363			-0.0004			0.0168			
F-test (all regressors)	8.82	***		2.50	***		5.29	***	3.45	***		0.98			2.11	***		

Notes: Returns are calculated at 20 minute frequency and are defined as 100 times the log difference of the mid quote where the mid quote is calculated as the average of the bid and ask quotes. *, ** and *** represent significance at 10, 5 and 1 percent respectively. Significance for the upper panel of the table is based on the t-statistic. Coefficients for each "news" regressor (in the lower panel of the table) represent the sum of all coefficients from lead 6 to lag 6. The individual F-tests are exclusion restrictions for the six leads and lags of each regressor. The Wald tests are for the null hypothesis that the sum of the six leads and lags is equal to zero.

Table 7: The Influence of Intervention News on Volatility

	USD-EUR					USD-GBP					YEN-USD				
Independent Variables	Benchmark		Benchmark + Reuters News			Benchmark		Benchmark + Reuters News			Benchmark		Benchmark + Reuters News		
Constant	-0.0001		-0.0004			0.0000		0.0000			-0.0001		-0.0001		
Japanese Intervention															
leads 2-6	-0.0015		-0.0044			0.0072		0.0065			-0.0256		-0.0281		
lead 1	-0.0411	***	-0.0426	***		-0.0133	***	-0.0159	***		-0.0068		-0.0109		
lag 0	-0.0299	***	-0.0228			0.0093		0.0110			-0.0223	*	-0.0352		
lag 1	-0.0255	***	-0.0266	**		-0.0164	**	-0.0147	**		-0.0130		-0.0125		
lags 2-6	-0.0171	***	-0.0163	**		-0.0049	*	-0.0045	*		-0.0094		-0.0076		
Lagged Dependent variable															
lag 1	0.3191	***	0.3126	***		0.2232	***	0.2214	***		0.4385	***	0.4339	***	
lag 2	0.1236	***	0.1191	***		0.1267	***	0.1253	***		0.0323		0.0299		
lag 3	0.1037	***	0.1015	***		0.0948	***	0.0933	***		0.0595	***	0.0575	***	
lag 4	0.0794	***	0.0791	***		0.0858	***	0.0880	***		0.0275	*	0.0298	*	
lag 5	0.0466	***	0.0478	***		0.0859	***	0.0877	***		0.0207		0.0216	*	
lag 6	0.0467	***	0.0496	***		0.0685	***	0.0698	***		0.0456	***	0.0468	***	
Macro Surprises															
UK	-0.0077		-0.0071			0.0000		-0.0001			-0.0036		-0.0042		
US	0.0079		0.0080			-0.0026		-0.0024			0.0168		0.0177		
Euro-zone	0.0042		0.0029			-0.0045		-0.0037			-0.0047		-0.0059		
Japan	0.0167	*	0.0169	**		0.0019		0.0019			0.0030		0.0029		
				F-test	Wald Test				F-test	Wald Test				F-test	Wald Test
News from Policymakers															
Euro-zone															
Oral Policy			-0.0223	***				0.0036	***				-0.0274	***	
Intervention			0.0002	***				-0.0044	***				-0.0210	***	
No intervenion			-0.0234	***				-0.0001	***				-0.0186	***	
Japan															
Oral Policy			-0.0216	***				-0.0071	***	*			-0.0377	***	
Intervention			-0.0130	***				-0.0002	***				0.0038	***	
No intervenion			0.2939	***				0.0057	***	*			-0.1088	***	
UK															
Oral Policy			0.0412	***				-0.0137	***				-0.0602	***	
Intervention			0.0321	***				0.0082	***	**			0.0082	***	
No intervenion			0.0500	***				0.0000	***	***			0.0290	***	
Joint															
Intervention			0.0708	***				-0.0022	***				0.0166	***	*
No intervenion			0.0209	***				0.0027	***				-0.0215	***	
News about Market's Expectations															
Euro-zone															
Intervention			0.0834	***				0.0181	***				0.0753	***	
No intervenion			-0.0176	***				-0.0101	***				0.0032	***	
Japan															
Intervention			-0.0220	***				0.0349	***				0.2280	***	
Joint															
Intervention			-0.0184	***	**			-0.0004	***				0.0110	***	
No intervenion			-0.0320	***				0.0025	***				0.0035	***	
News about Policymaker-Market Interactions															
Euro-zone intervention denied			0.0174	***				0.0000	***	***			0.3014	***	***
Market detects Japan intervention			-0.0134	***				-0.0015	***				0.0002	***	
News about Unrequited Interventions															
Euro-zone															
Unrequited actual intervention			0.0007	***				0.0033	***				-0.0116	***	
Unrequited oral intervention			-0.0606	***				-0.0172	***				-0.0536	***	
Japan															
Unrequited actual intervention			0.0228	***				-0.0004	***				0.0029	***	
Joint															
Unrequited actual intervention			0.0002	***	*			-0.0049	***				-0.0208	***	
Unrequited oral intervention			0.0013	***	***			-0.0008	***				0.0078	***	
Rbar-squared	0.2901		0.2910			0.2135		0.2131			0.2541		0.2548		
F-test (all regressors)	360	***	40	***		209	***	25	***		296	***	33	***	

