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'Assymetric Information, Price Discovery and Macroeconomic Announcements in FX Market: Do Top Trading Banks Know More? '

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Asymmetric Information, Price Discovery and Macroeconomic Announcements in FX Market: Do Top Trading Banks Know More?

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Abstract

This study investigates information asymmetry in the foreign exchange market by testing the hypothesis that top trading banks possess superior information on the macro-economy because they process greater order flow, which, according to the micro-structure literature, helps them aggregate the dispersed information and feel the general movements of the economy. Examining the information share of the banks in the Reuters EFX system using indicative GBP-$US data over 5 years, we find that the top 10 banks, out of 100 quoting banks in the market, have a monthly average share of over 70% of total market information, and around 80% during some U.S. macro announcements. These results suggest the possibility of private information over public news in the foreign exchange market.

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I. Introduction

Though the foreign exchange market is the largest financial market with a daily turnover of $US 1.9 trillion[1], it is not necessarily a market of perfect competition. According to Euromoney (May, 1995), the largest 10 foreign exchange banks accounted for 45% of global foreign exchange business in 1994. Consolidation in the banking sector since then brought further concentration in the foreign exchange market. The BIS triennial survey (2005) reports a substantial decline since 1995 in the number of banks accounting for 75% of local turnover. I n the U.S., there were only 11 banks conducting 75% of foreign exchange market transactions in 2004, compared to 13 banks in 2001, and to 20 banks in both 1998 and 1995. The same trend is found in the UK foreign exchange market. Such concentration suggests that top banks in foreign exchange business may exert greater impact on the price formation process than the relatively smaller banks. Supportive evidence for that is found in Cheung and Chinn's (2001) survey of the US market where 50% of currency traders agreed that there are dominant players in the GBP-$US market.

Such findings motivate our investigation on the information asymmetry in the spot foreign exchange market and its implications for the existence of private information. We test the hypothesis that top trading banks in the foreign exchange business have more information on the macro economy. The dominant banks' information advantage over their rivalries can be interpreted under a microstructure framework, where transactions play a central, causal role in price determination.[2] In foreign exchange market prices are determined collectively by macro economic factors, such as economic growth, consumption, unemployment and interest rates. Information about them is not directly observable on a real-time base, but dispersed widely among heterogeneous market players prior to public announcements. Even after the actual announcements, their interpretation is subject to the individual market participant's judgment. One needs to jigsaw together the dispersed partial information

[1] BIS triennial survey 2005.
[2] See, e.g., Glosten and Milgrom (1985) and Kyle (1985).

in order to form a complete picture of the macro economy. In foreign exchange markets customer order flow is one of the potential sources, which helps trading banks to aggregate this dispersed information and 'feel' the general movements of the economy.[3] For example, Lyons (1997) finds that foreign exchange order flows generated by international trades and services help dealers to 'know' the trade balance figures long before the statistics are published. One hence may expect that the more order flow a trader processes, the more information she could garner from it. Therefore, the dominant role of major banks in the global foreign exchange transactions may cause them in turn to have a dominant share of market information.

We test this hypothesis by examining the information share of the top trading banks relative to that of the rest of the banks in the GBP-$US market.[4] We also test whether this information advantage is prevalent during general scheduled macro news.

Our paper relates to two strands of literature, namely the studies, which have investigated information asymmetry, and the studies, which have examined the effects of news in the foreign exchange market. A number of studies have examined information asymmetry by looking at the price leadership amongst trading banks around central bank interventions. For example, Piers (1997) examines the quoting behaviour of dealers in the DM-$US market around Bundesbank interventions from October 1992 to September 1993 and finds evidence of price leadership by Deutsche Bank before the announcement of interventions. However, when de Jong, Mahieu, Schotman, and van Leeuwen (1999) repeated the analysis and Dominguez and Panthaki (2003) expanded it to include Federal Reserve intervention activities no specific bank was found to act as price leader. In contrast, Sapp (2002) using a bigger sample of DM-$US quotes from the Reuters'FXFX system from January 1991 to September 1993, finds that Chemical Bank's quotes are the first to contain new information. However, in the periods of uncertainty around central bank

[3] See, e.g., Lyons (1995), Bjonnes and Rime (2005), Rime (2001), Payne (2003) and Evans and Lyons (2005a).

[4] The top 10 banks are selected by Euromoney's biennial survey.

intervention, evidence suggests Deutsche Bank is the price leader. As it can be seen the results found in the above studies regarding price leadership amongst banks around central bank interventions as a public news item are mixed.

On the other hand, Menkhoff and Schmeling (2008) examine information asymmetry by analyzing traders' characteristics in a foreign exchange electronic limit order market via anonymous trader identities. They use ten days of interbank data of spot RUR-$US at the MICEX in Moscow. They relate these trader characteristics to traders' price impacts by forming random trader groups and estimating the permanent price impact of these groups' order flows. They find that more information is conveyed by those traders' trades, which simultaneously use medium-sized orders, have large trading volume, are located in a financial centre, trade early in the trading session, at times of wide spreads and when the order book is thin.

Our work relates also to studies, which have investigated the impact of macroeconomic news on exchange rates. For example, Almeida et al. (1998) study the different reactions of DM-$US to German and U.S. macro announcements. Andersen and Bollerslev (1998) examine the impact of macroeconomic announcements on the volatility of DM-$US, while Andersen, Bollerslev, Diebold and Vega (2003) expand the number of exchange rates to five and find significant and asymmetric response to good and bad U.S. scheduled news. A series of other studies have investigated the impact of both scheduled and unscheduled news announcements. For example, Melvin and Yin (2000) use Reuters Money-Market Headline News to extract all types of news related to the US, Germany and Japan. Using tick-by-tick data of the Yen-$US and DM-$US, they find that higher than normal public information brings more than normal quoting activity and volatility. Bauwens et al. (2005) investigate EUR-$US and find volatility to increase before the announcements of scheduled and unscheduled news. Dominguez and Panthaki (2006) further expand the news selection into those related to fundamentals, technical analysis and order flow, and examine their effects on the EUR-$US and GBP-$US. Their results suggest other non-scheduled news also matters in foreign exchange markets.

Finally, another group of studies has investigated the impact of macroeconomic

news as a joint quantity and price response. They examined whether macro announcement surprises have a systematic and significant effect on both order flow and prices. For example, Carlson and Lo (2006) apply a case-study approach and analyse the impact of a single macro announcement. They find that market characteristics were affected for hours following the announcement. Evans and Lyons (2003), Love and Payne (2007), Rime, Sarno and Sojli (2007) examine several news arrivals but over a few months and find that macroeconomic information releases have systematic effects on order flow and as established in earlier studies on exchange rate transaction prices. However, their results show that a substantial amount of the transmission of macroeconomic news to prices is incorporated via the trading process, i.e. order flow significantly increases the explanatory power of exchange rate fluctuations as compared to news alone.[5]

Our work has a number of novel features compared to previous research in this area. First, our study is one of the first to test general macro news effects under the heterogeneity market assumption, in contrast to previous work, which either implies the market homogeneity assumption, or only tests for the central bank intervention as public news under the heterogeneity assumption. Due to commercial confidentiality reasons, the data on prices and order flows are aggregated at certain lower frequency with no information on the identity of the trading banks. Some studies, however, do find that at least different types of dealers exert a different impact on prices because of their different trading motivations (see e.g. Fan and Lyons, 2003, and Evans and Lyons, 2005b).[6]

Second, our focus is on the top trading banks in the GBP-$US market as a group

[5] Evans and Lyons (2003) use DM/$US over 4 months, form 1st of May to the 31st August 1999; Love and Payne (2007) use transaction data on $US/EUR, GBR/EUR and $US/GBR over 10 months, from the 1st December to the 24th of July 2000; and Rime, Sarno and Sojli (2007) examine $US/EUR, $US/GBP and $US/Yen from the 13th Feb 2004 – 14th Feb 2005.

