Price Impacts of Deals and Predictability of the Exchange Rate Movements

Takatoshi ITO♣ and Yuko HASHIMOTO♦

June 11, 2006

Abstract:

This paper examines the price impact and the predictability of the exchange rate movement using the transaction data recorded in the electronic broking system of the spot foreign exchange market. With the institutional change in markets in recent years (such as the widespread use of computers in the FOREX markets), traders tend not to accumulate large positions during the day and square position at the end of business hours. In the actual transactions data, the number of deals (on each of Ask or Bid side) for a specified time interval may correspond to "order flows" in Richard Lyons' work. In the analysis, we examine the impact of order flows on the price quotation and movements: whether deals at the ask (bid) side in a row will have an impact on the exchange rate to depreciate (appreciate) depends on the depth of market.

Then, the price predictability is examined. We examine whether deals done at period t at either side predict the price movement for the next period, t+1, using information that is contained in the data set. From our regression to forecast the exchange rate for the next X minutes (X=1, 5, 15, 30), we find that coefficients are significantly different from zero for both 5-min and 1-min forecast horizons, but the significance disappears in the 30-minute interval. It is also found that t-statistics become larger as the prediction window becomes shorter. Price impacts of deals on one side of the market, that likely reflects order flows, are significant but short-lived. If one is in the market and observes these phenomena on the real time basis, price movements in the next few minutes may be predictable.

JEL: F31, F33, G15

♣ Takatoshi Ito *Corresponding Author
Professor, Graduate School of Economics, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo, 113-0033 Japan
Email: tito@e.u-tokyo.ac.jp   TEL: 81-3-5841-5608   FAX: 81-3-5841-5521
♦ Yuko Hashimoto
Faculty of Economics, Toyo University, 5-28-20 Hakusan, Bunkyo-ku, Tokyo, 112-8606 Japan
Email: yhashi@toyonet.toyo.ac.jp   TEL: 81-3-3945-7411, FAX: 81-3-3945-7667

1. Introduction

The overwhelming majority of the spot foreign exchanges are now transacted through the global electronic broking systems—EBS and Reuters D3000.[1] This is the contrast to the situation fifteen years ago, when brokers in the interbank market were mostly human. Euro/dollar and dollar/yen are one of the key currencies traded on EBS, whereas Reuters have strengths in transactions of sterling/dollar, CAD/dollar, AUD/dollar, and NZD/dollar.

The EBS system works as follows. (Details of the EBS system and characteristics of the data are explained in Ito and Hashimoto (2004).)   A bank dealer places a "firm" limit order, either ask or bid, with specified price and units that the dealer is ready to trade if hit. A member bank set credit limit to each of possible trading partners in the EBS system when it joins the system. The credit/counterparty risk is controlled by the EBS computer automatically. The computer collects these orders and show on the screen of each member the following information, "best ask", "best bid", "best ask for the member", and "best bid for the member."   If the former two do not agree with those of the latter two, respectively, then the member does not have a credit line with the market maker(s) that is (are) posting the best ask/bid.   The computer continuously clear the order whenever the sell and buy order matches at the same price. The electronic broking system is a centralized network of traders. In a sense, the electronic broking system can be regarded either as a collection of large numbers of market makers or as a continuous (Walrasian) auctioneer.   We will use a dollar/yen and euro/dollar data set provided by EBS.[2]

Retail customers place their buy or sell orders via banks, based on their private information. Then, banks, either adding their own positions or not, transmit those customers' orders to the electronic broking system.

As the trading system is highly computerized, trading strategies of banks have evolved too.   Until several years ago, bank dealers who received customers' orders were allowed by bank policy to hold their own proprietary positions for profit-taking. They tended to add their own positions when they executed the customers' orders if they felt that customer' orders contained some valuable information.   Receiving customers'

---

[1] For papers that use electronic broking systems, see Goodhard, Ito, and Payne (1996) and Goodhart and Payne (1996).
[2] The data set was provided for fee by the EBS Co., for the use at the University of Tokyo, Graduate School of Economics. The authors are grateful to EBS for such an arrangement.

orders meant a special information advantage in reading the direction of the foreign exchange market. See Lyons (1995, 1996, 1997, 1998, 2001) for modeling this line of reasoning. However, by now, dealers in the bank tend to have only very small amounts of their own proprietary positions. Proprietary trading has been shifted to an independent department, sometimes characterized as an in-house hedge fund. A proprietary trading section uses more computer modeling than private information possibly extracted from customers' trading. Spending millions of dollars on programmers (often physics Ph.D.s) and high-speed computers is a main feature of trading strategy. Clearly they see profit opportunities by betting on directions of the exchange rate in the very short-run, say a few minutes to several hours.

In contrast, many economists still believe that the exchange rate is a random walk, and it would be a profitless effort to conceive a model that can predict an exchange rate movement. The gap between the academic random walk and millions of dollars invested for a bet on predictable movements in the real world is remarkable. This is pointed out in Ito (2005). What is lagging is foreign exchange modeling in the academic literature.

Conventional wisdom in the academic literature is that the exchange rate follows random walk for frequencies less than annual, e.g., daily, weekly, or even monthly, whereas it shows some time trends and history dependence at lower frequencies. Some studies in the microstructure focuses on very high frequency movements of the exchange rate and show that the exchange rate may respond to pressures of customers' orders. Evans and Lyons (2002), for example, reported a positive relation between daily exchange rate returns and order flows for Deutsche mark/dollar. Berger et al. (2005) also showed a positive relationship between order flows and the exchange rate, while they reported no evidence of the predicting power of order flows for future exchange rate.

Therefore, we are interested in the relationship between pressures of sell orders or buy orders and the price movements responding to these orders in the next few minutes to half an hour. We do not have direct observations of order flows from customers to banks, but given the structural change in the bank themselves, customer orders themselves may not be that important any more. Orders from computer-generated programs in an in-house proprietary trading department are equally important. Therefore we take actual deals done in the market as the pressures in the market.

The EBS data record the ask-side deals or bid-side deals for every second. (Lowest given or highest paid are recorded for each second, when at least one trade on either side was executed.) Therefore by taking the difference between the number of ask-side trades and the number of bid-side trades, we can infer whether there are more sell orders or buy orders in the market.

The EBS data were exploited in two papers written by Federal Reserve Board economists. Chaboud, et al. (2004) analyzed the relationship between macro news announcement and trade volume, and found news releases tend to raise trade volume. Berger et al. (2005) showed the correlations between order flows and exchange rate movement. The trading volumes of the buyer-initiated trades (ask-side deals) in excess of the seller-initiated deals (bid-side deals) are considered to be order flows. They examined whether the exchange rate appreciates if there are more buyer initiated trades in several time aggregation, 1 minute, 5 minutes, 10 minutes, 1 hour, and 1 day. They find strong association of order flows and exchange rate changes, namely, an excess of buyer-initiated trades is associated with a rising price. The contemporary association is strongest in the shortest horizon. Although Berger et al. (2005) find a positive contemporaneous price impact of order flow, they argue that there is little evidence for predictability, namely lagged trades impacting on the price change in the next minute.

The objective of our paper is to analyze the forecasting power of order flows (actual deals in the preceding 30 minutes) on future exchange rage movements at various frequencies: 1, 5, 15 and 30-minute windows. The data used in the analysis is extracted from the EBS spanning from January 1999 to October 2003. Our measure of order flows is the "net ask deals" that is defined as the difference between the number of ask deals and bid deals. In our paper, "deal" in one minute is the number of seconds in which at least one deals were done. Although this is no precisely the trading volumes, it is close substitutes.[3]

The prices used to calculate exchange rate returns are based on actual transaction prices, not quoted prices (bid or ask) which may not represent market clearing prices—this is the same as Berger (2005) and Chaboud (2004). We then estimate price impact of deals in the following time periods up to 30 minutes. One innovation we have done over

---

[3] Berger (2005) and Chaboud (2004) use the actual volume data, but the use of the data is restricted in the central bank community.

Berger (2005) and Chaboud (2004) is that we have separated samples in intervention days and non-intervention days, based on (home-page-disclosed) information on intervention activities of the Japanese Ministry of Finance. The reason for this separation is to eliminate the possible abnormal behavior of prices when interventions are conducted, or they are suspected or rumored to be conducted.

We find strong evidence that order flows (deals) have prediction power for the price movement of the next period at 1-minute and 5-minute windows, while 30minute is found too long for prediction. The degree of price impact is found to diminish over time, although intervention may induce lagged price impact, and there may be an adjustment process in exchange rate movements.

The rest of this paper is organized as follows: In section 2 we describe the data. Section 3 shows the estimation model and reports the results. Section 4 concludes the paper.

2. Data[4]

The data set includes quote prices and deal prices information on the dollar/yen and the euro/dollar currency pairs. The sample period is from January 4,1998 to October 31, 2003 for USD/JPY and from January 3, 1999 to October 31, 2003 for EUR/USD.[5] It contains information of, among others, best bid, best ask, deal prices done on the bid side (lowest given) and deal prices done on the ask side (highest paid).[6] It does not contain any information on the volume associated with bid, offer, or deal, or any information on the identity of bid, ask, or deal. The EBS global system consists of three regional computer sites, based in Tokyo, London, and New York, and each region

---

[4] The authors are grateful to EBS for providing a proprietary data set for this academic purpose and to EBS analysts in New York for guidance on the nature of the data.

[5] Data are of the 1-second time slice. The system records, at every second, bid, offer, deals that are posted and carried out in the world-wide EBS system. Bid and offer rates are recorded at the end of time slice. For example, bid and offer rate at xx hour, yy minute, zz second. Fluctuations of the bid and offer rates within the second (in the time slice) are not recorded and cannot be inferred. It is theoretically possible that bid and offer rates move up and down within the second, but not shown in the data set. Deal rates are recorded on the basis of Highest Paid and Lowest Given in the 1-second time slice. See Ito and Hashimoto (2004) for details.

[6] The deal (on either side) recorded at zz second includes those that took place between zz-1 second to zz second. When there are multiple trades within one second, "lowest given price" and "highest paid price" will be shown. A highest paid deal means the highest price hit (done) on the ask side within one second and the lowest given deal means the lowest price hit (done) on the bid side within one second.

covers Europe, North America, and Asia, respectively. The system matches orders either within the site or across different sites.

We exclude all data from Friday 22:00(GMT, winter, 21:00 in summer) to Sunday 21:59(GMT, winter, 20:59 in summer, respectively). We do not drop, a priori, national holidays from samples, but we exclude hours or days where trade is extremely low.

To analyze returns at various frequencies, we use the last deal price of the time interval. For the x-minute frequency, we use the last deal price within the x minute window (x=1, 5, 15, 30). The number of bid and ask deals are separately counted within each frequency. For example, the number of bid deals in 5-minute equals the total number of seconds in which one or more deals took place.

3. Prediction window estimation

In this section, we examine whether order flows in period *t* will have a predictable power of price movement from period *t* to *t+1*. More precisely, whether relative number of deals on the bid and ask side will drive the price lower/higher moments later. For the proxy of order flows in the EBS data, we use "net deals" that is defined as the difference between the number of bid deals and that of ask deals during a specified frequency[7]. For testing the predictability of this framework, we use three frequencies, 1-minute, 5-minute, 15-minute and 30-minute windows. The sample period covers from January 4,1998 to October 31, 2003 for USD/JPY and from January 3, 1999 to October 31, 2003 for EUR/USD pair.

