

Sources of Information Advantage in the Foreign Exchange Market

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Abstract

This paper examines the sources of private information in the interbank foreign-exchange market using a transactions database that includes trading-party identities. We show that sustained post-trade returns rise with bank size, implying that larger banks have an information advantage. The larger banks exploit this information advantage in placing limit orders as well as market orders. We also show that the bank's private information does not come from their corporate or government customers or from some asset managers. Instead, the bank's private information appears to come from other asset managers, including hedge funds, and from the bank's own analysis.

Introduction

This paper provides evidence that large banks have a substantial information advantage relative to their smaller counterparts. It then traces that information advantage to two sources: the larger banks' more extensive network of financial customers and the banks' own insights. This analysis has numerous interconnected implications for our understanding of the microstructure of currency markets. It implies that private information is an important source of the positive influence of interbank order flow on returns. It implies that banks of different sizes adopt different business models. It implies that currency dealing banks are not simply conduits for private information generated by end users, but also generate private information of their own. Finally, our analysis indicates that banks use information in placing limit orders as well as market orders, which implies that order books should embody market-relevant information.

We analyze the complete interbank trading record of an active Scandinavian foreign-exchange dealing bank over a total of four weeks. Our dataset includes over 10,000 trades with roughly 300 other dealing banks worth over €15 billion. Uniquely among comparable datasets, ours includes counterparty identities. Our records are also uniquely comprehensive insofar as they include all of the bank's interbank trades in every trading venue. During our sample period, foreign-exchange dealing banks primarily traded with each other over three electronic interfaces – the EBS and Reuters brokerages and Reuters direct dealing – as well as occasional telephone exchanges. Other foreign exchange microstructure studies rely on data covering at most one of these interfaces. The trading records we study naturally reflect market-wide patterns because interbank trading generally takes place on electronic platforms where dealers cannot direct order flow to specific counterparties.

We follow Anand *et al.* (2005) in comparing post-trade returns for banks with varying amounts of information, a test made possible by our disaggregated data. Since the literature

suggests that information comes from bank customers, we initially identify a bank's information by the size of its customer base. We partition banks into four groups according to *Euromoney's* contemporary estimates of trading with customers. At the top are the "Immense" banks, meaning those among *Euromoney's* largest twenty. At the bottom are the "Small" banks, meaning those that *Euromoney* ranked below 100 or didn't rank at all.

We document that large banks do have an information advantage relative to small banks using simple averages of post-trade returns as well as structural vector autoregressions (SVARs) between post-trade returns and order flow, following Hasbrouck (1991). The results consistently indicate that banks with more customer business have more success anticipating returns, on average. The SVARs indicate, as well, that the maximum price impact is achieved after roughly five subsequent trades and is sustained indefinitely.

Our finding that large banks have an information advantage in the interbank currency market helps resolve an apparent inconsistency between two bank studies. Bjønnes and Rime (2005) finds that the big bank examined here earns substantial speculative profits, while Mende and Menkhoff (2006) finds that its relatively small bank profited little from speculative trades and earned most of its profits from customer spreads. Our evidence suggests that big and small banks operate under different business models. Big, informed banks profit from interbank trading as well as the bid-ask spreads earned from servicing customers, while small banks profit primarily from servicing customers.

These results are also relevant to our understanding of the nexus between order flow and returns. Three factors have been identified in the literature that could potentially explain why order flow apparently has a strong contemporaneous effect on returns: inventory effects, finite elasticity of demand and supply, and private information. Distinguishing among these hypotheses has been difficult because all three have the same first-order implication: positive order flow (stronger net purchases) is associated with a strengthening currency. Our analysis examines a more nuanced contrast. Under the information hypothesis order flow from

informed banks should have a stronger relation to post-trade returns than order flow from uninformed banks. Under the inventory and liquidity hypotheses, by contrast, the relation between order flow and returns is determined by factors relevant to all traders and thus should not vary across banks. Under the inventory hypothesis the key factors are the extent of inventory risk and the market's aversion to such risk (Stoll 1978). Under the liquidity hypothesis the key factor is the elasticity of demand. Our finding that post-trade returns vary across banks of different sizes supports the relevance of information for the contemporaneous correlation between order flow and returns.