Notes: Returns are calculated at 20 minute frequency and are defined as 100 times the log difference of the mid quote where the mid quote is calculated as the average of the bid and ask quotes. *, ** and *** represent significance at 10, 5 and 1 percent respectively. Significance for the upper panel of the table is based on the t-statistic. Coefficients for each "news" regressor (in the lower panel of the table) represent the sum of all coefficients from lead 6 to lag 6. The individual F-tests are exclusion restrictions for the six leads and lags of each regressor. The Wald tests are for the null hypothesis that the sum of the six leads and lags is equal to zero.

Table 8: The Influence of Intervention News on Transaction Frequency

	USD-EUR					USD-GBP					YEN-USD				
Independent Variables	Benchmark		Benchmark + Reuters News			Benchmark		Benchmark + Reuters News			Benchmark		Benchmark + Reuters News		
Constant	-0.0901		-0.1202			-0.1033		-0.0058			0.0238		0.0228		
Japanese Intervention															
leads 2-6	-4.1961	***	-1.0888			-1.2462		-0.0416			-0.7591	***	-0.8314	***	
lead 1	-4.6617	**	-2.2000			-4.6529		-2.6797			-0.6516	***	-0.5112		
lag 0	-4.9106	**	0.4313			-5.0647	**	-2.9112	*		-0.7455	***	-0.5577		
lag 1	-4.8273	**	-2.6017			-6.4330	**	-4.9652	*		-0.5991	***	-0.5347	**	
lags 2-6	-5.4774	***	-5.3553	***		-4.4389	***	-3.4090	**		-0.5534	***	-0.6662	***	
Lagged Dependent variable															
lag 1	0.7755	***	0.7699	***		0.6057	***	0.6012	***		0.4559	***	0.4528	***	
lag 2	0.0427		0.0435			0.1520	***	0.1499	***		0.1610	***	0.1637	***	
lag 3	0.0516	**	0.0535	**		0.1126	***	0.1135	***		0.0806	***	0.0777	***	
lag 4	0.0286		0.0302			0.0003		0.0018			0.0471	***	0.0464	***	
lag 5	0.0006		0.0022			-0.0130		-0.0119			0.0411	**	0.0432	**	
lag 6	-0.0202		-0.0228			-0.0082		-0.0075			0.0189		0.0183		
Macro Surprises															
UK	-0.7112		-0.4355			-3.4219		-3.3835			0.6023		0.6344		
US	-3.2518		-3.1317			-8.1411		-7.4204			-0.1137		-0.0810		
Euro-zone	5.0465		4.3927			2.8137		4.0070			0.1512		0.1080		
Japan	1.2362		1.2640			3.2781		3.3334			0.0457		0.0578		
				F-test	Wald Test				F-test	Wald Test				F-test	Wald Test
News from Policymakers															
Euro-zone															
Oral Policy				-0.8451	***				5.4976	***				-1.1338	***	*
Intervention				-7.8173	***				2.5021	***				0.0237	***	
No intervenion				-2.4841	***				-4.6132	***				-0.1862	***	
Japan															
Oral Policy				-9.5428	***				-13.8889	***				-3.2321	***	
Intervention				-5.5828	***				-3.2929	***				0.4353	***	
No intervenion				-8.8341	***				-16.4646	***				-0.6557	***	
UK															
Oral Policy				-4.6169	***				-35.9528	***				-3.6353	***	
Intervention				21.2232	***	**			24.4042	***	***			-0.7175	***	
No intervenion				62.0837	***				0.0000	***	***			-2.5963	***	***
Joint															
Intervention				-15.1287	***				-6.5957	***				1.4204	***	
No intervenion				-3.5515	***				13.2230	***				-2.2718	***	*
News about Market's Expectations															
Euro-zone															
Intervention				0.2503	***	**			15.9818	***				0.1355	***	
No intervenion				-17.6266	***				-14.3607	***				-1.3407	***	
Japan															
Intervention				-61.4805	***	***			-27.1369	***				-3.2594	***	
Joint															
Intervention				2.2816	***				0.9085	***				-0.4039	***	
No intervenion				10.1862	***				30.3033	***				7.9178	***	***
News about Policymaker-Market Interactions															
Euro-zone intervention denied				-19.4562	***				0.0000	***	***			5.4402	***	***
Market detects Japan intervention				-1.1506	***				-8.5638	***				-0.9340	***	
News about Unrequited Interventions															
Euro-zone															
Unrequited actual intervention				14.9062	***				2.2208	***				0.7883	***	
Unrequited oral intervention				-9.2145	***				-11.2818	***				-1.0867	***	
Japan															
Unrequited actual intervention				7.5046	***				4.4229	***				-0.2101	***	
Joint															
Unrequited actual intervention				-2.4655	***				-3.3131	***				0.0766	***	
Unrequited oral intervention				-3.8946	***				-5.5740	***				-0.6304	***	*
Rbar-squared	0.7444		0.7446			0.6529		0.6522			0.4814		0.4834		
F-test (all regressors)	2557	***	279	***		1440	***	170	***		805	***	89	***	