We will examine *netdeals* at period *t* help predict the price movements in period *t+1*. A similar attempt was made by Berger, et al (2005). They regarded a net excess of buyer-initiated trades as order flow. The "net excess of buyer-initiated trades" is the difference between the volume of the buyer-initiated trades, that is, deals done on the ask side, and the seller-initiated trades, that is, deals done on the bid side. They note

---

[7] The buyer-initiated trades (the seller-initiated trades) used in Berger et al. (2005) corresponds to the number of deals on ask side (the number of deals on bid side) in our paper, respectively. The order flow, the net excess of buyer-initiated trades in Berger et al. corresponds to the *netdeal* in our paper. Berger et al. had access to the data of actual transaction volumes---proprietary data of EBS---while we use the number of seconds in which at least one deals was done. The number of deals, rather than the signed (actual) volume, is good enough proxy for the volume of transaction. In fact, the actual transaction volume is not revealed to participants other than parties involved, so that they would not be able to be used in prediction of price movement in real time.

that a dealer tends to break up a large customer's order into small lots and execute them in a staggered manner, in order to avoid large impacts on prices.

A variable *netdeal* corresponds to "net excess buyer-initiated trades", as a proxy for order flow. We also use a *share of netdeal (snetdeal)*, the *netdeal* over the total number of deals (both bid and ask sides) during the period, instead of *netdeal*. Since the overall market activity varies from time to time, the share is able to scale *netdeal* by the degree of market activeness; for example, # deal ask=700 and # deal bid =690 when market is active and # deal ask=80 and # deal bid=70 when market is calm, then, *netdeal* is 10 for both cases but *share of netdeal* is 0.0072 and 0.067, respectively.

The estimation model is specified as follows. We examine whether deals done at period *t-1* at either side help predict the price movement for the next period, *t*, using information that is contained in the data up to period *t*.

$$\Delta s_t = \alpha_1 + \beta_1 * netdeal_{t-1} + \varepsilon_t \qquad (1)$$

$$\Delta s_t = \alpha_2 + \beta_2 * snetdeal_{t-1} + \varepsilon_t \qquad (2)$$

where Δs denotes the exchange rate return from period *t-1* to *t*. The estimation methodology is similar to that of Berger et al. (2005), in which they estimated the contemporaneous regression with time horizon of 1-minute, 5-minute, 10-minute, 1-hour, 1-day and 1-month. They went on to estimate another regression with lagged Δs and order flows up to five periods. In this paper, we first estimate equations (1) and (2), in order to avoid endogeneity of the contemporaneous regression and to extract predictability directly, and then extend the regression with longer lags later.

Three different definitions of returns are used for this variable: the midpoint of the deal ask and deal bid prices, the ask-side deal price, and the bid-side deal price, whereas Berger et al. (2005) use the midpoint of the ask and bid deal prices, which is a standard practice in the literature. However, the mid point may not represent a true state of the market, if the last ask side deal was done several minutes prior to the last bid deal. In other words, when the market is thin, or the market is one-sided (strong buy pressure or sell pressure) then the mid-point may not be representative. Therefore, we also use the bid-bid return and ask-ask returns, in addition to the midpoint price returns.

The parameters *β* are expected to be positive. The continuum of ask (bid) deals will drive the next period price to depreciate (appreciate) after eating up orders at the best offer (bid) price. If the parameter *β* is estimated insignificantly, the order flow at *t* does not carry any information content in prediction of price movements.

Other explanatory variables included in the regression are 1-10 lags of dependent variable as well as 1-10 lags of *netdeal* (*snetdeal*) variables. We also control for the time of the day (hour) effect for the regressions.[8]

Results

The regression results are summarized in Tables 1-1 and 1-2 (*netdeal*) and 2-1 and 2-2 (*share of netdeal*) for both USD/JPY and EUR/USD pairs.

Overall, as seen in Panel A of each Table, many of the t-statistics with the midpoint definition for price changes are not significant regardless of time frequencies. For USD/JPY regressions, two parameters are not significant at the 10% even at the 1-minute window. Among 18 estimations, about half of them have negative (wrong) signs. For EUR/USD regressions, many parameters are insignificantly estimated or have negative signs, as seen for USD/JPY results. The lack of prediction power of order flow if the midpoint definition is used is consistent with that of Berger et al (2005).

The regressions results of either ask-side deal returns and bid-side deal returns, shown in Panels B in Tables 1-1 and 1-2, report the prediction power of order flow at higher frequency for both currencies.

Panels B and C of Table 1-1 summarize predictability results using bid deal prices only and ask-side deal price only for the USD/JPY pair. The coefficients are positive and significant for both 1-minute and 5-minute windows. However, from the 30-minute window result, half of them are found to have negative sign: furthermore, two of them (1998 and 1999) are significantly negative at 10%. At the 30-minute frequency, order flow has prediction power at the 1% significance level in 2000 only. It is found that t-statistics become larger as the prediction window becomes shorter. A significantly positive β in both ask-side deal and bid-side deal returns confirms the excess demand of

---

[8] It is well known that foreign exchange markets have intra-day seasonality, see Ito and Hashimoto (2004) and Ito, Lyons, and Melvin (1998) for such a phenomenon for the yen market, and more generally, Andersen and Bollerslev (1997, 1998) and Baillie and Bollerslev (1990).

dollar (more deals on ask side than bid side) for dollar (or excess supply of dollar) drives the exchange rate to depreciate (appreciate, respectively).

The estimation results of deal bid and deal ask returns of EUR/USD are shown in Panels B and C of Table 2-1, respectively. Again, it is found significantly positive coefficients at the 1-minute and the 5-minute frequencies. T-statistics is largest for the 1-minute prediction window, and smallest for the 30-minute window, although most of the coefficients at the 30-minute frequency are not significant.

Table 1-1, 1-2

The regression results summarized in Tables 2-1 and 2-2 show results using *share of netdeal*. Again, we obtain almost the same results as *netdeal* estimation. The predictability of midpoint returns is not high, even at the 1-minute window. For the bid-side deal and ask-side deal returns, the prediction power is found higher in the higher frequency.

Table 2-1, 2-2

Overall, our tests turned out to be successful in finding some predictive power of exchange rate changes based on order flows for both USD/JPY and EUR/USD. The dispersed information or private information affecting the fundamental value of currencies is transmitted through order flow. However, the predictability (and information) is short-lived. We fail to detect moderate predictability even at the 30-minute frequency.

Our results are consistent with the view that the exchange rate movement is predictable in the very short run.

4. Intervention vs No-Intervension

Now, we investigate predictability distinguishing days in which interventions were conducted from those in which there was no intervention. Whether the predictability pattern (significance of the predictability) is different for these two groups of days. As for the Japanese monetary authorities' BOJ intervention, there were three USDJPY interventions (days) in 1998, 11 USDJPY interventions and 3 EURJPY interventions in

1999, 4(USDJPY) and 2(EURJPY) in 2000, 7(USDJPY) and 3(EURJPY) in 2001, 7(USDJPY) and 1(EURJPY) in 2002, and 80(USDJPY, 65 by October 31) and 9(EUROJPY) in 2003. All of the USDJPY interventions, except those in 1998, were of USD-buying and JPY-selling.

For the general descriptions of Japanese interventions and their effectiveness, see Ito (2003, 2004, 2005). Ito (2005) suggests that the objective and style of interventions have changed over time, corresponding to the Vice ministers. The period from April 1991 to June 1995 is characterized by frequent interventions of small sizes; the period from June 1995 to December 2002 by very infrequent large-scale interventions; and the period from January 2003 to March 2004 by very frequent, increasingly large-scale interventions. The interventions suddenly stopped in mid-March 2004, and no intervention has been conducted since then.

Those interventions from 1995 to 2002 were most effective in the sense the exchange rate changed on the day of interventions. Therefore, the predictability and the relationship between deals and the subsequent price changes on the days of intervention may be quite different from those without interventions. In order to obtain homogeneous data set, the regressions were conducted in samples with interventions and without interventions. Only the days of interventions are identified and disclosed, but what time of the day those interventions were conducted are not. Hence we are not able to do more elaborate examinations of the exchange rate behaviors just (a few minutes) after interventions.

In general, whether interventions are aggressively conducted to move the level of the exchange rate (1995-2002) or to defend a certain barrier, for example, affect the predictive power regressions.

In this section, we separate samples of intervention days from No-intervention days. Then, we estimate the predictability using Equation (1) in section 3. Since the Euro-JPY intervention was not frequent, we apply the estimation only for USDJPY transaction. For intervention samples, the parameter β is expected to remain significant even at longer prediction window because of the intervention, where price is intentionally driven by authorities.

Before conducting estimation, we quickly check if there is any statistical difference in

variables between Intervention and No-Intervention samples.

2001 1min window						2002 30min window					
Intervention						Intervention					
	Mean	Std.	Variance	Skewness	Kurtosis		Mean	Std.	Variance	Skewness	Kurtosis
Midpoint	0.00106	0.0341	0.00116	2.905	31.546	LDPRICE	0.00262	0.1432	0.02052	2.975	17.854
Deal Bid Return	0.00101	0.0355	0.00126	2.628	25.886	CHANGEDB	0.00256	0.1434	0.02055	2.861	17.278
Deal Ask Return	0.00100	0.0360	0.00130	2.528	27.238	CHANGEDA	0.00244	0.1450	0.02102	2.931	17.512
NETAB	0.15775	3.8477	14.805	0.047	1.407	NETAB	4.059	22.026	485.152	-0.089	3.076
SNETAB	0.01127	0.3563	0.12697	-0.098	-0.586	SNETAB	0.03553	0.1525	0.02326	0.172	2.474
NOB	3721					NOB	322				
NO Intervention						NO Intervention					
	Mean	Std.	Variance	Skewness	Kurtosis		Mean	Std.	Variance	Skewness	Kurtosis
LDPRICE	-0.00029	0.0223	0.00050	-0.234	18.804	LDPRICE	-0.00104	0.0856	0.00732	-0.341	5.248
CHANGEDB	-0.00033	0.0240	0.00057	-0.146	15.854	CHANGEDB	-0.00107	0.0860	0.00739	-0.333	5.096
CHANGEDA	-0.00038	0.0239	0.00057	-0.311	15.474	CHANGEDA	-0.00106	0.0860	0.00739	-0.332	5.197
NETAB	0.15844	3.7111	13.772	0.029	1.095	NETAB	3.389	17.769	315.743	0.238	1.395
SNETAB	0.01593	0.3624	0.13132	-0.030	-0.674	SNETAB	0.02425	0.1636	0.02678	0.030	2.862
NOB	120856					NOB	11955				

Tables above summarize the statistics of Midpoint returns, Deal bid and ask returns, *netdeal* and *share of netdeal*. They are picked up as examples of intervention days and no-intervention days for 1-minute and 30-minute. As clear from the tables, we do not see a significant difference between Intervention samples and NO-intervention samples regardless of the prediction window. This may reflect the fact that central bank intervention is not a frequent event (maybe several times a day at most) and each intervention does not take a long time on the intervention day. Even in the intervention day, intervention is temporary event and the rest of the day is a no-intervention sample.

Results

The regression results of intervention day are summarized in Tables 3-1 and 3-2, and results of No-intervention are summarized in Tables 4-1 and 4-2.

On intervention days, order flow does not predict midpoint returns at all. As for the bid-side deal and ask-side deal returns, we find significant predictability at the 1-minute window as seen in Panels B and C of Tables 3-1 and 3-2. What is very interesting is to find a diminishing predictability at 5-minute window. The estimated parameter, β, becomes insignificant in a very short period and this is quite contrary to what we've expected.

The main guess is as follows. After exchange rate moves in one direction for a very short period of time in a day, the price moves around to adjust for overshooting as soon as market intervention stops. This adjustment process may violate the usual 5- and 15-minute patterns of price movement.