The relevance of information to returns gains further support from our examination of correlations among the trades of banks in the different size groups. Under the inventory and liquidity hypotheses, the trading of informed and uninformed banks should be uncorrelated. By contrast, under the information hypothesis trading should be positively correlated among informed banks and negatively correlated between informed and uninformed banks. We document this second pattern in our data.

Our evidence complements other new evidence indicating that information is relevant to the nexus between order flow and contemporaneous returns. Indirect support for this hypothesis is presented in Evans and Lyons (2007), who show that the trading of Citibank's end users has predictive power for macroeconomic developments. Evans and Lyons (2005) shows that end-user order flow also has predictive power for exchange rates themselves. While Evans and Lyons (2007) focus on fundamental information, we take no position on the nature of the information on which banks are trading. Our analysis extends the results from existing studies showing that dealers' information is positively related to their interbank trading activity (Menkhoff and Schmeling 2010; Moore and Payne 2009) and quoting frequency (Phylaktis and Chen 2010).

Having identified a pronounced information asymmetry in the foreign-exchange interbank market we next examine the origins of banks' private information. We first

calculate, for each individual bank, average post-trade returns. We then examine how this is related to the bank's share of business from non-financial ("corporate") customers, governments including central banks, and seven types of financial customers: unit trusts, mutual funds, insurance firms, pension funds, investment managers, hedge funds, and non-market making banks, with all shares taken from the *Euromoney* FX Survey for 1999. We also examine how a bank's average post-trade returns are related to the amount of its interbank trading that cannot be explained by its customer business. This unexplained interbank trading is measured as the residual from a regression of the bank's share of total interbank trades on its market shares among the customer types.

These regressions indicate that the banks do not gain information from the trades of corporate customers, governments, unit trusts, mutual funds, and insurance firms. By contrast, the trades of pension funds, investment managers, hedge funds, and non-market-making banks may bring information to the market, so we refer to these customers as "potentially-informed investors." The gains to increasing market share among informed customers can be substantial. Consider a moderately active bank like ours, that trades a few billion euros per week. If it were to raise its market share with these potentially-informed financial customers by one percentage point, it could expect to earn an extra € million in profits annually. By contrast, our results indicate that raising a bank's share of corporate, government, or uninformed business does not enhance its profitability from interbank speculation, though it could well enhance customer-service income. Among asset managers, our evidence points suggestively towards hedge funds and investment managers as relatively informed.

Our analysis also highlights a new and perhaps surprising source of private information in currency markets: the dealers themselves. We find that a bank with "unexplained" interbank trading one standard deviation higher than the average earns an extra 0.23 basis points per trade or, for our bank €5.7 million per year.

We provide further support for these conclusions by examining the determinants of a bank's decision to use aggressive trades (e.g., market orders), rather than passive trades (e.g., limit orders). For each bank we calculate the share of aggressive trades, and regress this share on the customer market shares described above plus the residual interbank market share. The results suggest that a bank's tendency to place aggressive orders is not influenced by its share of corporate, government, or real-money financial customers but intensifies with the bank's share of investment managers and hedge funds. These results also support our previous conclusion that some banks bring their own information to the market: banks with higher residual interbank market share have a stronger tendency to place aggressive orders.

Our evidence suggests that currency dealers aggregate the information in customer order flow as hypothesized by Lyons (2001) and Evans and Lyons (2005, 2007). There are three hypotheses, however, about the nature of the information embedded in customer order flow. It could be that the trades of corporate customers unintentionally reflect information about the current state of the real economy. A large manufacturer, for example, might find it needs to import more raw materials to satisfy rising demand. The manufacturer might not know that its experience is shared broadly across the economy, but the dealer could see many manufacturers funding imports and be able to infer the broader pattern. The currency dealer, who sees the trades of many such customers, could potentially extract the broader signal from the noise (Evans and Lyons 2005). Alternatively, the trades of an institutional investor might unintentionally reflect information about the current state of investor wealth or risk tolerance.