[6] Both studies use customer trade data, which span over 6 years, on a daily frequency and relate to Citibank, whose market share in major customer business is about 10-15 percent. However, the data are split into three customer-type categories, hedge funds, mutual funds and non-financial corporations, which allow the authors to examine the differential impact of news.

versus the rest of the market players, as opposed to the behaviour of individual dealer's quotes in earlier studies. We call the latter tests "individual tests" compared to our approach, which we refer to as "group tests". Our grouping method, i.e. top trading banks compared to the rest of the market players grouped as another entity called non-top group, catches the major factors that contribute to market heterogeneity. We use a unique GBP-$US database, which identifies the quoting banks and enables us to group the top banks according to the Euromoney survey. Our group approach is more appropriate for studying the impact of general macro announcements on the price discovery. The individual tests relate mainly to German central bank intervention as in Peiers (1997) and Sapp (2002). For German central bank interventions, certain banks have an advantage compared to other banks in detecting and interpreting the interventions. For example, Deutschebank traded a significant portion of the intervention- related market order of the Bundesbank, the German central bank. As a result, it could garner private information on the future movements of the exchange rate from these orders (see Covrig and Melvin (2002)). This, however, might not necessarily be the case with forecasting and interpreting general macro announcements. The information on these announcements is widely dispersed amongst traders and customers, hence no order flows containing information on any category of macro news are directed to, or monopolized by a specific bank. However, if order flow does contain information, the aggregation of large banks could be expected to collectively process much more order flow than any individual bank. Therefore, private information should be detected by the group method as we have defined it above. This allows us to test whether size is an important factor which contributes to the information advantage of the trading banks during normal times, and in particular during times of public news.

Furthermore, our approach is more appropriate for our sample of 5 years, which is used to derive robust results, as opposed to the short horizons of earlier studies. Due to the natural market evolution, some banks may not possess informational advantage after a year or two, and in some cases even discontinue their market presence. In addition, the competition among electronic trading systems also changes

the availability of some banks' quotes. These factors impose a challenge to long horizon tests of 5 to 10 years. In contrast, a group is a portfolio and hence is subject to continuous update of its components limiting the negative impact of the above mentioned factors.

Another feature of our work is the focus on GBP-$US. Most of the earlier work has been on DM-$US, for short periods when using high frequency data and covering a few dealers. We use indicative GBP-$US data, which include all market players, over the period of January 1994 to December 1998, and calculate the information shares using both the Hasbrouck (1995) information share (IS) technique, and the Gonzalo and Granger (1995) common component (PT) method providing robustness to our results. Previous related work has relied on one of these methods.

Our results show that the top 10 banks, out of one hundred quoting banks, have a dominant share (monthly average of over 70%) of the price information in the Reuters EFX system[7]. Furthermore, when testing 21 categories and 1035 items of U.S. announcements, we find that during some categories of news announcements, the top 10 banks' information share is further expanded to around 80%. The results indicate that size is an important factor, which contributes to the information advantage of trading banks. They also indicate that top trading banks might have either more private information over public news, or might be better at interpreting macro news. We further explore this view by examining the relationship between the top trading group's information share and the volatility of GBP-$US. We find a positive association, which according to Admati and Pfleiderer (1988) is an indication of informed trading as informed traders are prone to transact during periods of high volatility.

The structure of the remainder of the paper is as follows. Section II, looks at the

[7] Melvin and Yin (2000) use quote frequency as an indication of information process and find that quotes are related to information arrival. In our case it is not possible to have a prior expectation of how private information would influence the quote behavior of banks. This was confirmed by banks' quote frequency tests around public news arrival during our sample period, which present no particular pattern (results could be made available by the authors).

selection of the top trading banks, exchange rate data and macro announcements used in our tests. Section III, describes our methodology. Section IV, reports the empirical results and discusses the implications. Section V, concludes the paper.

II. Data

A. Selection of the Top Trading Banks

We use Euromoney's biennial foreign exchange market polls as a guide for our selection of top banks. We include the voted top 10 banks in GBP-$US market into the top group, and leave the rest of the banks in what we call the non-top group. All the quotes from the top group will be treated as being from one entity, and the same applies to the non-top group. Using such a method, we investigate whether the top group takes up more information share during normal intraday trading time and whether scheduled macro news impact on their information share.

The first 5 criteria used by Euromoney to rank the banks are reported in Table 1.[8] Those are price and quote speed, which are directly related to information (see Melvin and Yin (2000)); customer relationship, i.e. better relationship suggests more efficient information flow between banks and their customer; and higher credit rating and liquidity, which also suggest greater market trading capability, which enables banks to infer more private information from customer order flow. The top ten banks in GBP-$US market from 1994 to 1998 voted in the survey are displayed in Table 2.

B. Exchange Rate Data

Our data are EFX tick-by-tick GBP-$US spot quotes, as posted on the Reuters 'FXFX' screen, which have subsequently been collected and filtered by the Olsen and Associates over the period January of 1994 to December of 1998. There are advantages to using longer period, five years in our case, to study the possible existence of private information in the foreign exchange market. First the longer

[8] See Euromoney, May 1995.

period evens out possible outliers of the banks in our sample. For instance, if a certain bank performs exceptionally well during a particular year, that year's information share figure may be inflated by such a factor. Therefore, by having a longer sample period, such a result could be identified. Secondly, a longer sample period also allows us to observe the impact of increasing market concentration on the information shares of the two bank groups over the years.

It should be noted that our paper is the first one to use GBP-$US data, which identifies the banks that made the quotes. Other than DEM-$US and $US-JPY, GBP-$US is the third largest trading currency[9]. During our sample period, the currency takes over 10% of global turnover against U.S. dollar[10].

The EFX data are indicative quotes, which means that even though the dealers may intend to trade at their quoted prices they have no commitment to do so. Goodhart, Ito and Payne (1996) and Danielsson and Payne (2002) find that the basic characteristics of 5-minute foreign exchange returns constructed from quotes closely match those calculated from transactions prices. Phylaktis and Chen (2006) compare four months (inside this paper's time window) of EFX data to D2000-1 transaction data, and find that EFX data are in fact superior to the latter data set by measuring the embedded information. Since around this sample period Reuters' trading system takes more than 90% of the world's direct inter-dealer transactions[11], this finding is supportive of the quality of the data used in this study.

There are also other reasons why indicative data are more suitable than transaction data in conducting our empirical tests. For example, Goodhart and O'Hara (1997) suggest that indicative quotes are better than transaction prices in demonstrating traders' heterogeneous price interpretation, as transaction price needs agreement between two parties, while the indicative quotes are not so restrictive.

[9] See in Triennial Central Bank Survey of Foreign Exchange Market (2004).
[10] Although Huang and Masulis (1999) find that quotes submission activity in less liquid currencies is different from those most liquid ones, we believe it is not a serious issue in GBP_USD due to its relatively large global trading turnover, and in our study only highly active trading hours are studied.
[11] See in Evans (2002).

Hasbrouck (1995) indicates that an analysis of a stock, if based on last sale prices, would have problems of autocorrelation induced by infrequent trading. Though this issue is less severe in foreign exchange markets, the last sale prices would be less informative. Indicative quotes, on the other hand, could be updated in the absence of trades. Finally, an empirical investigation using transaction data may turn out to be biased because it ignores the informational content of non-trading intervals. This sampling bias is reduced when using bid-ask quote series, which are continuously updated by the market makers.

In Table 2, we can find that the voted top 10 banks in GBP-$US are roughly the same during the years 1994-95, 1996-97, and 1998. Thus, we form three different top groups for those three time periods. The rest of the banks in each period are allocated to the non-top group.

After setting up the two groups, we count the quotes for each group during our sample period. Graph 1 shows that from October 1995 onwards, the total quotes appearing on the FXFX have more than doubled. The Olsen and Associates, which provide our data, explain that this is due to the different data delivery method of Reuters before and after October 1995. The data fed into the system since then have been significantly increased. However, the quotes from the top group are relatively stable at 25% of total quotes. As we show later, the information shares of both groups experience no fundamental change following the quote frequency jump.[12]

Graph 2 presents the intraday quotes distribution of both groups. As the top group is composed of only European and U.S. banks, its quoting activity is heavily concentrated during London and New York trading hours. Non-top group's quoting distribution reflects Asian trading banks' presence during Tokyo trading hours.[13]

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[12] The increased data fed into the Reuters system decrease the average quote duration from around 6 seconds to 3 seconds, which have no big impact on the data we selected at a 5 minute frequency.