Table 3-1, 3-2

Regression results of No-intervention samples are summarized in Tables 4-1 and 4-2. The results are almost the same as those of Full sample regressions (in section 3). Predictability remains significant up to 5-minute window, but it diminishes at 30-minute window.

Table 4-1, 4-2

5. Price impact duration

In the analysis above, we found that the exchange rates are not predicable longer than 30 minute frequency, since we find the diminishing price impact longer than 15-minute window. Finally, we examine the price impact duration. Is the current exchange rate movement is affected by the past 1 minute transaction, or by the transaction of past 5 minutes? Or, the past 30 minutes transaction will fully affect the current exchange rate movement?

In order to examine the cumulative effect on the current exchange rate, we consider the following mode.

$$\Delta s_t = \alpha + \beta_0 snetdeal_t + \sum_{i=1}^{30} \beta_i snetdeal_{t-i} + \upsilon_t \qquad (3)$$

For example, the past 1 minute effect of transaction on the current price movement is captured by β_1, and the past 14-minute effect is expressed as $\beta_1 + \beta_2 + \beta_3 + \cdots + \beta_{14}$. We calculate the price impact up to 30 minutes.

In estimating equation (3), again, we use three returns (midpoint of the deal ask and the deal bid price, deal ask price, and deal bid price) for Δs, where "*snetdeal*" denotes the share of *netdeal*.[9] Lagged independent variables (up to 30 lags) are also included in the estimation. As for the USDJPY, we separate intervention samples and no-intervention

---

[9] Since we do not see a large difference in estimation results of equations (1) and (2), the estimation in this section was conducted using *snetdeal* only.

samples. The calculated price impact, $\sum_{i=1}^{p} \beta_i$ (p equals up to 30), with vertical bars of one s.e., are summarized in Figures1-6 (USDJPY) and in Figures 7-9 (EURUSD).

The price impact, the sum of β_i, is expected to be positive. For example, if the number of deals done on the ask-side exceeds the number of deals done on the bid-side for USDJPY, the USD will appreciate vis-à-vis the Japanese yen due to more buyer initiated trades occurred. Therefore, the *snetdeal* is positively associated with the returns.

Results

Results are summarized in Figures 1 through 9. Figures 1-3 show the price impact of USDJPY of intervention samples, Figures 4-6 show the price impact of no-intervention samples, and Figures 7-9 show the price impact of EURUSD trades. In each figure, the horizontal axis shows the duration from 1 minute to 30 minutes and the vertical axis shows the price impact with s.e.   The price impact is not significantly different from zero when vertical bar of s.e. cross the horizontal axis of zero.

In Figures 1-3 the price impact of USDJPY exchange rate of intervention samples are shown. Although the duration of significant price impacts varies from year to year, more coefficients are significant at higher (longer) lags. For example, the bid-side deal returns in 2002 (Figure2) shows that coefficients of over 20 minutes are mostly significant, whereas many coefficients within 20 minutes are not significantly different from zero.   Another noteworthy finding is that some of the estimated coefficients (over 20-minute) become significantly negative which are shown in the bid-side deal returns in 1999 and 2000, ask-side deal returns in 1999 and 2003.   This means that the price moves down even when buy orders exceeds the sell orders.   From these two findings, we suspect that (i) intervention may induce lagged price impact, and (ii) there may be an adjustment process in exchange rate movements for intervention days.   This may make sense because interventions would not be known for several minutes, and then the market reacts to these interventions.   The lagged reaction may be explained by these sudden shocks and slow reaction in the market.

Figures 1-3

Figures 4-6 summarize the price impact of no-intervention samples of USDJPY. Overall, price impact duration with midpoint price returns varies across year. Some of the coefficients are significantly negative in 1998, 1999, 2000, and in 2002. Estimation with bid-side deal returns or ask-side deal returns show that most of the price impact remains significantly positive for 10-20 minutes. In 2003 the price impact is significantly positive for the whole 30 minutes (bid-side and ask-side deal returns). In 1999, the price impact becomes significantly negative at higher lags---19-30 minutes for bid-side deal returns and 12-30 minutes fro ask-side deal returns.

Figures 4-6

Figures 7-9 show the price impact of EURUSD trades. Results of midpoint price returns show that price impact is significantly negative for 30 minutes in 1999 and in 2000, but becomes insignificant most of the time after 2001. Estimation with bid-side deal returns or ask-side deal returns show that the price impact duration varies from year to year, but the significance diminishes mostly within 10-20 minutes. It is also interesting to see that the price impact over 20 minutes are significantly negative in 2000 (bid-side deal returns) and in 1999 and 2002 (ask-side deal returns).

Figures 7-9

6. Conclusion

We examine the price impact of order flows using the transaction data recorded in the electronic broking system of the both USD/JPY and EUR/USD spot foreign exchange markets. At the 1-minute and 5-minute frequencies, our results show a strong predictive power of order flow for future exchange rate movement, whereas we fail to find any predictability at the half-hour window. The results confirm that the private information may be contained in prices via order flows, but such information is very short-lived.

Although we found some evidence that price movements are predictable given trades information a minute earlier. However, this does not necessarily mean there was a profitable opportunity. First, the estimation was done for a whole sample, and predictability is tested as an in-sample exercise. For the profitable opportunity, the exercise has to be done as out-of-sample simulations. A task of more sophisticated out-of-sample simulations is left for future research.

References:

Andersen, Torben G. and Tim Bollerslev (1997). "Intraday Periodicity and Volatility Persistence in Financial Markets," *Journal of Empirical Finance*, vol. 4: 115-158.

Andersen, Torben G. and Tim Bollerslev (1998). "Deutsche Mark-Dollar Volatility: Intraday Activity Patterns, Macroeconomic Announcements, and Longer Run Dependencies," Journal of Finance, Vol. 53, Issue 1, February: 219-265.

Baillie, Richard T. and Tim Bollerslev (1990). "Intra-Day and Inter-Market Volatility in Foreign Exchange Rates," Review of Economic Studies, vol. 58: 565-585.

Berger, David, Alain P. Chaboud, Sergey V. Chernenko, Edward Howorka,Raj S. Knshnasami Iyer, David Liu, and Jonathan H. Wright, (2005). "Order flow and Exchange Rate Dynamics in Electronic Brokerage System Data," Board of Governors of the Federal Reserve System International Finance Discussion Papers No.830, April.

Chaboud, Alain P.; Sergey V. Chernenko, Edward Howorka; Raj S. Krishnasami Iyer, David Liu and Jonathan H. Wright, 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, International Finance Discussion Papers, Number 823, November.

Goodhart, Charles; Takatoshi Ito; and Richard Payne, (1996) "One Day in June 1993: A Study of the Working of the Reuters 2000-2 Electronic Foreign Exchange Trading System," in J. A. Frankel, G. Galli, and A. Giovannini (eds.) The Microstructure of Foreign Exchange Markets, Chicago: The University of Chicago Press: 107-179.

Goodhart, Charles and Richard Payne, (1996) "Microstructural Dynamics in a Foreign Exchange Electronic Broking System" *Journal of International Money and Finance*, vol. 15, no. 6: 829-852.

Goodhart, Charles, and Maureen O'Hara, (1997). "High Frequency Data in Financial Markets: Issues and Applications" *Journal of Empirical Finance*, vol. 4: 73-114.

Ito, Takatoshi, 2004. "The Yen and the Japanese Economy, 2004." C. F. Bergsten and J. Williamson, (eds.) *Dollar Adjustment: How Far? Against What?, ch.8,* Washington, D.C.: Institute for

International Economics: 171-196

Ito, Takatoshi, 2003. "Is Foreign Exchange Intervention Effective?: the Japanese experiences in the 1990s" in Paul Mizen (ed.), *Monetary History, Exchange Rates and Financial Markets*, Essays in Honour of Charles Goodhart, Volume 2, CheltenhamU.K.; Edward Elgar Pub. 2003: 126-153. [NBER working paper no. 8914, April 2002]

Ito, Takatoshi, 2005. "Interventions and Japanese Economic Recovery" *International Economics and Economic Policy* (IEEP), vol. 2, no. 2-3, November 2005: 219-239.

Ito, Takatoshi, 2005. "The Exchange Rate in the Japanese Economy: the Past, Puzzles, and Prospects," *Japanese Economic Review*, vol. 56, no.1, March 2005: 1-38.

Ito, Takatoshi, Richard K. Lyons, and Michael T. Melvin, (1998). "Is There Private Information in the FX Market? The Tokyo Experiment" The Journal of Finance, vol. LIII, no. 3, June: 1111-1130.

Ito, Takatoshi and Yuko Hashimoto (2004), "Microstructure of the Dollar/yen Foreign Exchange Market: Patterns of Intra-day Activity in the Electronic Broking System" NBER working paper, no. 10856, October.

Lyons, Richard (1995). "Tests of Microstructural Hypotheses in the Foreign Exchange Market," Journal of Financial Economics, vol. 39: 321-351.

Lyons, Richard (1996). "Foreign Exchange Volume: Sound and Fury Signifying Nothing?" in J. A. Frankel, G. Galli, and A. Giovannini (eds.) The Microstructure of Foreign Exchange Markets, Chicago: The University of Chicago Press: 183-205.

Lyons, Richard (1997). "A simultaneous trade model of the foreign exchange hot potato". Journal of International Economics 42, 275-2

Lyons, Richard (1998). "Profits and Position Control: A Week of FX dealing" *Journal of International Money and Finance*, vol. 17: 97-115.

Lyons, Richard (2001). *The Microstructure Approach to Exchange Rates*, Cambridge: MIT Press.

Table 1-1: Prediction power

Panel A: Midpoint return (USD/JPY)

	1min window				5min window				15min window				30min window			
	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB
1998	6.84E-05	4.70E-05	1.46	59362	-1.21E-04	4.29E-05	-2.83	52164	1.74E-05	5.25E-05	0.33	23061	1.05E-05	4.84E-05	0.22	11411
1999	1.29E-04	3.82E-05	3.38	56285	2.73E-05	3.62E-05	0.75	51677	1.74E-05	5.25E-05	0.33	22717	1.47E-05	6.88E-05	0.21	11676
2000	-9.21E-05	4.30E-05	-2.14	34082	3.11E-05	3.38E-05	0.92	46927	-1.64E-05	4.52E-05	-0.36	22130	5.17E-05	6.30E-05	0.82	11781
2001	-6.11E-05	3.66E-05	-1.67	40839	4.51E-05	3.16E-05	1.43	47766	4.66E-06	4.06E-05	0.11	22194	-1.37E-04	5.92E-05	-2.31	11729
2002	-3.55E-05	3.19E-05	-1.11	46065	7.73E-06	2.91E-05	0.27	49101	-8.46E-05	4.04E-05	-2.09	22420	-5.82E-05	5.39E-05	-1.08	11773
2003	1.54E-06	3.35E-05	0.05	39474	-5.30E-06	2.88E-05	-0.18	42296	-8.37E-06	8.37E-05	-0.10	19005	-1.31E-04	5.49E-05	-2.40	9851

Panel B: Deal bid return (USD/JPY)