Finally, the trades of the active trading community (hedge funds and the like) might carry information actively acquired through intentional investigation of available data (Osler 2009). To learn about the economy's current state and exploit yet-to-be revealed macro statistical releases, insightful market participants sift through existing data for empirical regularities with forecasting potential. The agents that most aggressively seek currency-relevant information are reported to be currency-focused hedge funds and CTAs (commodity

trading advisors), but any speculative agents could conceivably be motivated to do so. We note that corporate customers generally do not speculate (Goodhart 1988; Osler 2009), in part because it is extremely costly to protect against rogue traders and other risks.

Our evidence indicates that the information embedded in customer currency trades does not concern the state of the real economy, since corporate customer market share does not enhance returns to dealers' speculative trades. This is consistent with the little extant evidence on sources of private information in currency markets, which suggests that financial customers are better informed than corporate customers though the evidence is not yet considered definitive. Fan and Lyons (2003) suggest that financial-customer order flow carries information relative to short-term returns while commercial-customer order flow carries information relative to the long-term, but their analysis is based on the visual inspection of two charts. Carpenter and Wang (2003) suggest that financial order flow carries more information than commercial order flow, based on the observation that dealers update their quotes after trades with financial customers but not after trades with corporate customers. However, their analysis is based on observations from one small online retail dealer, and the online world of currency trading is still peripheral to the overall market. Finally, this idea is supported indirectly by results reported in Osler et al. (2009) showing that the dealer they study is more likely to place a market order after a financial-customer trade than after a commercial-customer trade. Osler and Vandrovysh (2009) find that hedge funds have information while real-money managers do not. Their data have the advantage that they are the actual trades of customers, unlike ours which concern a bank's overall market share. Their data have the disadvantage of comprising a relatively small sample confined to price-contingent trades.

Like the original theories of asymmetric information in equity markets (Glosten and Milgrom (1985); Kyle (1985); Naik et al. 1997), none of the extant theories of information in currency markets envisions dealers as originating private information. The only evidence of

which we are aware for dealer-provided information in any market is provided in Valseth (2010), which concerns the Norwegian bond market. The currency-relevant information originated by banks could reflect the extensive research staffs hired by large dealing banks, with access to the best available data. Alternatively, it could reflect dealers' intuition: research shows that with long experience individuals become intuitively aware of patterns that help forecast outcomes (Gladwell, 2005). Such patterns might not be apparent to researchers far away from the market and focused on data, but might nonetheless become apparent to dealers who spend years watching the markets move all day, every day.

The evidence we present supports the price discovery hypothesis presented by Osler et al. (2009), who suggest that dealers tend to place market orders in the interbank market parallel to the trades of their informed customers and that financial customers are the ones with information. Our results also support the strategic dealing hypothesis (Naik et al. 1997) as applied to foreign exchange (Osler et al. 2009; Ramadorai 2008), which states that dealers set narrow spreads to customers who are most likely be informed, with the goal of attracting such trades and potentially inferring the associated information. In order for such behavior to be rational there must be profitable uses for the information. Our paper also confirms Osler et al.'s suggestion that profits from informed interbank trading can motivate the narrow spreads quoted to informed customers.

Our analysis is also relevant to a separate line of inquiry within microstructure: whether information influences the placement of limit orders, and thus order-book structure. A tendency for informed agents to use market orders is well understood, but in recent years it has also become widely understood that some informed agents will rationally use limit orders. An informed dealer might rationally choose to place limit orders if he does not expect his information to affect prices immediately (Kandel and Liu 2006). Alternatively, a dealer that is typically informed might recognize, when he has no information, that picking-off risk is relatively low and limit-order placement correspondingly safe (Bloomfield, O'Hara, and Saar

2005). We find that large banks earn higher returns to their limit orders than small banks, which suggests that banks exploit available information when placing limit orders as well as when placing market orders. These results parallel the findings of Linnainmaa (2010) that the executed limit orders of individual investors earn less, on average, than the executed limit orders of institutional investors on the Finnish Stock Exchange. Since Linnainmaa also finds that the same-day return to limit orders is positive, one infers not only that institutional investors are better informed than individual investors, but that all investor types sometimes use limit orders when informed. These results suggest that there may be information in the order book as well as in order flow (Anand and Subrahmanyam 2008). Empirical evidence that information can be extracted from equity order books is provided in Härdle et al. (2009) and Latza and Payne (2010).