[13] The 24-hour trading day is usually separated into 7 sessions that correspond to the opening and closing times of major foreign exchange markets. The 7 sessions are: 1) 21:00 to 8:00, the period between the closing time of New York and the closing time of Tokyo, which represents the Asian trading hours; 2) 8:00-9:00, first hour of London opening with inventory effects; 3) 9:00-12:00, the hours until New York opens; 4) 12:00-13:00, the first hours of New York opening; 5) 13:00-15:00, the overlapping

We investigate only trading hours between 8:00 to 16:00 GMT, when London and New York markets are active to avoid sparse trading. We exclude weekends and holidays for the same reason. There are in total 1,214 valid trading days during our sample period. Following general practice, we convert our data into 5-minute frequency. For each 5-minute time slot, the last quotes from each group are chosen as the representative quotes of the top and non-top groups.

C. Macro Announcement Data

In our analysis, we test the effects of 21 categories of US government macro announcements, as listed in Table 3.[14] We exclude 8 categories of announcements from the 29 categories of major US macro announcements, because of either the high frequency of announcements (e.g. initial claim is announced weekly), or because they overlap with other announcements, e.g. civilian unemployment rate is announced at the same time as the non-farm payroll. Except for GDP related announcements, which are quarterly, and Fed funds rate announcements, which are on a six-week base, all remaining items of news are announced monthly.

The news effect is investigated during a 4-hour time window, 2 hours before and 2 hours after a specific announcement. The concern is that the information over the public news could be revealed after as well as before the announcement, if there is asymmetric information. Private information should cause the price to adjust itself before the announcements, and then to continue to affect the news interpretation.

Though some announcements, e.g. the target federal funds rate announcements from FOMC, are announced outside our daily GMT window, we still include them due to their importance.[15] In our sample period, we have a total of 1035 items of valid announcements.

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trading hours of the two major markets; 6) 17:00-18:00, London closing hour; 7) 18:00-21:00, the hours till New York closes.

[14] The scheduled announcement time data are provided by Francis X. Diebold.

[15] We assume that the announcement takes place at 14.00 GMT. The information share over this news category is therefore mainly a measurement of the top group's capability of forecasting the actual result, and not of their news interpreting power after the announcement.

III. Methodology

A. Measures of Information Share

IS and PT models are the two most prevalent common factor models. They are directly related and the results of both models are primarily derived from the vector error correction model (VECM). They provide similar results if the VECM residuals are uncorrelated. However, if substantial contemporaneous correlations exist the two models usually provide different results. Hasbrouck (1995) handles this correlation by using Cholesky factorization. Therefore, the IS results are variable order dependent. Hasbrouck (1995) suggests that different orders may be used and upper and lower information share bounds be averaged to arrive at a final information share result. However, the bounds are often very much apart since high frequency exchange rate data have a high residual correlation. Therefore in our paper, we use both IS and PT models as complementary methods. The following estimation approaches for both models are mainly adapted from Baillie et al. (2002).

We consider the two price quotes from the two groups of banks to be $I(1)$ processes, $P_t = (p_{1t}, p_{2t})'$ with the differential being the error correction term $d_t = \beta' P_t = p_{1t} - p_{2t}$, where β is the cointegration vector. Both models start from the estimation of the following VECM:

$$\Delta P_t = \alpha\beta' P_{t-1} + \sum_{j=1}^{k} A_j \Delta P_{t-j} + e_t, \tag{1}$$

where α is the error correction vector and e_t is a zero-mean vector of serially uncorrelated innovations with covariance matrix Ω

$$\Omega = \begin{pmatrix} \sigma_1^2 & \rho\sigma_1\sigma_2 \\ \rho\sigma_1\sigma_2 & \sigma_2^2 \end{pmatrix}. \tag{2}$$

The VECM has two parts: the first part, $\alpha\beta' P_{t-1}$, represents the long-run or equilibrium dynamics between the price series, and the second part, $\sum_{j=1}^{k} A_j \Delta P_{t-j}$,

shows the short-term deviation induced by market imperfections.

Hasbrouck (1995) transforms Eq. (1) into a vector moving average (VMA) in an integrated form

$$P_t = \psi(1)\sum_{s=1}^{t} e_s + \psi^*(L)e_t, \quad (3)$$

where $\psi(L)$ and $\psi^*(L)$ are matrix polynomials in the lag operator, L. If we denote $\psi = (\psi_1, \psi_2)$ as the common row vector in $\psi(1)$, Eq. (3) becomes

$$P_t = \iota\psi(\sum_{s=1}^{t} e_s) + \psi^*(L)e_t, \quad (4)$$

where $\iota = (1,1)'$ is a column vector of ones.

Hasbrouck (1995) states that the increment ψe_t in Eq. (4) is the component of the price change that is permanently impounded into the price and is presumably due to new information. If price innovations are significantly correlated across prices, Hasbrouck (1995) uses Cholesky factorization $\Omega = MM'$ to eliminate the contemporaneous correlation, where:

$$M = \begin{bmatrix} m_{11} & 0 \\ m_{12} & m_{22} \end{bmatrix}. \quad (5)$$

If we further denote $\alpha_\perp = (\gamma_1, \gamma_2)'$, which is also the Γ in Gonzalo and Granger (1995)'s PT model, then the information shares of the two prices are:

$$S_1 = \frac{(\gamma_1 m_{11} + \gamma_2 m_{12})^2}{(\gamma_1 m_{11} + \gamma_2 m_{12})^2 + (\gamma_2 m_{22})^2}, \text{ and} \quad (6)$$

$$S_2 = \frac{(\gamma_2 m_{22})^2}{(\gamma_1 m_{11} + \gamma_2 m_{12})^2 + (\gamma_2 m_{22})^2}. \quad (7)$$

In order to get the information share of each group, the order of them is changed and the calculation process is repeated. The average of the two results is suggested by Hasbrouck to be the information share.

Gonzalo and Granger (1995) define the common factor to be a combination of the variables P_t, such that $h_t = \Gamma P_t$, where Γ is the common factor coefficient

vector. The information shares of the two prices according to the PT model are as follows:

$$S_1 = \frac{\gamma_1}{\gamma_1 + \gamma_2}, \text{ and} \tag{8}$$

$$S_2 = \frac{\gamma_2}{\gamma_1 + \gamma_2}. \tag{9}$$

Thus, the Granger and Gonzalo's (1995) approach is concerned with only the error correction process, which involves only permanent as opposed to transitory shocks that result in a disequilibrium. It ignores the correlation among the two prices and measures each price's contribution to the common factor on the basis of its error term. The price, which adjusts the least to the other price movements has the leading role in the price discovery process. In contrast, Hasbrouck (1995) defines price discovery in terms of the variance of the innovations to the common factor assuming that price volatility reflects the flow of information. Information share in this model is each price's relative contribution to the variance.[16]

We conduct the usual procedures of unit root and cointegration tests before the information shares of each group are estimated. Unless otherwise stated, the price series in our empirical tests satisfy both conditions.

B. Estimation Process and Confidence Bands

We measure information shares of prices quoted between 8:00 to 16:00 GMT, when London and New York markets are active. As a result, a directly estimated ECM would cause lagged returns to contain the overnight price jump and the previous trading day's price changes. We thus use return series that exclude overnight and

[16] According to Baillie et al. (2002) the two models complement each other and provide different views of the price discovery process between markets. On the other hand, de Jong (2002) concludes that Hasbrouck's measure is a more proper measure of the amount of information generated by each market. Harris et al. (2002) have different view and employ Granger and Gonzalo (1995) to estimate and test common factor components attributable to each market. The market with the highest normalised factor weight has the biggest contribution to revelation of the innovations underlying the common stochastic trend in those stocks.

previous trading day's returns and apply Seemingly Unrelated Regression (SUR) method.

SUR, also known as the Zellner's method, estimates the parameters of the system while taking heteroskedasiticity and contemporaneous correlation in the errors across equations into consideration. The ECM is expressed in the SUR form with the cointegration vector restricted to be $(1\ -1)$. The optimum lag order is specified by minimizing Schwarz-Bayesian criterion (BIC). Lagged overnight and previous trading day's returns and price levels are accordingly purged when the regressions are estimated.