	1min window				5min window				15min window				30min window			
	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB
1998	1.23E-03	3.81E-05	32.39	85759	4.13E-04	4.15E-05	9.96	56584	1.01E-04	6.31E-05	1.60	23291	-6.82E-05	4.82E-05	-1.41	11563
1999	8.62E-04	3.16E-05	27.28	83501	3.48E-04	3.51E-05	9.92	55892	1.74E-05	5.25E-05	0.33	23181	-1.04E-04	6.89E-05	-1.51	11721
2000	8.95E-04	3.27E-05	27.33	57486	4.13E-04	3.23E-05	12.78	51947	2.82E-05	4.76E-05	0.59	22887	1.53E-04	6.32E-05	2.42	11864
2001	7.87E-04	2.90E-05	27.10	65602	2.99E-04	3.05E-05	9.78	52434	-1.64E-05	4.52E-05	-0.36	22801	7.17E-05	5.92E-05	1.21	11807
2002	7.06E-04	2.57E-05	27.42	71298	3.01E-04	2.80E-05	10.74	53771	7.74E-05	4.04E-05	1.92	22936	5.34E-05	5.38E-05	0.99	11860
2003	7.02E-04	2.69E-05	26.07	60984	3.45E-04	2.78E-05	12.39	46235	5.18E-05	4.03E-05	1.28	19332	-2.77E-05	5.49E-05	-0.50	9888

Panel C: Deal ask return (USD/JPY)

	1min window				5min window				15min window				30min window			
	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB
1998	1.15E-03	3.39E-05	34.04	103254	3.75E-04	4.08E-05	9.17	58399	6.66E-05	6.24E-05	1.07	23595	-6.54E-05	4.80E-05	-1.36	11659
1999	9.40E-04	2.93E-05	32.07	94737	3.21E-04	3.45E-05	9.31	57935	-1.42E-04	5.21E-05	-2.73	23186	-1.04E-04	6.87E-05	-1.52	11790
2000	8.60E-04	3.12E-05	27.57	64783	3.62E-04	3.20E-05	11.30	53329	5.54E-05	4.68E-05	1.18	22939	1.34E-04	6.25E-05	2.14	11909
2001	8.14E-04	2.72E-05	29.89	74258	2.87E-04	2.99E-05	9.58	54469	1.05E-04	4.44E-05	2.36	23151	5.29E-05	5.92E-05	0.89	11853
2002	7.31E-04	2.39E-05	30.62	80963	2.87E-04	2.76E-05	10.41	55570	8.47E-05	4.01E-05	2.11	23348	4.84E-05	5.38E-05	0.90	11914
2003	6.85E-04	2.55E-05	26.84	67323	3.46E-04	2.72E-05	12.70	47975	4.74E-05	4.00E-05	1.18	19609	-1.37E-05	5.48E-05	-0.25	9947

Table 1-2: Prediction Power

Panel A: Midpoint price (EUR/USD)

	1min window				5min window				15min window				30min window			
	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB
1999	-2.86E-05	1.79E-05	-1.594	91520	-5.40E-05	2.45E-05	-2.206	48991	6.40E-06	3.67E-05	0.174	21078	1.05E-05	4.84E-05	0.216	11411
2000	2.81E-05	2.09E-05	1.343	112134	-2.98E-05	3.07E-05	-0.974	50772	-1.69E-04	4.45E-05	-3.792	21945	-2.85E-05	5.85E-05	-0.488	11800
2001	-3.10E-05	2.00E-05	-1.550	103181	1.24E-05	2.83E-05	0.438	50312	-2.10E-05	4.09E-05	-0.513	22280	-1.07E-04	5.32E-05	-2.002	11823
2002	-2.17E-05	1.76E-05	-1.229	87459	5.10E-06	2.23E-05	0.229	50838	-1.11E-05	3.20E-05	-0.348	22584	-6.70E-07	4.25E-05	-0.016	11871
2003	2.20E-05	1.66E-05	1.325	104325	4.14E-05	2.42E-05	1.714	47643	-5.47E-07	3.60E-05	-0.015	19821	7.04E-05	4.89E-05	1.439	9997

Panel B: Deal bid price (EUR/USD)

	1min window				5min window				15min window				30min window			
	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB
1999	4.31E-04	1.62E-05	26.646	114416	7.49E-05	2.39E-05	3.139	52864	-5.14E-05	3.62E-05	-1.419	21925	-6.82E-05	4.82E-05	-1.413	11563
2000	5.44E-04	1.92E-05	28.398	134956	1.49E-04	2.98E-05	5.009	54434	-3.47E-05	4.40E-05	-0.789	22742	-2.29E-04	5.83E-05	-3.921	11870
2001	4.40E-04	1.83E-05	24.099	125122	1.87E-04	2.75E-05	6.801	54354	5.96E-05	4.05E-05	1.471	22880	1.30E-05	5.32E-05	0.244	11907
2002	3.22E-04	1.57E-05	20.447	111072	1.65E-04	2.16E-05	7.630	55038	-4.82E-06	3.17E-05	-0.152	23228	-6.66E-05	4.25E-05	-1.567	11935
2003	3.56E-04	1.53E-05	23.311	124722	1.56E-04	2.37E-05	6.578	50476	4.89E-05	3.60E-05	1.359	20004	-1.96E-05	4.90E-05	-0.399	10001

Panel C: Deal ask price (EUR/USD)

	1min window				5min window				15min window				30min window			
	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB
1999	4.43E-04	1.58E-05	28.005	120848	5.58E-05	2.35E-05	2.373	54220	-5.74E-05	3.59E-05	-1.599	22402	-6.54E-05	4.80E-05	-1.363	11659
2000	5.22E-04	1.88E-05	27.722	140058	1.60E-04	2.95E-05	5.425	55785	-4.24E-05	4.37E-05	-0.970	22991	-2.47E-04	5.82E-05	-4.235	11911
2001	4.49E-04	1.80E-05	24.987	131243	1.83E-04	2.72E-05	6.720	55755	5.73E-05	4.02E-05	1.424	23244	1.45E-05	5.31E-05	0.273	11920
2002	3.23E-04	1.53E-05	21.046	117025	1.64E-04	2.14E-05	7.687	56226	-1.66E-05	3.17E-05	-0.522	23287	-7.14E-05	4.25E-05	-1.682	11956
2003	3.51E-04	1.51E-05	23.300	129025	1.54E-04	2.33E-05	6.618	52020	3.40E-05	3.58E-05	0.950	20089	-1.45E-05	4.89E-05	-0.297	10015

Table 2-1: Predictability using Share of order flow (USD/JPY)

Panel A: Midpoint return(USD/JPY): Explanatory variable: Share of netdeal

	1min window				5min window				15min window				30min window			
	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB
1998	8.96E-04	5.86E-04	1.53	59309	-3.34E-03	1.28E-03	-2.62	52163	-5.66E-03	4.08E-03	-1.39	23051	-7.79E-03	0.010252	-0.76	11760
1999	1.09E-03	4.69E-04	2.34	56268	1.81E-04	1.03E-03	0.18	51677	1.27E-03	3.24E-03	0.39	22717	5.38E-03	8.24E-03	0.65	11666
2000	-1.17E-03	4.89E-04	-2.38	34082	-5.49E-04	8.28E-04	-0.66	46927	8.73E-04	2.42E-03	0.36	22130	-1.18E-03	5.93E-03	-0.20	11781
2001	-1.00E-03	4.16E-04	-2.42	40831	1.62E-07	8.15E-04	0.00	47753	-4.55E-03	2.38E-03	-1.91	22184	-9.69E-03	5.74E-03	-1.69	11729
2002	-8.51E-04	3.78E-04	-2.25	46065	-1.23E-03	7.77E-04	-1.58	49101	-3.57E-03	2.26E-03	-1.58	22420	-3.43E-03	5.54E-03	-0.62	11773
2003	-1.11E-04	3.90E-04	-0.28	39425	-4.17E-04	7.52E-04	-0.55	42259	-4.36E-03	2.27E-03	-1.92	18960	-7.74E-03	5.81E-03	-1.33	9818

Panel B: Deal bid return(USD/JPY) : Explanatory variable: Share of netdeal

	1min window				5min window				15min window				30min window			
	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB
1998	0.012122	3.94E-04	30.74	85175	0.014294	1.10E-03	12.94	56563	9.89E-03	4.00E-03	2.47	23281	-8.46E-03	0.010136	-0.83	11784
1999	8.74E-03	3.13E-04	27.93	83350	0.010158	8.98E-04	11.32	55892	5.14E-03	3.07E-03	1.67	23171	1.17E-03	8.08E-03	0.14	11711
2000	7.74E-03	2.87E-04	26.95	57464	9.84E-03	6.98E-04	14.10	51947	5.15E-03	2.23E-03	2.31	22887	8.17E-03	5.77E-03	1.42	11864
2001	7.23E-03	2.58E-04	28.02	65580	7.50E-03	6.93E-04	10.83	52414	7.30E-03	2.23E-03	3.28	22791	3.78E-03	5.63E-03	0.67	11807
2002	6.82E-03	2.40E-04	28.41	71278	8.00E-03	6.61E-04	12.10	53771	5.67E-03	2.13E-03	2.66	22936	4.95E-03	5.39E-03	0.92	11860
2003	6.49E-03	2.49E-04	26.08	60897	7.91E-03	6.47E-04	12.22	46177	4.70E-03	2.17E-03	2.16	19285	-4.43E-03	5.74E-03	-0.77	9854

Panel C: Deal ask return(USD/JPY) : Explanatory variable: Share of netdeal

	1min window				5min window				15min window				30min window			
	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB
1998	0.011134	3.30E-04	33.69	102361	0.013348	1.07E-03	12.52	58366	7.35E-03	3.84E-03	1.92	23585	-0.012048	0.010017	-1.20	11829
1999	8.90E-03	2.78E-04	32.01	57933	9.62E-03	8.53E-04	11.28	50772	5.07E-03	3.08E-03	1.65	23186	5.98E-04	7.97E-03	0.07	11780
2000	7.19E-03	2.62E-04	27.41	64748	9.15E-03	6.83E-04	13.38	53329	5.65E-03	2.24E-03	2.53	22939	6.06E-03	5.69E-03	1.06	11899
2001	7.40E-03	2.33E-04	31.70	74234	7.06E-03	6.64E-04	10.64	54446	6.00E-03	2.17E-03	2.76	23141	2.04E-03	5.55E-03	0.37	11853
2002	7.02E-03	2.14E-04	32.86	80945	7.66E-03	6.33E-04	12.11	55570	5.72E-03	2.06E-03	2.77	23348	3.32E-03	5.30E-03	0.63	11914
2003	6.18E-03	2.26E-04	27.30	67253	7.28E-03	6.19E-04	11.77	47906	5.29E-03	2.12E-03	2.50	19550	-2.78E-03	5.62E-03	-0.49	9906

Table 2-2: Predictability using Share of order flow (EUR/USD)

Midpoint return(EUR/USD): Explanatory variable: Share of netdeal

	1min window				5min window				15min window				30min window			
	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB
1999	-6.18E-04	2.64E-04	-2.337	91520	-1.98E-03	8.67E-04	-2.289	48991	-2.29E-03	2.59E-03	-0.887	21077	-5.66E-03	5.89E-03	-0.961	11401
2000	2.83E-04	3.26E-04	0.866	112134	-4.52E-04	1.21E-03	-0.373	50772	-3.64E-03	3.39E-03	-1.075	21945	-7.35E-03	7.77E-03	-0.946	11800
2001	-5.35E-04	3.03E-04	-1.763	103165	1.46E-04	1.04E-03	0.140	50295	-2.74E-03	2.84E-03	-0.967	22277	-5.39E-03	6.82E-03	-0.790	11821
2002	-5.32E-04	2.67E-04	-1.990	87459	-3.16E-04	7.82E-04	-0.404	50838	-1.73E-03	2.23E-03	-0.774	22584	-3.13E-03	5.40E-03	-0.580	11871
2003	6.08E-05	2.67E-04	0.228	104272	4.42E-04	9.31E-04	0.474	47564	-5.03E-03	2.97E-03	-1.693	19787	-6.56E-03	7.92E-03	-0.828	9997