Notes: Transaction frequency is calculated as the number of transactions in any given 20 minute period. *, ** and *** represent significance at 10, 5 and 1 percent respectively. Significance for the upper panel of the table is based on the t-statistic. Coefficients for each "news" regressor (in the lower panel of the table) represent the sum of all coefficients from lead 6 to lag 6. The individual F-tests are exclusion restrictions for the six leads and lags of each regressor. The Wald tests are for the null hypothesis that the sum of the six leads and lags is equal to zero.

Table 9: The Influence of Order Flow on Returns

	Return on order flow		
Independent Variables	USD-EUR	USD-GBP	YEN-USD
Constant	-0.0007	-0.0008 ***	-0.0004
Lagged Dependent Variable			
lag 1	0.1675 ***	0.0219	0.0569
lag 2	0.1092 ***	0.0279 **	0.1166 ***
Order Flow			
Contemporaneous	0.0039 ***	0.0014 ***	0.0104 ***
lag1	-0.0010 ***	-0.0002 ***	-0.0008
lags 2-6	0.0000	0.0000	-0.0003 **
Rbar-squared	0.0279	0.1429	0.0677
F-test (all regressors)	1310 ***	448 ***	221 ***

Notes: Returns and order flow are calculated at 20 minute frequency. Returns are defined as 100 times the log difference of the mid quote .The mid quote is calculated as the average of the bid and ask quotes. Order flow is the net of the total buys and total sells, where a buy (sell) refers to a trade in which the initiator is a purchaser (seller) of the denominator currency (euro for USD-EUR, sterling for USD-GBP and US dollar for YEN-USD). *, ** and *** represent significance at 10, 5 and 1 percent, respectively. Significance is based on the t-statistic.