We employ the bootstrapping method to find the confidence bands of the information share. Following Li and Maddala's (1997) suggestion, we use the stationary bootstrap method to resample the residuals, i.e. the bootstrapped residual block length follows a geometric distribution. Specifically, let ε_1^* be the first randomly resampled observation from estimated $\{\hat{\varepsilon}_t\}(t=1,...,n)$ so that $\{\varepsilon_1^* = \hat{\varepsilon}_j\}$ for $1 \le j \le n$. Then the adjacent $\{\varepsilon_2^*\}$ has the following distribution

(10) $$\Pr(\{\varepsilon_2^* = \hat{\varepsilon}_{j+1}\}) = 1-p \quad \text{and} \quad \Pr(\{\varepsilon_2^* = \hat{\varepsilon}_i\}) = p,$$

where $p\,(0 \le p \le 1)$ is the probability of the geometric distribution of the random block length, and $1 \le i \le n$.

The stationary bootstrap method keeps the stationary nature of the resampled residuals compared to the moving block method. It is also less sensitive to the selection of the probability p.

We first estimate the ECM with optimum lag with the purged return series. The estimated parameters and residuals are stored. The resampled residuals are then inserted back into the estimated ECM. With the new Δp_t constructed from the resampled residuals, the ECM is estimated again and the information shares recalculated. All of the ECM estimation is corrected for heteroskedasticity. We repeat the process by 200 times and the 95% and 5% confidence bands of the information

shares are hence obtained.

IV. Empirical Results

A. Preliminary Analysis

Before estimating the information shares of our two groups of trading banks, we examine the lead-lag relationships between them. This is a preliminary analysis, which tests the speed of the information embedded in the return of the two prices.[17] If the top group's quotes are faster in incorporating trading information into the price, its return should lead the non-top group's return, i.e. the top group's return could predict the non-top group's return.

We estimate the cross correlations between two series p and q as follows

$$r_{p,q}(l) = \frac{c_{pq}(l)}{\sqrt{c_{pp}(0)}.\sqrt{c_{qq}(0)}}, \tag{11}$$

where $l = 0, \pm 1, \pm 2, \ldots$ and

$$c_{pq}(l) = \begin{cases} \sum_{t=1}^{T-l}((p_t - \bar{p})(q_{t+l} - \bar{q}))/T & l = 0, 1, 2, \ldots \\ \sum_{t=1}^{T+1}((\mathrm{q_t} - \bar{q})(p_{t-l} - \bar{p}))/T & l = 0, 1, 2, \ldots \end{cases} \tag{12}$$

Graph 3 shows the lead lag relationship between the returns of the two groups. The contemporaneous correlation between the two return series is understandably high at 0.27. When the top group's return is in the lag, the correlation is around 0.1 and statistically significant. However, when the non-top group's return is in the lag, there is no significant correlation, which suggests that the predictability runs only in one direction, from the top group to the rest of the trading banks.

B. Information Shares

We subsequently estimate the top group's monthly information share during the

[17] Many studies have investigated the lead and lag relationships between cash and futures markets, see e.g. Chan, 1992; de Jong and Nigman, 1997.

60 months of our sample period. Since we only consider the London and New York trading hours, we eliminate overnight lag returns to avoid overnight price jumps generating excessive noise and use seemingly unrelated regression (SUR) to estimate our models. Throughout this paper, we only present the top group's result, since the top and non-top groups' information shares add up to 100%. Thus, the non-top group's information share is 100% minus the top group's information share.

In Graphs 4 and 5, we present the information share of the top group using the PT and IS methods respectively. As it can be seen the top group's information share fluctuates around 70% in most of the months. The only months that deviate from the average are at the beginning and end of our period. During the five years, the top group's informational share as a percent of total market information is 73% by PT model (71% by IS model) (see Table 4). Over the 60 months, only once the top group's information share drops below 50% according to both models. In Table 5 we present the yearly results in order to see the trend more clearly. The top group starts with a relatively small share in 1994, then experiences a rise in 1995 and once again a fall in 1996. For the next two years its share jumps significantly and reaches around 80% in 1998. The general upward trend of the top group's information share is in line with the increased market concentration in the global foreign exchange business.

C. Robustness Tests

In this section, we subject our analysis to a number of robustness tests. First of all, we test whether the information share results are sensitive to removing the 10 banks that quote the least from the non-top bank group. It is well-known that many of the smaller, especially smaller foreign banks, submit indicative quotes in the EFX market to advertise that they are present in the market. This means that they may submit quotes that mimic those of the larger banks and may simply repeat the same quoted bid and ask price for long periods. As a result, these quotes may contain very little information and would be contained in the non-top bank group. We thus

estimate the information shares by removing the 10 banks that quote the least from the non-top bank group. Our results are virtually unchanged from those in the previous section.[18]

Secondly, we test the robustness of our results to the grouping method and estimate the information share of the top 5 banks instead of the top 10 (see Graph 5). The top 5 banks in the Euromoney survey are unchanged during our five year sample period, though a few of them went through merger and acquisition. Although the results are less strong than those of the top 10 banks, the average monthly information share is 62% by PT model (60% by IS model) of the total market information. The number of months during which the top 5 banks information drops below 50% increases to 8 months by PT model (10 months by IS) compared to one month when using the top 10 banks. As it can be seen the top 5 banks still take the dominant share of the market information, although this advantage is somewhat reduced. This could be due to the strengthening of the rivalry group.

Our final robustness test relates to the length of the interval. We calculate the information share of the top 10 banks using 10-minute data frequency instead of 5 to check whether the top group still takes the dominant information share. As the time elapses, the market information is expected to be disseminated more evenly between the top and non-top groups. Therefore, it is expected that the top group's information share will be less than when it is measured at higher frequency, i.e., 5-minute in our case. In Graph 8, the information share of the top banks using 10-minute frequency is displayed. As expected, the average monthly information share drops to 60% according to PT model (57% according to IS model) from the previous results of over 70%, according to both models.

D. Market Volatility and Information Share

In this section, we explore whether the fluctuations of the top group's information share could be linked to market volatility. Admati and Pfleiderer (1988)

[18] The results can be made available by the authors.

suggest that volatility is associated with private information. To maximize their potential profit from their private information, informed traders are prone to transact during periods of high trading activity. Thus, the informed transactions are linked with increased volatility. In the context of our paper, the above implies that we should expect the information share of the top group to be positively correlated with the market volatility.

Graph 6 shows the scatter plot of the monthly GBP-$US volatility, as proxied by the standard deviation, against the information share of the top group (PT). The positive correlation between the market volatility and information share is indicated by the fitted regression line. More specifically, the regression suggests that a 10% increase in the top group's information share corresponds to 0.2% rise of market volatility (see Table 6). Given that the average monthly market volatility is 3%, this positive link is relatively strong. This provides supporting evidence on the private information content of the top group's information share.

E. Information Share during Macro Announcements

To test whether macro announcements have any impact on the information share of the top banks, we import 21 U.S. news announcements and estimate the information share of the top banks during these announcement days for each type of news separately. More specifically, the prices quoted between the four hours around the announcement, 2 hours before and 2 hours after, are first collected. Then all the prices from the two groups are compiled into two time series and the SUR method is applied. Though UK macro announcements may have an impact on the information share of the banks, we assume that these effects are insignificant.[19]

The results are reported in Tables 7 and 8 and displayed in Graph 7. Among the 21 announcements, the two GDP announcements and the Fed funds rate produce the largest information shares (over 80% according to the PT model) for the top 10 banks. This is an interesting finding compared to Evans and Lyons (2005b) result. In their

[19] As reported in Andersen et al. (2003), the impact of most non-US announcements is insignificant on the level of major exchange rates.

paper, GDP preliminary and Fed funds rate announcements are the only two announcements that have a significant impact on order flow for just one day, while their other 16 announcements have relatively longer effects. It may suggest that these two announcements cause more concentrated and intensive reaction from market players, which forces the top banks to release their information advantage in only a few hours, instead of spreading the advantage over several days like in the case of other announcements. Another interesting finding is that the trade balance, which is an important determinant in traditional exchange rate theory, contributes very little to the information advantage of the top banks. This may be explained by the relatively easy predictability of the trade balance figure by the market players. Therefore, top banks are less likely to know more than their rivalries.