Deal bid return(EUR/USD) : Explanatory variable: Share of netdeal

	1min window				5min window				15min window				30min window			
	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB
1999	5.90E-03	2.03E-04	29.082	114366	4.77E-03	7.41E-04	6.437	52862	3.28E-03	2.32E-03	1.413	21923	-2.98E-03	5.66E-03	-0.526	11553
2000	7.46E-03	2.57E-04	29.052	134948	7.07E-03	1.03E-03	6.882	54434	2.58E-03	3.06E-03	0.841	22742	-9.49E-03	7.65E-03	-1.241	11870
2001	5.98E-03	2.36E-04	25.305	125077	7.50E-03	8.72E-04	8.605	54336	5.37E-03	2.64E-03	2.035	22878	-2.18E-03	6.69E-03	-0.326	11896
2002	4.57E-03	1.98E-04	23.103	111056	5.58E-03	6.57E-04	8.492	55038	1.44E-03	2.07E-03	0.696	23228	-4.18E-03	5.32E-03	-0.786	11935
2003	4.92E-03	2.09E-04	23.590	124588	7.17E-03	8.16E-04	8.790	50386	8.25E-03	2.91E-03	2.840	19962	-2.22E-03	7.92E-03	-0.281	10001

Deal ask return(EUR/USD) : Explanatory variable: Share of netdeal

	1min window				5min window				15min window				30min window			
	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB
1999	5.86E-03	1.91E-04	30.626	120772	4.48E-03	7.00E-04	6.404	54202	1.21E-03	2.22E-03	0.547	22387	-3.71E-03	5.52E-03	-0.671	11649
2000	7.13E-03	2.46E-04	29.009	140053	6.80E-03	9.75E-04	6.974	55778	2.46E-03	2.99E-03	0.822	22991	-9.31E-03	7.49E-03	-1.242	11911
2001	5.96E-03	2.25E-04	26.463	131198	7.37E-03	8.30E-04	8.881	55735	4.36E-03	2.55E-03	1.711	23240	-3.15E-03	6.57E-03	-0.480	11916
2002	4.32E-03	1.87E-04	23.167	128915	4.85E-03	6.33E-04	7.670	56226	7.48E-04	2.05E-03	0.364	23287	-4.90E-03	5.28E-03	-0.927	11956
2003	4.79E-03	2.01E-04	23.882	117006	6.57E-03	7.59E-04	8.662	51925	7.80E-03	2.87E-03	2.720	20055	-3.00E-03	7.85E-03	-0.382	10005

Table 3-1: Predictability of Intervention day

Panel A: Midpoint return(USD/JPY): Explanatory variable: netdeal

	1min window				5min window				15min window				30min window			
	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB
1998	-4.96E-04	5.10E-04	-0.97	972	8.88E-04	5.97E-04	1.49	505	-1.26E-03	1.02E-03	-1.24	180	3.26E-04	1.48E-03	0.22	90
1999	-7.40E-05	2.17E-04	-0.34	3451	2.87E-04	2.41E-04	1.19	2234	-1.85E-04	3.53E-04	-0.52	912	-1.26E-04	4.79E-04	-0.26	446
2000	3.60E-05	3.46E-04	0.10	936	1.73E-04	3.30E-04	0.53	815	1.32E-03	5.27E-04	2.50	362	8.50E-04	6.84E-04	1.24	192
2001	-3.28E-04	2.36E-04	-1.39	1475	4.42E-05	2.23E-04	0.20	1343	-3.88E-04	3.30E-04	-1.17	583	4.13E-05	4.00E-04	0.10	308
2002	2.05E-04	2.34E-04	0.88	1835	-2.14E-04	2.70E-04	-0.79	1413	3.00E-04	3.42E-04	0.87	608	-1.10E-04	4.06E-04	-0.27	316
2003	9.98E-05	1.22E-04	0.82	4233	-2.01E-04	9.24E-05	-2.17	4205	-1.84E-04	1.25E-04	-1.48	1936	-1.17E-04	1.78E-04	-0.66	990

Panel B: Deal bid return(USD/JPY) : Explanatory variable: netdeal

	1min window				5min window				15min window				30min window			
	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB
1998	2.24E-03	4.62E-04	4.84	1177	1.00E-03	6.04E-04	0.17	506	9.65E-04	9.97E-04	0.97	180	-1.41E-03	1.48E-03	-0.95	90
1999	1.38E-03	1.86E-04	7.41	4647	-1.89E-04	2.37E-04	-0.80	2329	-1.09E-03	3.59E-04	-3.03	919	-4.14E-04	4.94E-04	-0.84	450
2000	1.68E-03	2.69E-04	6.26	1441	7.68E-04	3.10E-04	2.48	917	-5.36E-04	5.24E-04	-1.02	367	1.43E-03	6.91E-04	2.06	192
2001	6.23E-04	1.99E-04	3.14	2369	-1.70E-04	2.29E-04	-0.74	1399	-4.20E-04	3.29E-04	-1.28	593	-7.82E-04	3.98E-04	-1.96	310
2002	6.06E-04	1.98E-04	3.06	2625	5.66E-05	2.58E-04	0.22	1543	1.85E-04	3.35E-04	0.55	623	2.84E-04	4.04E-04	0.70	317
2003	5.56E-04	9.92E-05	5.61	6409	3.12E-04	8.97E-05	3.48	4617	6.29E-05	1.25E-04	0.50	1964	6.35E-05	1.78E-04	0.36	994

Panel C: Deal ask return(USD/JPY) : Explanatory variable: netdeal

	1min window				5min window				15min window				30min window			
	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB
1998	2.15E-03	3.84E-04	5.60	1441	2.29E-04	5.82E-04	0.39	540	9.08E-04	1.02E-03	0.89	180	-1.75E-03	1.52E-03	-1.15	90
1999	1.40E-03	1.81E-04	7.70	5062	-3.27E-05	2.34E-04	-0.14	2420	-1.11E-03	3.58E-04	-3.11	916	-2.09E-04	4.97E-04	-0.42	445
2000	1.45E-03	2.98E-04	4.85	1379	8.09E-04	3.33E-04	2.43	901	-3.88E-04	5.21E-04	-0.74	378	1.39E-03	6.92E-04	2.01	192
2001	1.04E-03	1.86E-04	5.58	2384	-5.03E-05	2.11E-04	-0.24	1477	-4.89E-04	3.29E-04	-1.49	590	-8.76E-04	3.95E-04	-2.22	308
2002	6.91E-04	1.86E-04	3.71	2673	-2.20E-05	2.58E-04	-0.09	1537	2.05E-04	3.38E-04	0.61	628	3.20E-04	4.07E-04	0.79	317
2003	4.42E-04	9.02E-05	4.91	6851	3.18E-04	8.60E-05	3.70	4783	-1.21E-05	1.24E-04	-0.10	2008	8.58E-05	1.78E-04	0.48	1003

Table 3-2: Predicatbility of Intervention day using Share of order flow

Panel A: Midpoint return(USD/JPY): Explanatory variable: Share of netdeal

	1min window				5min window				15min window				30min window			
	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB
1998	-6.38E-03	7.76E-03	-0.82	972	-0.010665	0.025797	-0.41	505	-0.126037	0.110995	-1.14	180	0.108002	0.33684	0.32	90
1999	6.94E-04	2.96E-03	0.23	3451	-7.44E-04	7.91E-03	-0.09	2234	9.91E-04	0.025867	0.04	912	-0.07147	0.072545	-0.99	446
2000	-3.32E-05	4.83E-03	-0.01	936	-5.91E-03	0.010213	-0.58	815	0.075347	0.033983	2.22	362	0.076352	0.077756	0.98	192
2001	-4.08E-03	2.77E-03	-1.47	1475	4.52E-03	6.63E-03	0.68	1343	-0.022636	0.019754	-1.15	583	0.029212	0.046691	0.63	308
2002	-8.88E-05	3.13E-03	-0.03	1835	-0.012102	8.75E-03	-1.38	1413	0.0248	0.025131	0.99	608	-0.013629	0.058432	-0.23	316
2003	8.93E-04	1.46E-03	0.61	4233	-2.78E-03	2.59E-03	-1.07	4205	-3.13E-03	7.62E-03	-0.41	1936	1.31E-03	0.020939	0.06	990

Panel B: Deal bid return(USD/JPY) : Explanatory variable: Share of netdeal

	1min window				5min window				15min window				30min window			
	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB
1998	0.020653	6.26E-03	3.30	1169	0.023285	0.025762	0.90	506	0.015743	0.110412	0.14	180	-0.392515	0.33359	-1.18	90
1999	0.014872	2.10E-03	7.10	4647	2.86E-03	7.20E-03	0.40	2329	-0.033593	0.024988	-1.34	919	-0.045707	0.068052	-0.67	450
2000	0.017253	2.90E-03	5.96	1441	0.012073	7.92E-03	1.52	917	-6.01E-03	0.033599	-0.18	367	0.095703	0.078835	1.21	192
2001	8.47E-03	1.84E-03	4.59	2369	-7.59E-03	6.35E-03	-1.20	1399	-0.022543	0.018843	-1.20	593	-0.070901	0.045904	-1.54	310
2002	5.44E-03	2.18E-03	2.49	2625	9.80E-03	7.29E-03	1.34	1543	0.022471	0.023546	0.95	623	0.057858	0.057903	1.00	317
2003	6.05E-03	9.50E-04	6.36	6402	6.80E-03	2.20E-03	3.09	4612	1.22E-03	7.44E-03	0.16	1959	0.011716	0.021009	0.56	991

Panel C: Deal ask return(USD/JPY) : Explanatory variable: Share of netdeal

	1min window				5min window				15min window				30min window			
	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB
1998	0.01844	4.64E-03	3.97	1441	0.030465	0.023096	1.32	540	0.021233	0.111591	0.19	180	-0.460245	0.335358	-1.37	90
1999	0.013803	1.96E-03	7.04	5062	4.34E-03	6.70E-03	0.65	2420	-0.036803	0.026476	-1.39	916	-0.041144	0.074732	-0.55	445
2000	0.012562	3.14E-03	4.00	1379	9.58E-03	8.87E-03	1.08	901	-8.36E-03	0.030594	-0.27	378	0.064822	0.079422	0.82	192
2001	0.010379	1.68E-03	6.17	2384	-4.76E-03	5.53E-03	-0.86	1477	-0.033417	0.018972	-1.76	590	-0.090555	0.046083	-1.97	308
2002	5.69E-03	1.96E-03	2.90	2673	8.09E-03	7.49E-03	1.08	1537	0.027134	0.023404	1.16	628	0.063649	0.058456	1.09	317
2003	4.93E-03	8.30E-04	5.94	6851	6.27E-03	2.06E-03	3.05	4783	-1.86E-03	7.11E-03	-0.26	2008	0.011446	0.020337	0.56	1003

Table 4-1: Predictability of NO-Intervention day

Panel A: Midpoint return(USD/JPY): Explanatory variable: netdeal

	1min window				5min window				15min window				30min window			
	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB
1998	8.45E-05	4.69E-05	1.80	58390	-1.31E-04	4.28E-05	-3.06	51659	-8.19E-05	6.28E-05	-1.30	22881	-1.79E-05	8.33E-05	-0.21	11680
1999	1.51E-04	3.80E-05	3.97	52834	2.30E-05	3.61E-05	0.64	49443	2.37E-05	5.28E-05	0.45	21805	1.45E-05	6.92E-05	0.21	11230
2000	-9.21E-05	4.30E-05	-2.14	33146	2.57E-05	3.39E-05	0.76	46112	-2.25E-06	4.74E-05	-0.05	21768	2.14E-05	6.30E-05	0.34	11589
2001	-5.59E-05	3.69E-05	-1.52	39364	4.28E-05	3.19E-05	1.34	46423	-7.72E-06	4.56E-05	-0.17	21611	-1.42E-04	6.01E-05	-2.37	11421
2002	-5.71E-05	3.18E-05	-1.79	44230	-9.27E-06	2.91E-05	-0.32	47688	-3.90E-05	4.11E-05	-0.95	21812	-4.74E-05	5.49E-05	-0.86	11457
2003	5.08E-06	3.98E-05	0.13	27141	3.99E-05	3.51E-05	1.13	29778	-5.24E-05	4.95E-05	-1.06	13336	-4.81E-05	6.73E-05	-0.71	6924