Table 10. The Influence of Intervention News on Order Flow

	USD-EUR		USD-GBP		YEN-USD	
Independent Variables	Benchmark	Benchmark + Reuters News	Benchmark	Benchmark + Reuters News	Benchmark	Benchmark + Reuters News
Constant	0.2666	0.2759 **	0.3996 ***	0.4634 ***	0.0506 *	0.0851 ***
Japanese Intervention						
leads 2-6	-0.0745	-0.5618	0.8630	0.6523	0.2239 *	0.0924
lead 1	-0.0506 **	1.2326	-1.0250	-0.6853	0.0915	-0.1048
lag 0	-0.2786 **	-0.5813	1.4212	1.9847	-0.0975 **	-0.1959
lag 1	-0.2626 **	0.0313	-0.6675	-0.6011	-0.0596 **	-0.1645
lags 2-6	-0.2666 **	0.0604	-0.5724 *	-0.7803	-0.0506 *	-0.0836
Lagged Dependent variable						
lag 1	0.0399	0.0379 **	0.0407 **	0.0370 **	0.1448 ***	0.1405 ***
lag 2	-0.0202 ***	-0.0237	0.0091	0.0068	0.0449 **	0.0440 **
Macro Surprises						
UK	3.0779	2.9382	2.7724	2.6714	-0.6831	-0.7494
US	-0.3832	-0.3064	1.7723	1.7367	-0.3029	-0.2943
Euro-zone	2.1095	1.8050	-0.8338	-1.1205	-0.5074	-0.5557
Japan	-0.5666 ***	-0.7007	1.1653	1.0225	-0.0051	-0.0362
		F-test Wald Test		F-test Wald Test		F-test Wald Test
News from Policymakers						
Euro-zone						
Oral Policy		5.6522		-0.9875		-0.1881 ***
Intervention		5.6845 *		-5.2476		0.5707 ***
No intervenion		-4.9886		0.9475		-0.6269 ***
Japan						
Oral Policy		-5.1987		1.6619		-0.8987 ***
Intervention		0.4738		-1.5611		0.3872 ***
No intervenion		-6.2427		-13.4875		0.4510 ***
UK						
Oral Policy		-1.5977		6.1912		-8.3645 ***
Intervention		7.3140		-15.6653 **		2.7784 ***
No intervenion		-73.2060 ***		0.0000		-14.0207 *** **
Joint						
Intervention		-1.2165		6.2558		0.9641 ***
No intervenion		0.3160		2.0383 **		-1.8633 ***
News about Market's Expectations						
Euro-zone						
Intervention		-3.6648 **		2.1373		5.1265 ***
No intervenion		-3.6073		-6.1506		-2.6148 ***
Japan						
Intervention		-0.9566		24.0111 **		-0.5457 ***
Joint						
Intervention		-3.3238		4.4762		-2.0084 ***
No intervenion		-15.1552 **		-0.1322		1.0609 *** **
News about Policymaker-Market Interactions						
Euro-zone intervention denied		3.2289		0.0000		-12.9331 *** ***
Market detects Japan intervention		-1.0236		1.1837		-0.3967 ***
News about Unrequited Interventions						
Euro-zone						
Unrequited actual intervention		1.3072		-1.0556		-0.4556 *** *
Unrequited oral intervention		-10.0007		5.7612		3.3315 ***
Japan						
Unrequited actual intervention		2.5613		-0.6994		-0.3581 ***
Joint						
Unrequited actual intervention		0.1258		-1.0981		1.0570 ***
Unrequited oral intervention		1.7268		-1.1626		-0.5606 ***
Rbar-squared	0.0014	0.0010	0.0016	0.0013	0.0244	0.0263
F-test (all regressors)	2.89 **	1.11	2.86 **	1.13	31.43 ***	3.63 ***

Notes: Order flow are calculated at 20 minute frequency. It is the net of the total buys and total sells, where a buy (sell) refers to a trade in which the initiator is a purchaser (seller) of the denominator currency (euro for USD-EUR, sterling for USD-GBP and US dollar for YEN-USD). *, ** and *** represent significance at 10, 5 and 1 percent respectively. Significance for the upper panel of the table is based on the t-statistic. Coefficients for each "news" regressor (in the lower panel of the table) represent the sum of all coefficients from lead 6 to lag 6. The individual F-tests are exclusion restrictions for the six leads and lags of each regressor. The Wald tests are for the null hypothesis that the sum of the six leads and lags is equal to zero.