We are also interested in the news effect by allocating macro announcements into different categories. Following Andersen et al (2003), we allocate news into 8 different groups, such as real activity, forward looking and net export etc. Table 9 reports the result. As we can see, FOMC, i.e. Fed funds rate, is related with the highest information share from the top banks. Given the importance of the interest rates in the foreign exchange market, this is a reasonable result. GDP announcements are the category of news that are linked to the next highest information share. As an indicator of economic growth, GDP has long been one of the important determinants of exchange rates. Treasury budget, as the only category in the Government purchase category, has the next highest information share together with prices. It may have an impact on exchange rates through its effect on interest rates. An expanded treasury budget deficit would indicate an increase in interest rates, increased capital flows and an effect on the exchange rate.

V. Conclusion

This study is one of the first papers to tackle directly the information asymmetry issue in the foreign exchange market. Traditional exchange rate theory assumes that the agents in a given market are homogeneous and therefore, the price formation

process is only determined by public information. However, when we cast our eyes in the foreign exchange market, the assumption of market players' homogeneity is unsound and misleading. Correctly assessing and depicting the picture of market participants' heterogeneity in an information sense may help us solve and explain the exchange rate determination puzzle.

We investigate this information asymmetry by testing the hypothesis that major trading banks in the foreign exchange market have more information on the macro economy garnered from the larger order flow they process. According to Evans (2002) trading banks collect information from the customer trading, inter-dealer trading, and from after-announcement news interpretation, or non-common-knowledge. Using indicative GBP-$US data over the period of January 1994 to December 1998, we indeed find that the top 10 trading banks, out of one hundred quoting banks, have a dominant share (monthly average of over 70%) of the price information in the Reuters EFX system. This information share increases over the years corresponding to the rising market concentration of the banks. This importance of size is in agreement with Menkhoff and Schmeling (2008), who find that traders who have large trading volume have high price impact.

In our analysis we also test whether the top 10 banks' information advantage is prevalent during general scheduled macro news. After testing for 21 categories and 1035 items of U.S. announcements, we find that during some categories of news announcements, the top 10 banks' information share is further expanded to around 80%. This suggests that top trading banks might have either more private information over public news, or might be better at interpreting macro news. This view is also supported by the positive association between the information share of the top trading group and the volatility of GBP-$US for according to Admanti and Pfleiderer (1998) informed traders are prone to transact during periods of high trading activity. This is the first study to test general scheduled macro news effects under the heterogeneity market assumption, in contrast to previous work, which either implies the assumption of market homogeneity, or only tests the impact of central bank intervention as public news under the heterogeneity market assumption.

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Table 1. Euromoney Survey's Criteria of Top Banks

	Corporations	Institutions	Banks	Others	Total
1. Relationship	**100**	**10**	**48**	**7**	**165**
2. Price alone	**91**	**14**	**49**	**10**	**164**
3. Quote speed	**74**	**12**	**50**	**9**	**145**
4. Credit rating	**66**	**10**	**27**	**7**	**110**
5. Liquidity	**41**	**11**	**38**	**7**	**97**

Source: Euromoney research, Euromoney May 1995. There were in total 16 criteria listed in the original table. The first column displays the most important 5 criteria judged by the total votes (given in the last column) from the customers of currency trading banks. The votes from each business type of customer are listed separately in the columns in the middle.

Table 2. Top Ten Banks in GBP-$US

99	98		97	96		95	94	
1	**1**	**HSBC**	**1**	**4**	**HSBC Midland**	**1**	**1=**	**NatWest Markets**
2	**2**	**Citibank**	**2**	**1**	**Chase**	**2**	**4**	**HSBC Mkts/Midland**
3	**3**	**Chase Mahattan**	**3**	**3**	**BZW**	**3**	**3**	**Barclays**
4	**4**	**NatWest Global**	**4**	**2**	**NatWest**	**4**	**1=**	**Citibank**
5	**5**	**Barclays Capital**	**5**	**5**	**Citibank**	**5**	**5**	**Chase Mahattan**
6	**6**	**Deutsche Bank**	**6**	**-**	**Royal Bank of Canada**	**6**	**9**	**Chemical**
7	**7**	**Royal Bank of Canada**	**7**	**6**	**Standard Chartered**	**7**	**10**	**Bank of America**
8	**-**	**Warburg Dillon Read**	**8**	**7**	**Bank of America**	**8**	**-**	**Lloyds**
9	**9**	**Bank of America**	**9**	**-**	**SBC Warburg**	**9**	**-**	**Standard Chartered**
10	**12**	**ABN Amro**	**10**	**9**	**Deutsche Morgan Grenfell**	**10**	**6**	**Indosuez**

Source: Euromoney, May 1995, 1997, and 1999.

Table 3. U.S. Announcements

	Item	Frequency	EST	#N
1	GDP Advanced	QTR	8:30	13
2	GDP Preliminary	QTR	8:30	16
3	GDP Final	QTR	8:30	13
4	Fed Funds Rate	6WK	14:20	38
5	Personal Income	MTH	8:30	45
6	Factory Orders	MTH	10:00	51
7	Consumer Confidence	MTH	10:00	53
8	Index of Leading Indicators	MTH	8:30	55
9	Housing Starts	MTH	8:30	57
10	Durable Goods Orders	MTH	*8:30	57
11	Construction Spending	MTH	10:00	57
12	Retail Sales	MTH	8:30	58
13	Treasury Budget	MTH	14:00	58
14	Consumer Price Index	MTH	8:30	58
15	Business Inventories	MTH	*10:00	58
16	Nonfarm Payrolls	MTH	8:30	58
17	Consumer Credit	MTH	15:30	58
18	Industrial Production	MTH	9:15	58
19	NAPM	MTH	10:00	58
20	Capacity Utilization	MTH	9:15	58
21	Merchandise Trade Balance	MTH	8:30	58
			Total #N	1035

* The announcement times were irregular or changed during our sample period.
The third column reports the scheduled announcements frequency, where QTR, MTH and 6WK stand for quarterly, monthly and 6 weeks respectively. EST is the U.S. Eastern Standard Time. Last column reports the total number of the corresponding announcements during our sample period

Table 4. Descriptive Statistics: Top Group's Monthly Information Share

	Mean	Std. D.	Kurtosis	Skewness	Min	Max	Count
PT	73.1%	10.5%	0.29	0.09	45.7%	98.2%	60
IS	71.2%	8.4%	1.01	0.41	49.1%	94.6%	60

Table 5. Yearly Information Share of Top Group

	1994	1995	1996	1997	1998
PT	67.5%	72.1%	68.4%	76.3%	81.0%
IS	68.2%	69.8%	68.6%	72.3%	77.2%

Table 6. Market Volatility and Information Share

$v_t = c + \beta PT_t + \varepsilon_t$

Coefficient	Estimate	Std. Error	t-Statistic	Prob.
c	0.01	0.01	1.55	0.13
β	0.02	0.01	2.28	0.03
Obs. 60		R-squared	0.08	

v_t is the monthly GBP-$US volatility, and PT_t is the monthly top group's information share. Estimation is done by the ordinary least square.

Table 7. Macro News and Top-group's Information Share – PT Approach

News	PT	Bootstrap 95%	Bootstrap 5%
GDP Preliminary	87.8%	95.9%	71.0%
GDP Final	83.4%	89.9%	76.1%
Fed Funds	82.5%	88.9%	77.0%
Retail Sales	81.0%	88.4%	75.1%
Consumer Confidence	79.8%	86.3%	74.3%
Government Budget Deficit	78.2%	82.3%	73.1%
CPI	78.2%	83.1%	73.9%
Business Inventories	76.1%	81.0%	70.5%
Housing Start	75.7%	79.1%	71.4%
NAPM	75.0%	82.8%	59.8%
Durables	74.8%	80.5%	69.3%
Non-farm Employment	74.5%	79.8%	69.6%
Unemployment	74.5%	79.2%	69.0%
Capacity Utility	74.2%	79.7%	70.7%
Industrial Production	74.2%	80.1%	69.8%
Factroy Orders	74.1%	78.0%	70.1%
Personal Income	73.5%	82.1%	66.4%
Consumer Credit	72.1%	77.8%	66.7%
Trade Balance	71.3%	75.9%	67.8%
Leading	71.0%	77.7%	64.3%
GDP Advanced	67.8%	86.4%	58.3%
Construction Spending	59.3%	75.6%	46.1%

The information share of the top group is estimated by creating time series of prices quoted in between the 4 hours around the announcement, with 2 hours before and 2 hours after the news. Then all the prices from the two groups are compiled into two time series and SUR method is applied.