Panel B: Deal bid return(USD/JPY) : Explanatory variable: netdeal

	1min window				5min window				15min window				30min window			
	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB
1998	1.21E-03	3.80E-05	31.95	84582	4.26E-04	4.14E-05	10.30	56078	1.19E-04	6.29E-05	1.89	23111	-6.49E-05	8.32E-05	-0.78	11714
1999	8.34E-04	3.15E-05	26.47	78854	3.86E-04	3.50E-05	11.01	53563	-3.37E-05	5.24E-05	-0.64	22262	-8.62E-05	6.91E-05	-1.25	11271
2000	8.65E-04	3.28E-05	26.37	56045	4.09E-04	3.24E-05	12.62	51030	7.42E-05	4.70E-05	1.58	22520	1.32E-04	6.31E-05	2.10	11672
2001	7.98E-04	2.92E-05	27.30	63233	3.19E-04	3.07E-05	10.36	51035	1.32E-04	4.52E-05	2.93	22208	1.00E-04	6.00E-05	1.67	11497
2002	7.36E-04	2.56E-05	28.75	68673	2.93E-04	2.80E-05	10.44	52228	6.21E-05	4.09E-05	1.52	22313	2.42E-05	5.48E-05	0.44	11543
2003	8.15E-04	3.16E-05	25.78	42663	3.71E-04	3.39E-05	10.93	32537	8.96E-05	4.94E-05	1.81	13570	-3.88E-05	6.72E-05	-0.58	6958

Panel C: Deal ask return(USD/JPY) : Explanatory variable: netdeal

	1min window				5min window				15min window				30min window			
	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB
1998	1.13E-03	3.38E-05	33.41	101813	3.88E-04	4.08E-05	9.50	57859	8.36E-05	6.22E-05	1.34	23415	-1.18E-04	8.31E-05	-1.41	11749
1999	9.10E-04	2.91E-05	31.27	89675	3.43E-04	3.44E-05	9.97	55515	-6.86E-05	5.22E-05	-1.31	22270	-9.71E-05	6.88E-05	-1.41	11345
2000	8.44E-04	3.12E-05	27.08	63404	3.56E-04	3.20E-05	11.12	52428	6.72E-05	4.67E-05	1.44	22561	1.12E-04	6.24E-05	1.80	11717
2001	8.02E-04	2.75E-05	29.22	71874	3.02E-04	3.02E-05	10.00	52992	1.23E-04	4.48E-05	2.74	22561	8.65E-05	6.00E-05	1.44	11545
2002	7.47E-04	2.38E-05	31.32	78290	2.87E-04	2.76E-05	10.41	54033	6.90E-05	4.06E-05	1.70	22720	8.46E-06	5.48E-05	0.15	11597
2003	8.04E-04	3.05E-05	26.34	46755	3.87E-04	3.32E-05	11.66	33665	1.00E-04	4.89E-05	2.05	13792	-3.02E-05	6.70E-05	-0.45	7002

Table 4-2: Predictability of NO-Intervention day (using Share of order flow)

Panel A: Midpoint return(USD/JPY): Explanatory variable: Share of netdeal

	1min window				5min window				15min window				30min window			
	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB
1998	1.05E-03	5.84E-04	1.81	58337	-2.97E-03	1.27E-03	-2.34	51658	-4.74E-03	4.05E-03	-1.17	22871	-7.59E-03	0.010142	-0.75	11670
1999	1.16E-03	4.63E-04	2.51	52834	5.01E-04	1.02E-03	0.49	49443	1.01E-03	3.23E-03	0.31	21805	7.00E-03	8.18E-03	0.86	11230
2000	-1.14E-03	4.87E-04	-2.34	33146	-4.51E-04	8.26E-04	-0.55	46112	-9.06E-05	2.40E-03	-0.04	21768	-4.28E-03	5.90E-03	-0.73	11589
2001	-9.42E-04	4.19E-04	-2.25	39364	-2.06E-04	8.18E-04	-0.25	46423	-4.14E-03	2.39E-03	-1.73	21611	-0.010122	5.77E-03	-1.75	11421
2002	-9.05E-04	3.74E-04	-2.42	44230	-1.36E-04	7.63E-04	-1.78	47688	-5.00E-03	2.23E-03	-2.24	21812	-2.28E-03	5.50E-03	-0.41	11457
2003	-1.65E-04	4.56E-04	-0.36	27141	2.66E-05	9.02E-04	0.03	29778	-4.16E-03	2.70E-03	-1.54	13336	-3.47E-04	6.80E-03	-0.05	6924

Panel B: Deal bid return(USD/JPY) : Explanatory variable: Share of netdeal

	1min window				5min window				15min window				30min window			
	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB
1998	0.012034	3.92E-04	30.71	84006	0.014245	1.10E-03	12.99	56057	0.011342	3.97E-03	2.86	23101	-2.44E-03	0.010028	-0.24	11694
1999	8.46E-03	3.09E-04	27.35	78854	0.010501	8.89E-04	11.81	53563	7.78E-03	3.05E-03	2.55	22262	3.47E-03	8.03E-03	0.43	11271
2000	7.50E-03	2.86E-04	26.24	56045	9.90E-03	6.97E-04	14.20	51030	5.48E-03	2.22E-03	2.47	22520	7.43E-03	5.73E-03	1.29	11672
2001	7.22E-03	2.59E-04	27.91	63233	7.91E-03	6.93E-04	11.41	51035	7.99E-03	2.23E-03	3.58	22208	6.12E-03	5.65E-03	1.08	11497
2002	7.03E-03	2.36E-04	29.75	68673	7.76E-03	6.50E-04	11.94	52228	5.09E-03	2.10E-03	2.42	22313	3.31E-03	5.36E-03	0.62	11543
2003	7.11E-03	2.87E-04	24.80	42663	8.80E-03	7.75E-04	11.36	32537	7.71E-03	2.57E-03	3.00	13570	-4.49E-03	6.71E-03	-0.67	6958

Panel C: Deal ask return(USD/JPY) : Explanatory variable: Share of netdeal

	1min window				5min window				15min window				30min window			
	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB	Coefficient	s.e.	t-stat	NOB
1998	0.011005	3.29E-04	33.42	100920	0.013307	1.06E-03	12.57	57826	8.67E-03	3.80E-03	2.28	23405	-6.03E-03	9.91E-03	-0.61	11739
1999	8.63E-03	2.74E-04	31.57	89675	9.78E-03	8.45E-04	11.58	55515	7.59E-03	3.05E-03	2.49	22270	2.43E-03	7.89E-03	0.31	11345
2000	7.10E-03	2.60E-04	27.27	63404	9.26E-03	6.80E-04	13.61	52428	5.99E-03	2.22E-03	2.69	22561	5.91E-03	5.65E-03	1.05	11717
2001	7.29E-03	2.35E-04	31.04	71874	7.43E-03	6.66E-04	11.17	52992	6.87E-03	2.18E-03	3.15	22561	4.78E-03	5.57E-03	0.86	11545
2002	7.17E-03	2.11E-04	33.92	78290	7.53E-03	6.21E-04	12.14	54033	5.18E-03	2.04E-03	2.54	22720	1.22E-03	5.26E-03	0.23	11597
2003	6.88E-03	2.67E-04	25.75	46755	8.39E-03	7.45E-04	11.27	33665	7.86E-03	2.49E-03	3.16	13792	-2.34E-03	6.51E-03	-0.36	7002

Figure 1

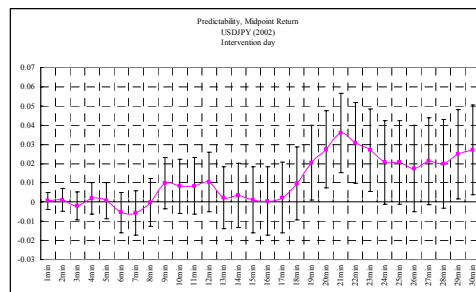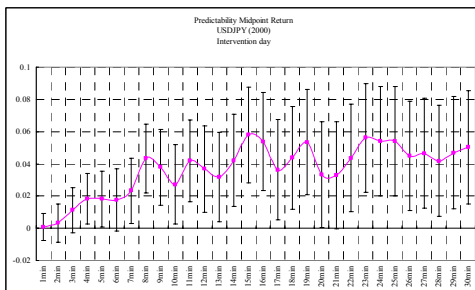Midpoint return, Intervention day

1998

Predictability, Midpoint Return
USDJPY (1998)
Intervention day

2001

Predictability, Midpoint return
USDJPY (2001)
Intervention day

1999

Predictability, Midpoint Return
USDJPY (1999)
Intervention day

2002

Predictability, Midpoint Return
USDJPY (2002)
Intervention day

2000

Predictability Midpoint Return
USDJPY (2000)
Intervention day

2003

Predictability, Midpoint Return
USDJPY (2003)
Intervention day
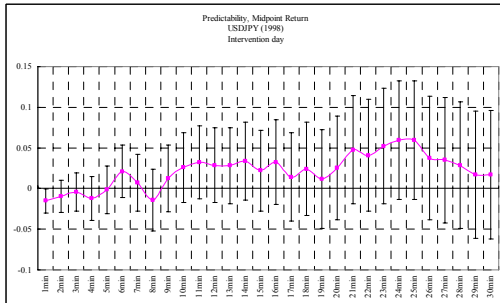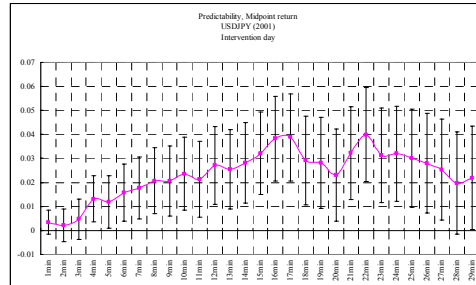
Figure 2:

Deal Bid Return, Intervention day
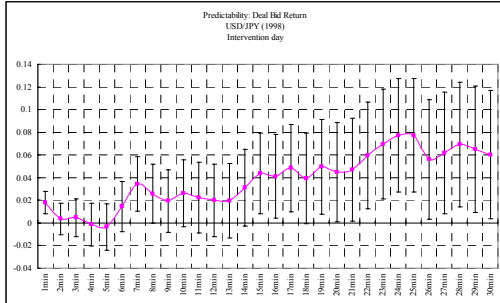
1998

2001
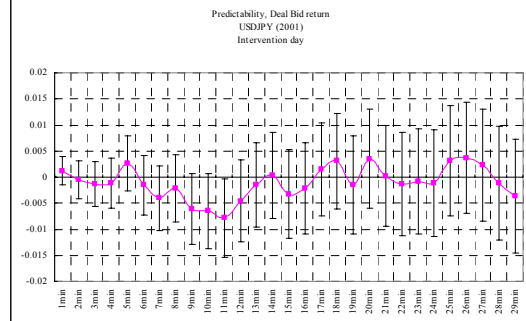
1999
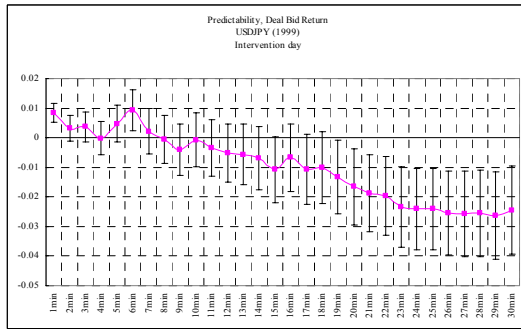
2002
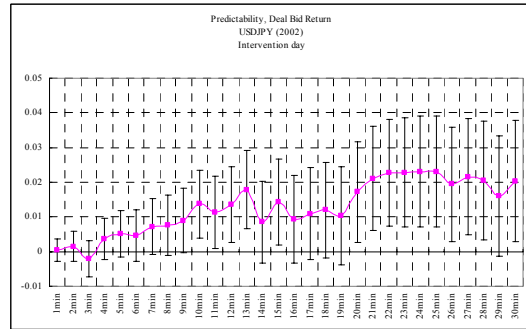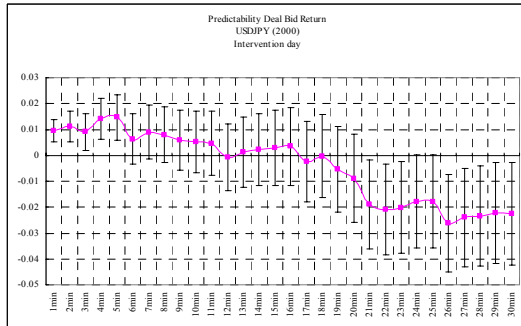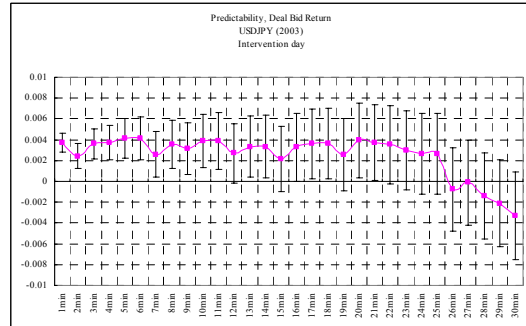
2000

2003

Figure 3:

Deal ASK Return, Intervention day

1998

Predictability: Deal Ask Return
USD/JPY (1998)
Intervention day

2001

Predictability, Deal Ask return
USDJPY (2001)
Intervention day

1999

Predictability, Deal Ask Return
USDJPY (1999)
Intervention day

2002

Predictability, Deal Ask Return
USDJPY (2002)
Intervention day

2000

Predictability Deal Ask Return
USDJPY (2000)
Intervention day

2003

Predictability, Deal Ask Return
USDJPY (2003)
Intervention day
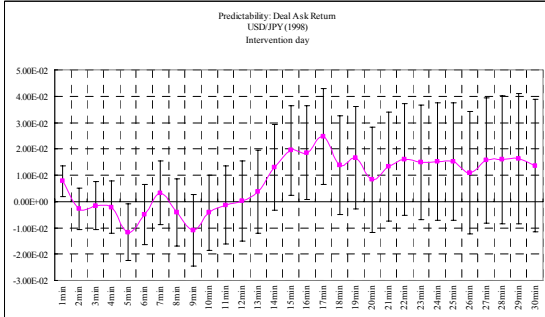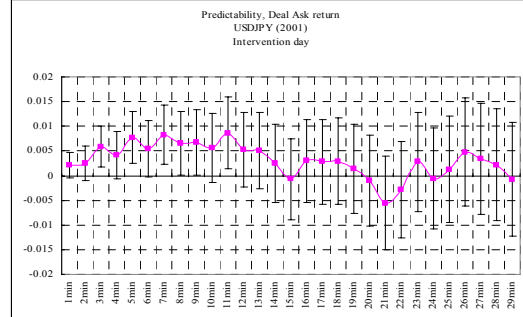
Figure 4:

No-Intervention, Midpoint return

1998
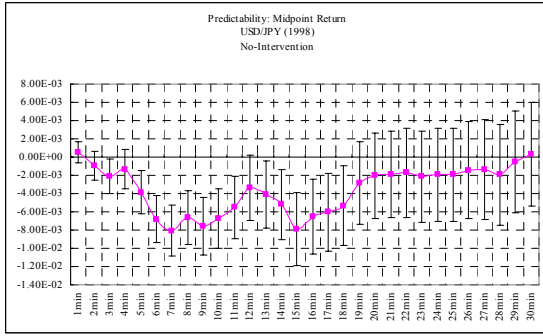
2001
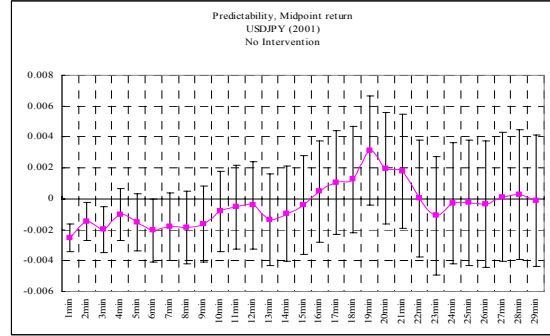
1999
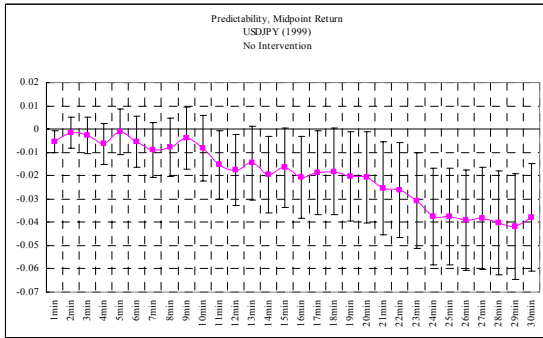
2002
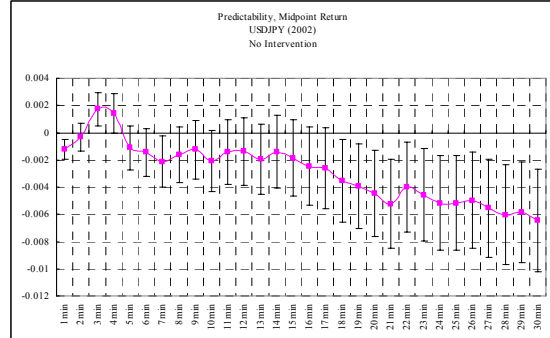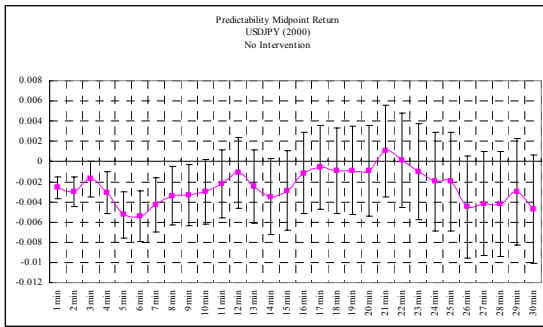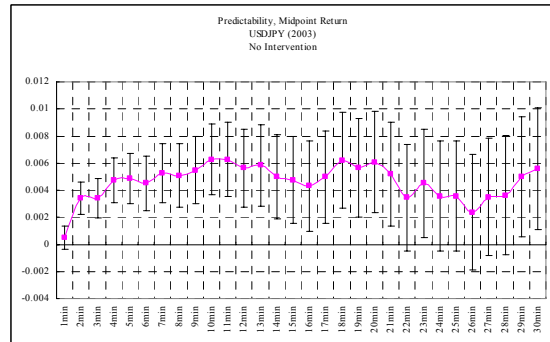
2000

2003

Figure 5:

No-intervention: Deal Bid return

1998
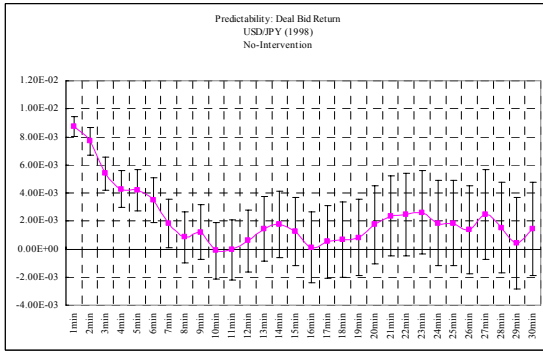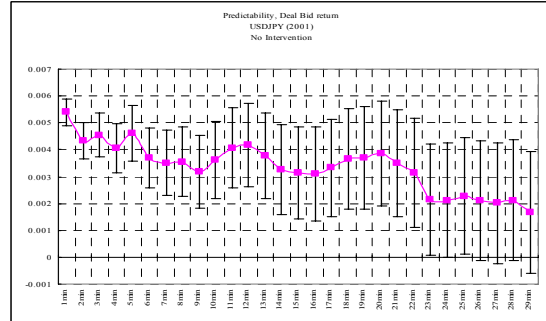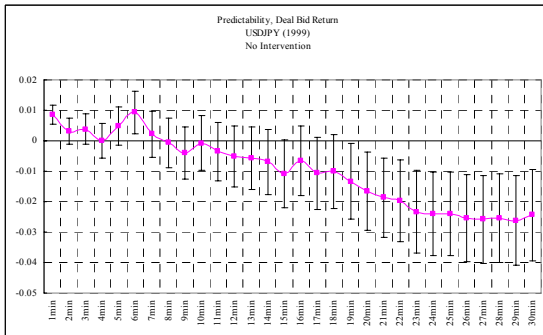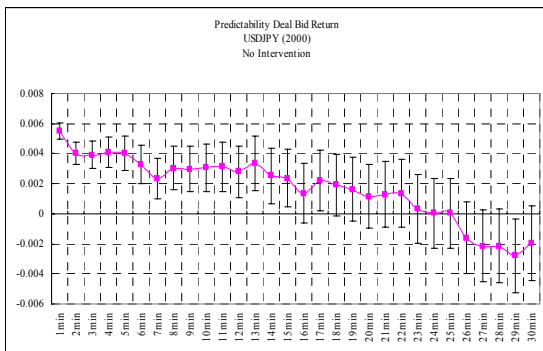
1999
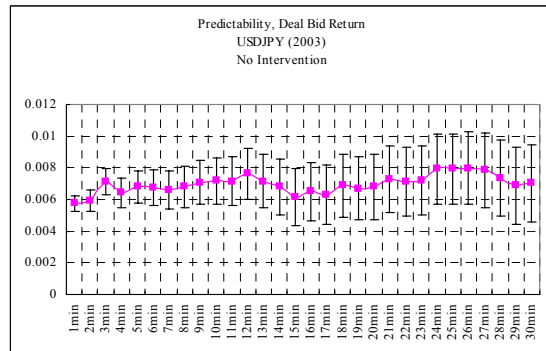
2000

2001

2002

2003

Figure 6:

No-intervention: Deal ASK return

1998
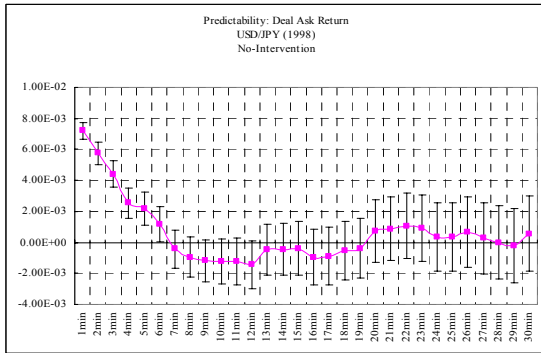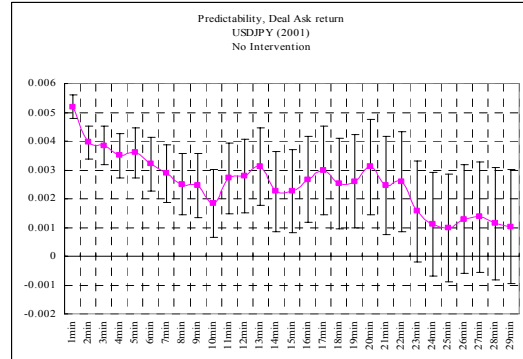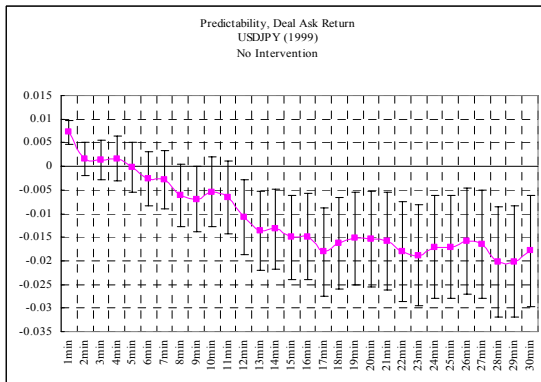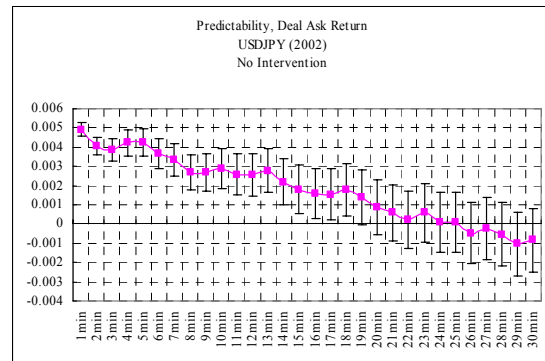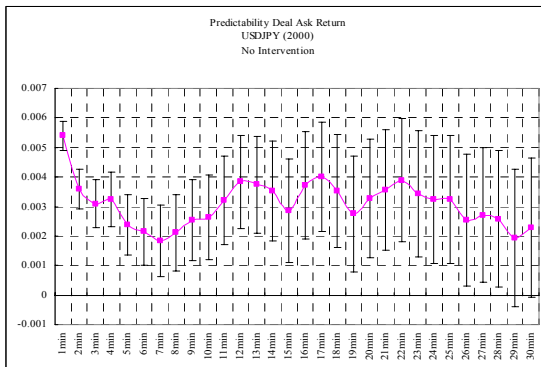
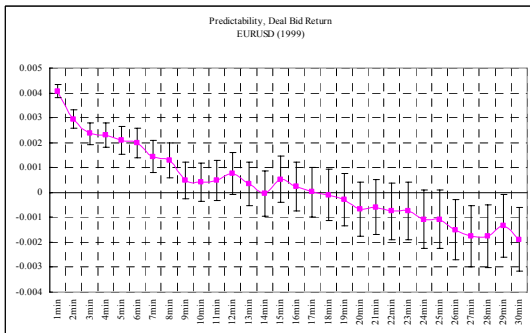

1999
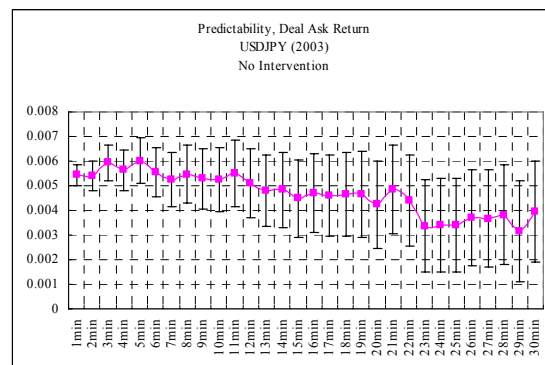
2000

2001

2002

2003

Figure 7

Midpoint return (EURUSD)
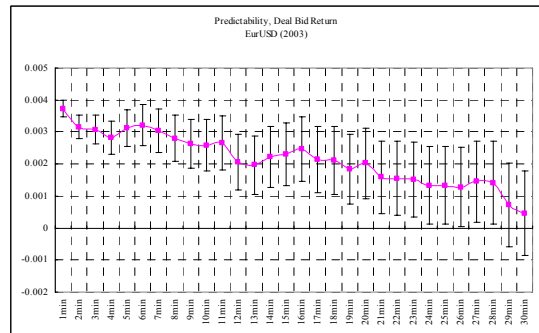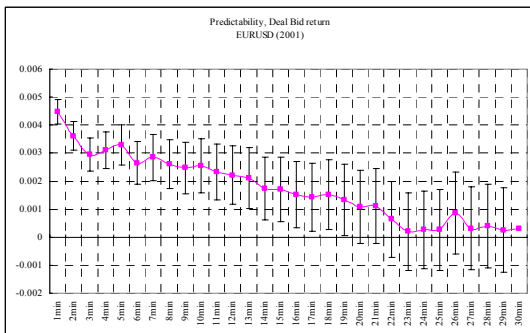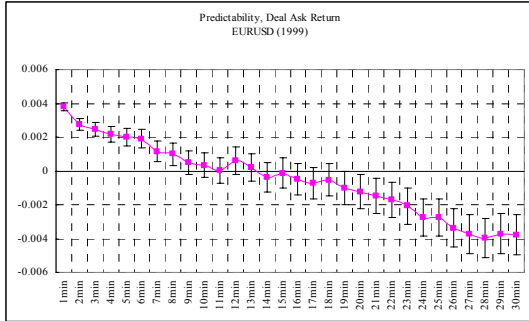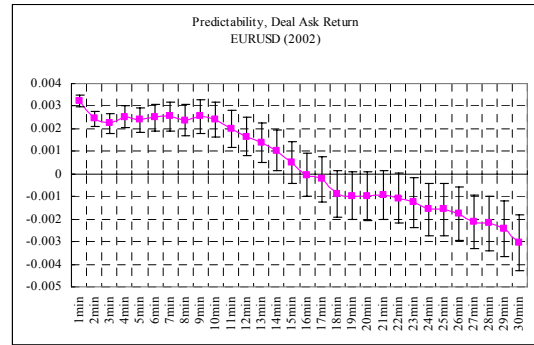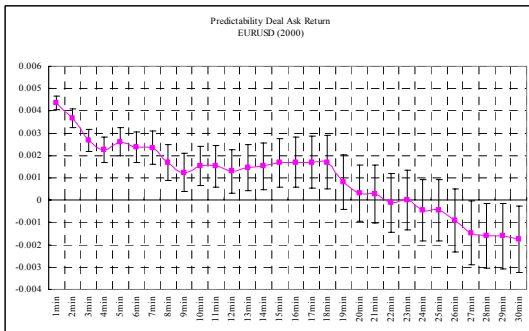
1999
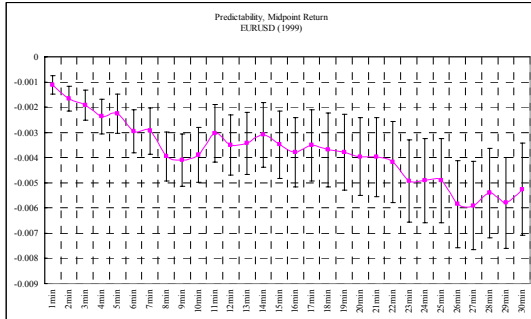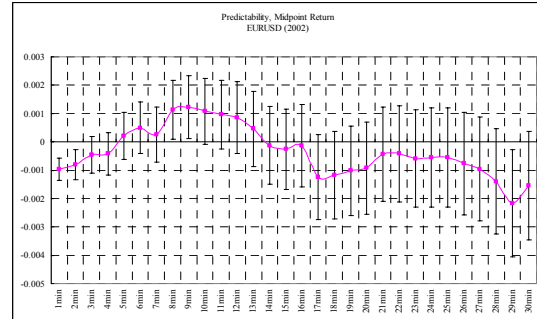
2002

2000
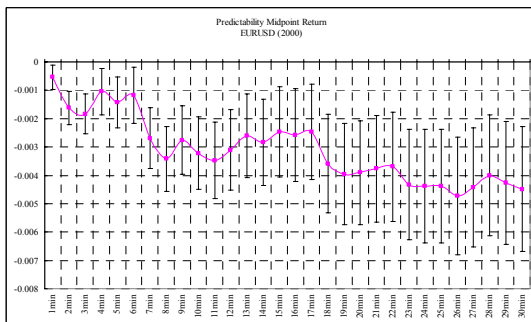
2003
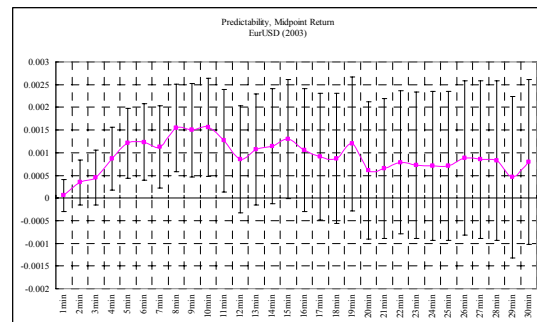
2001
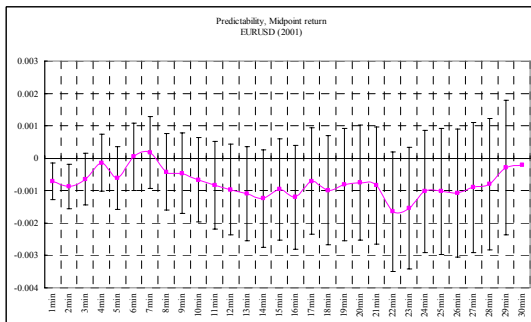
Figure 8

Deal Bid return (EURUSD)

1999

Predictability Deal Bid Return
EURUSD (2000)

2002

Predictability, Deal Bid Return
EURUSD (2002)

2000

Predictability, Deal Bid Return
EURUSD (1999)

2003

Predictability, Deal Bid Return
EurUSD (2003)

2001
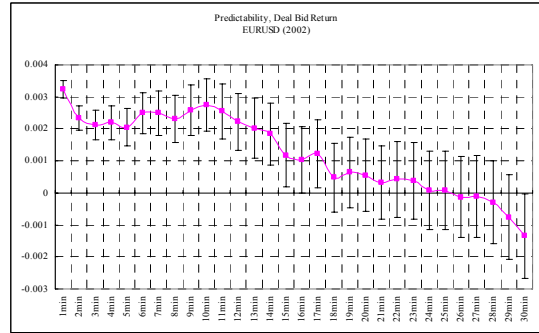
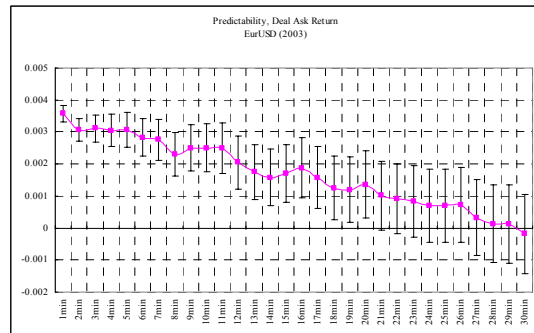Predictability, Deal Bid return
EURUSD (2001)

Figure 9

Deal Ask return (EURUSD)

1999

Predictability, Deal Ask Return
EURUSD (1999)

2002

Predictability, Deal Ask Return
EURUSD (2002)

2000

Predictability Deal Ask Return
EURUSD (2000)

2003

Predictability, Deal Ask Return
EurUSD (2003)

2001

Predictability, Deal Ask return
EURUSD (2001)