Table 8. Macro News and Top-group's Information Share – IS Approach

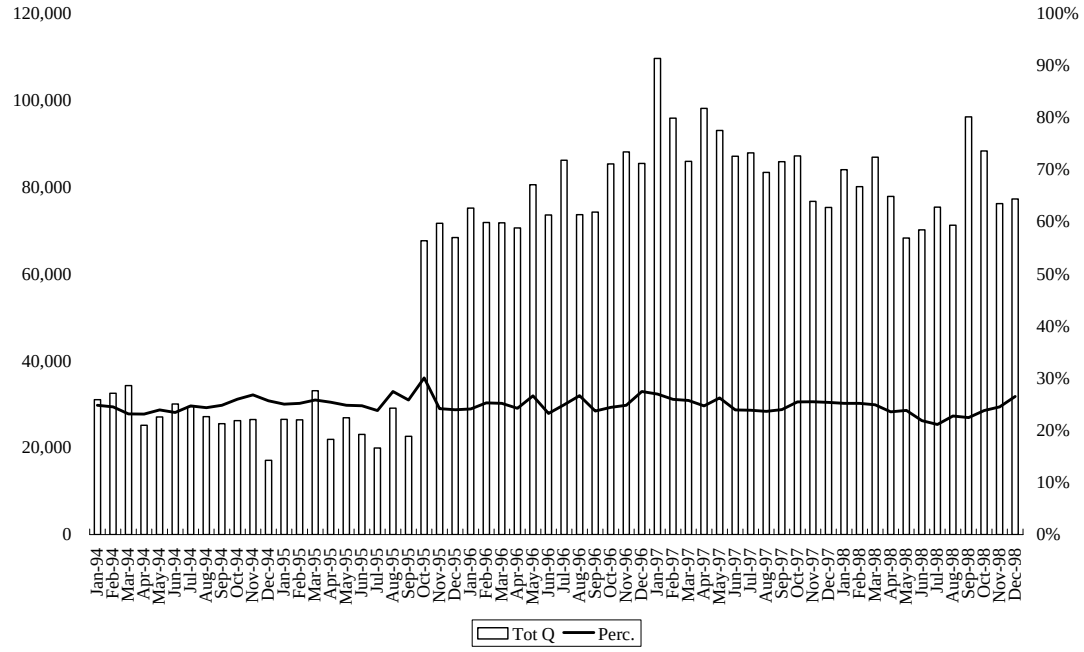
News	IS	Bootstrap 95%	Bootstrap 5%
GDP Preliminary	85.8%	91.9%	71.7%
Fed Funds	80.3%	83.3%	75.6%
GDP Final	79.7%	85.4%	72.9%
Retail Sales	77.4%	82.6%	73.2%
Consumer Confidence	76.4%	81.5%	72.0%
CPI	76.2%	80.4%	72.8%
Government Budget Deficit	76.2%	79.5%	71.9%
Factroy Orders	73.3%	76.7%	69.5%
Business Inventory	73.1%	77.3%	68.3%
Capacity Utility	72.3%	77.7%	69.0%
Industrial Production	72.3%	77.9%	68.3%
Non-farm Employment	72.3%	75.7%	69.2%
Unemployment	72.3%	75.6%	68.5%
Housing Start	72.1%	75.7%	68.2%
Durables	71.9%	76.0%	67.6%
Personal Income	71.5%	78.1%	65.5%
Trade Balance	70.1%	74.7%	66.5%
Consumer Credit	69.6%	73.1%	65.5%
NAPM	69.1%	77.0%	59.8%
Leading	68.4%	73.6%	62.8%
GDP Advanced	67.2%	79.1%	58.2%
Construction Spending	61.6%	74.8%	49.4%

See notes to Table 7.

Table 9. News Effect by Category

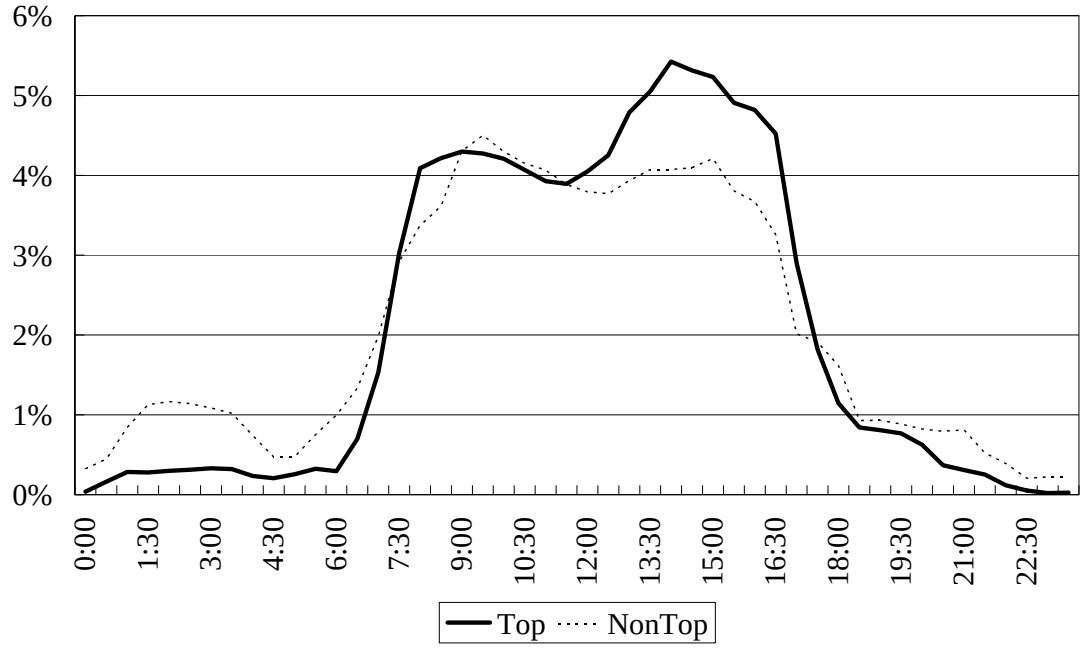
	Category	#N	PT	IS
1	FOMC	38	82.5%	80.3%
2	GDP	42	79.6%	77.6%
3	Government Purchase	58	78.2%	76.2%
4	Prices	58	78.2%	76.2%
5	Forward Looking	223	75.4%	71.5%
6	Real Activity	277	74.9%	72.6%
7	Net export	58	71.3%	70.1%
8	Investment	223	71.1%	70.0%

Graph 1. Monthly Quotes from Top Group and as a Percentage of Total Quotes



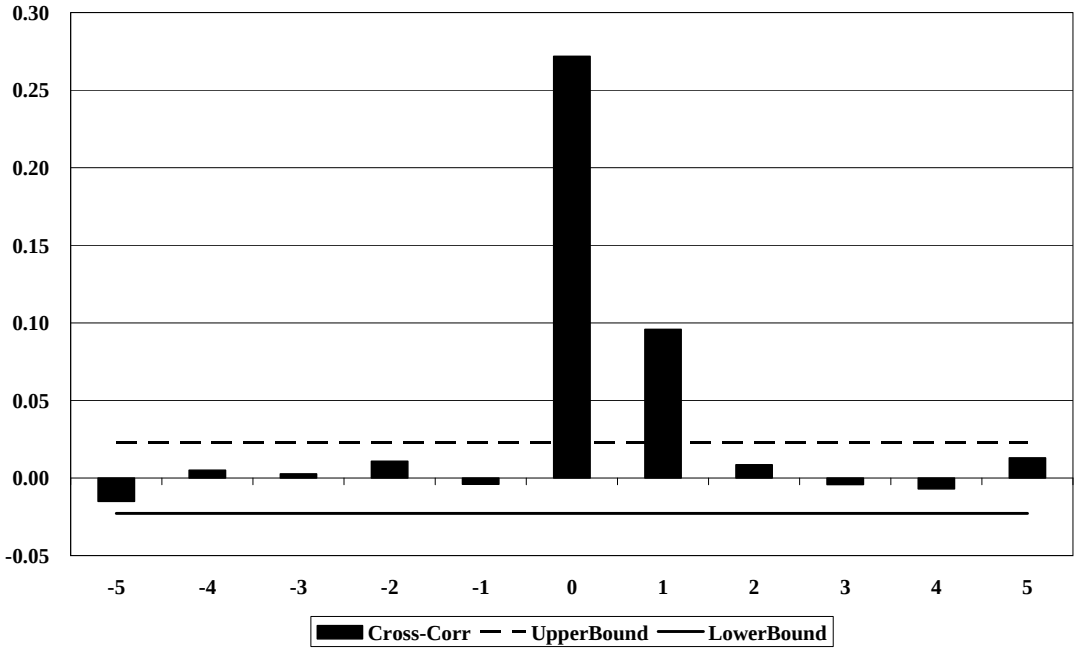
The column stands for the number of quotes in each month from the top ten banks, which form the top group. The line stands for the percent of the top group's quotes compared to that of total quotes from all the banks in the same month.

Graph 2. Daily Quotes Distribution of Both Groups



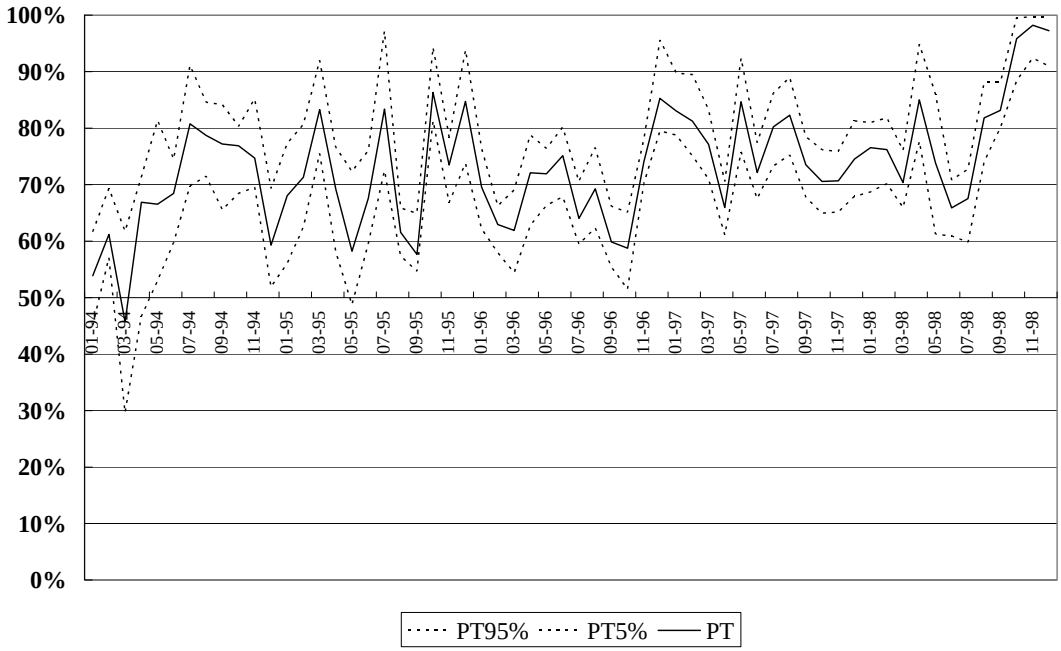
Each half hour's quotes from each group are aggregated and presented as the percentage of total quotes. The intraday result is the average of the sample period. The 24-hour trading day is usually separated into 7 sessions that correspond to the opening and closing times of major foreign exchange markets. The 7 sessions are: 1) 21:00 to 8:00, the period between the closing time of New York and the closing time of Tokyo, which represents the Asian trading hours; 2) 8:00-9:00, first hour of London opening with inventory effects; 3) 9:00-12:00, the hours until New York opens; 4) 12:00-13:00, the first hours of New York opening; 5) 13:00-15:00, the overlapping trading hours of the two major markets; 6) 17:00-18:00, London closing hour; 7) 18:00-21:00, the hours till New York closes.

Graph 3. Cross Correlations of the Top and Non-top Group's Return



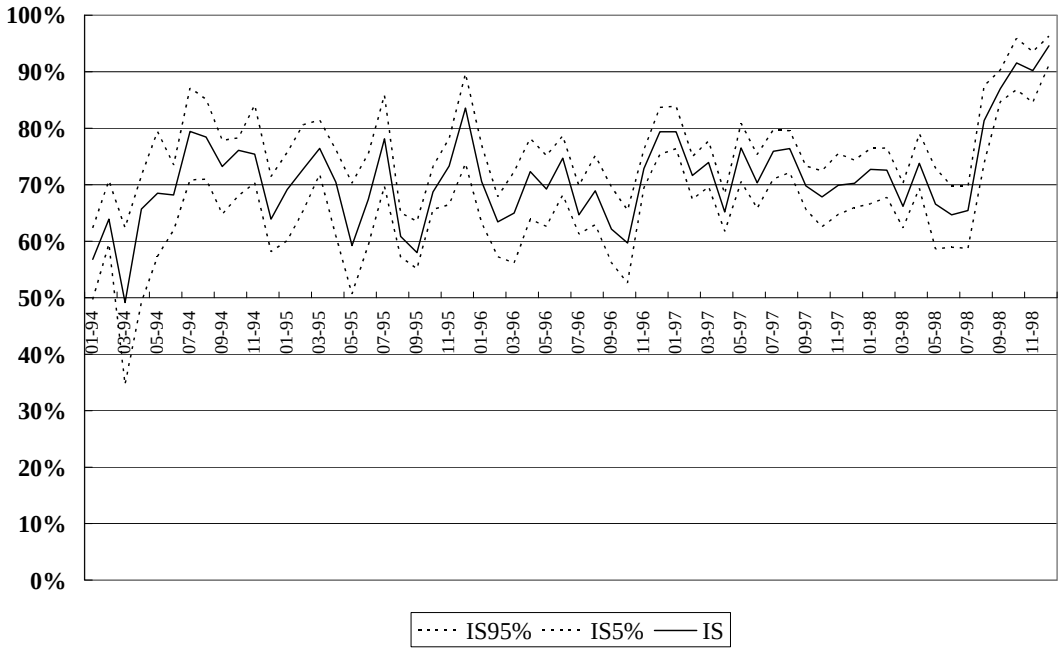
The positive figure on the x-axis means that top group's return is in the lag. Each lag stands for 5 minutes. The upper and lower bounds of the cross correlogram are the approximate two standard error bounds computed as $\pm 2/\sqrt{T}$, where T is the available number of observations.

Graph 4. Top Group's Monthly Information Share – PT Method

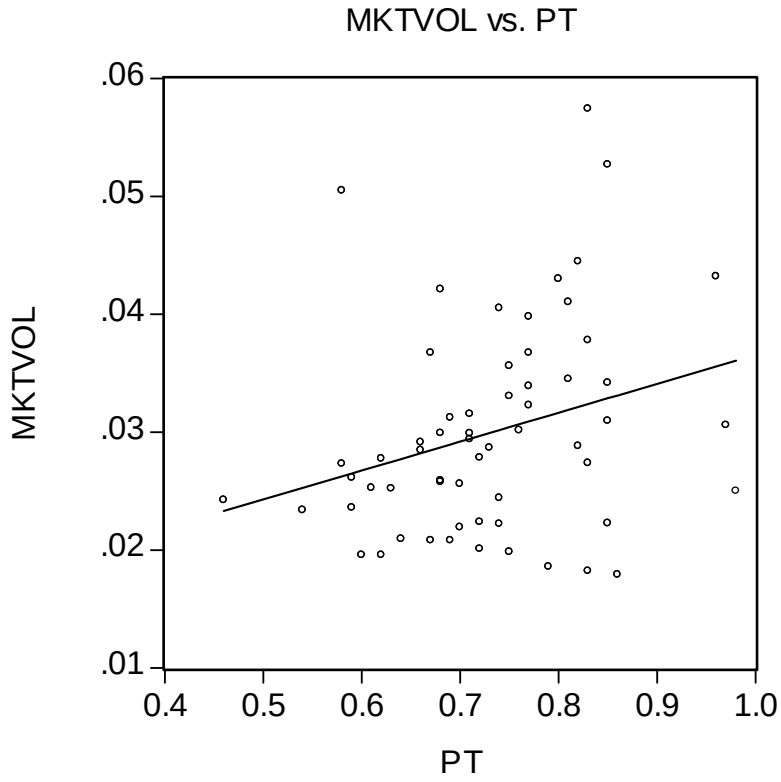


The 95% and 5% confidence bands are calculated by stationary bootstrapping the ECM by 200 times and then the 10^{th} and 190^{th} largest re-estimated information share values are chosen.

Graph 5. Top Group's Monthly Information Share – IS Method

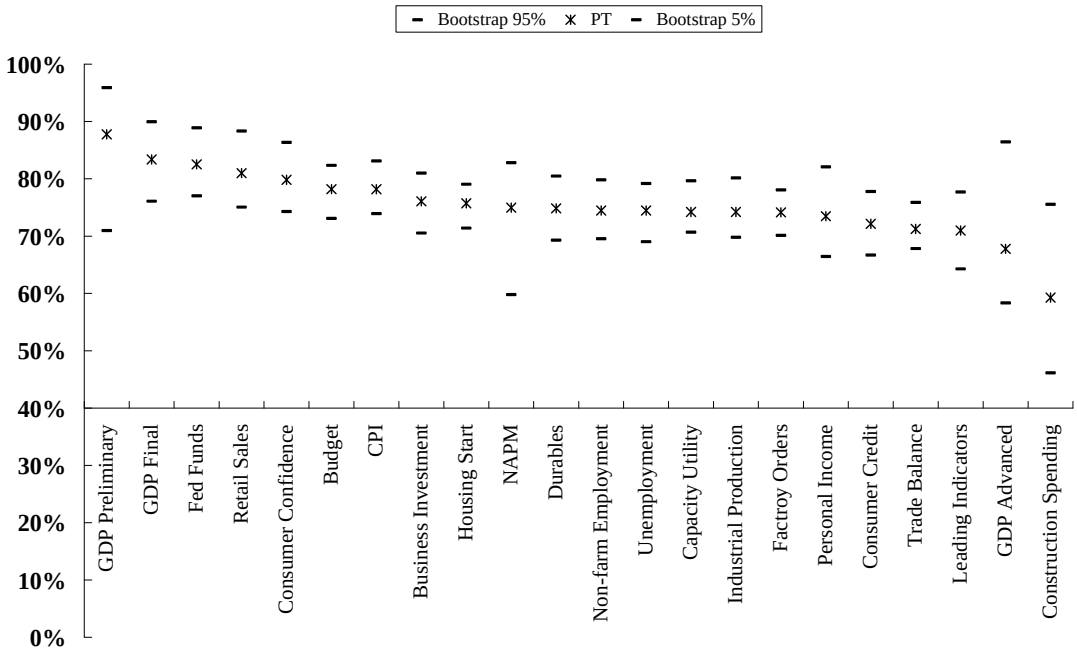


Graph 6. Scatter Diagram of Market Volatility against (PT)

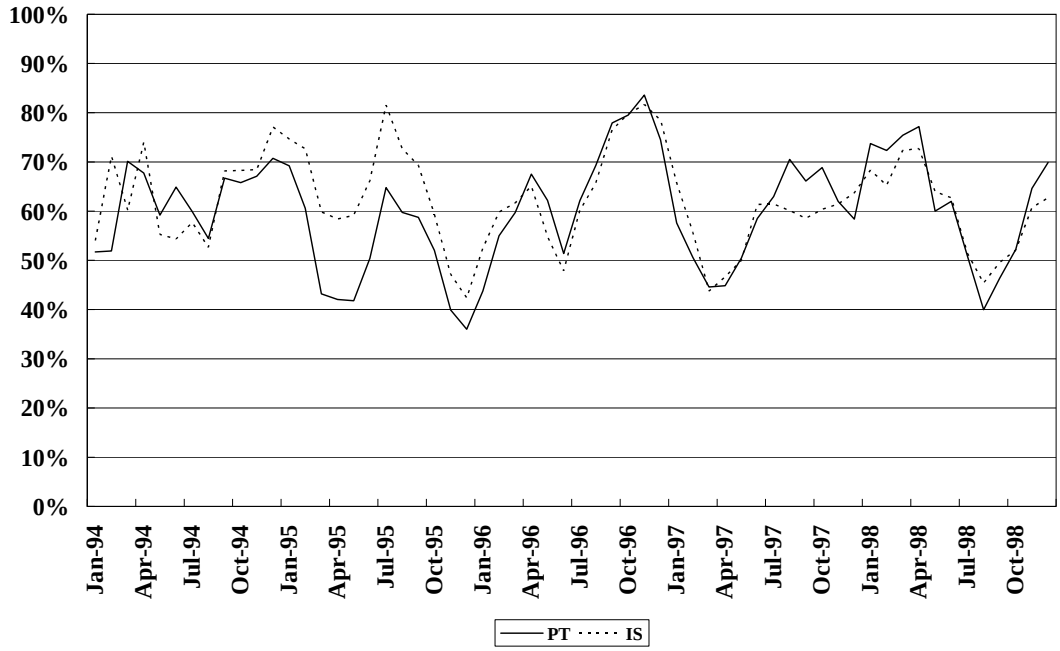


The GBP-$US exchange rate monthly volatilities, proxied by the standard deviation, are plotted against the monthly information share of the top group using the PT approach. The fitted line is the slope of the OLS regression of the volatilities against the information share.

Graph 7. Macro Announcements and Top Group's Information Share

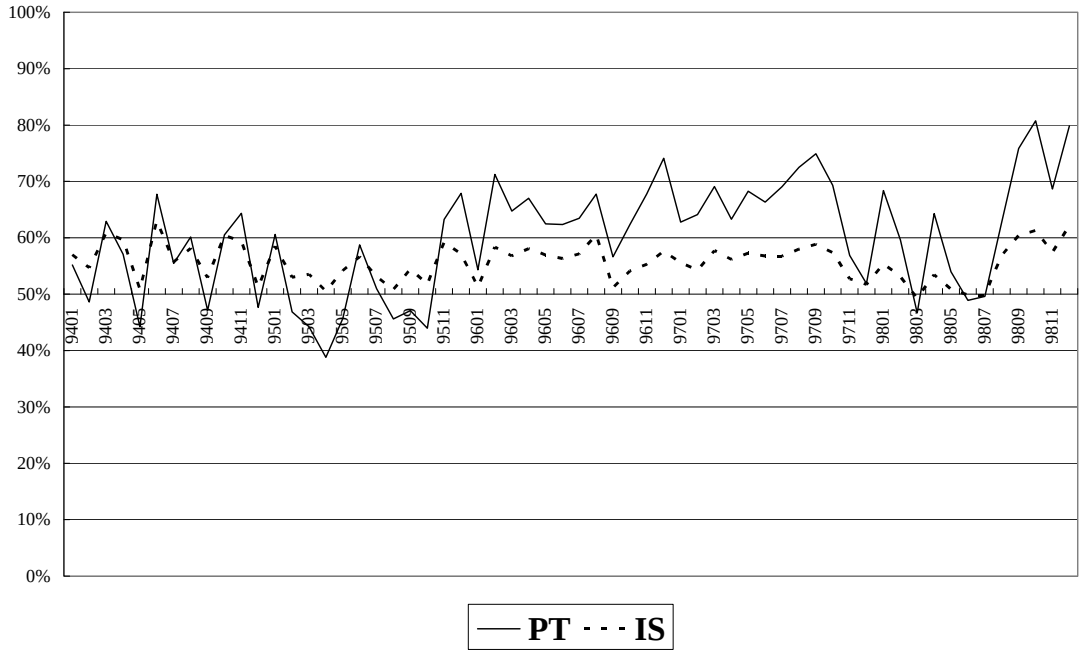


Graph 8. Top 5 Banks' Monthly Information Share



The top 5 banks are chosen from the Euromoney triennial survey.

Graph 9. Top 10 Banks' Monthly Information Share (10-minute frequency)



The top 10 banks' information share is recalculated using 10-minute frequency data.