Section 1 describes our data. Section 2 provides evidence that large banks have a significant information advantage in the interbank foreign-exchange market and that their information is fundamental. Section 3 provides evidence that the banks gain their information advantage from their large share of financial-customer business and from their own insights, but not from their corporate-customer business. Section 4 concludes.

1. Background

This section introduces the interbank market, describes our data, motivates our focus on bank size, and shows that interbank trades at our bank reflect previous findings in the literature.

1. Aggressive and Passive Trades: The Structure of the Interbank Market

The structure of the foreign exchange market, though changing rapidly, still has at its core two tiers. In one tier, customers trade with dealers at banks; in the other, dealers trade with each other. A new, third tier has been added within the past decade, in which retail investors trade with trade “aggregators” who, in turn, trade with the dealing banks. Thirty percent of customer trades are intended to cover the transaction needs of firms importing or exporting

products for use in production or trade (B.I.S. 2010). Most of the other customer trades are placed by financial firms, a category that includes hedge funds, investment managers, mutual funds, pension funds, endowments, insurance firms, and non-dealing banks. Additional customers include governments, including central banks, and governments. These customer trades are only observed by the parties to the trades, since there are no disclosure requirements in foreign exchange markets.

Individual bank dealers use the interbank market to unload inventory accumulated in customer trades, and they typically do so within just a few minutes. One of their standard responsibilities, however, is to speculate via the interbank market with the bank's own funds. Each dealer has his/her own separate account which is constrained by intraday and overnight position and loss limits. Most dealers begin and end the day with zero inventories.

There are two primary routes for interbank trading. Dealers can call each other directly to request quotes, like regular customers. Far more commonly, however, dealers trade via brokers. In our sample period the major currency markets had already shifted away from voice brokers relied primarily on two electronic brokerages that exclusively served foreign exchange dealers, Reuters Matching and EBS.ⁱ

The possibility of both direct and indirect interbank trading complicates our nomenclature. Most readers will be familiar with the simple dichotomy of order-driven markets: limit orders and market orders. In the foreign exchange setting, however, we must generalize these concepts to "aggressive trades" and "passive trades." The aggressor is the bank placing the market order or the bank that calls another bank directly. The passive counterparty is the bank placing the limit order or the bank that provides a quote when called directly by another bank.

2. *Data*

Our data include detailed information on the interbank transactions of three spot traders working for a large Scandinavian bank. We focus on the dealers' dollar-mark trades during March 2 through March 6, 1998 and their euro-dollar trades during August 2 through August 20, 1999.ⁱⁱ (The change of currency reflects the adoption of the euro in January 1999.) Results from the two samples are entirely consistent, though the latter sample provides greater precision since it has many more observations. The key features of the market that would create information asymmetries, including the extent frequency of a bank's customer trades and the nature its customers, have not changed over the intervening years, despite the market's many other changes. Thus data from 1998 and 1999 should be fully suitable for examining our core questions.

We believe this is the first interbank transactions dataset that includes counterparty identities and that comprehensively covers all interbank trading venues.ⁱⁱⁱ Most microstructure datasets include trades through just one exchange, but our data cover trades with electronic brokers, trades with voice-brokers, and internal trades (trades within the bank). For each trade we know the time of the transaction; the name of the counterparty; the trade initiator; the quantity traded; and the transaction price. Our analysis uses transaction time and trades are in correct chronological order.

The 1998 data include 2,043 transactions worth in aggregate roughly \$4 billion. The 1999 dataset is substantially larger, with 9,306 transactions worth in aggregate almost €15 billion. For both samples the frequency of trades is on the order of one transaction per minute. There were 259 counterparty banks in 1998 and 287 in 1999. In both years, over 90 percent of trades were entered electronically and the majority of these were executed through an electronic broker.

Our other important source of data is the *Euromoney* Annual Foreign Exchange Survey, specifically those of 1998 and 1999. This survey, which is widely respected within the practitioner world, solicits information about foreign-exchange dealers from their customers. The information includes the volume of the customer's business with a dealer and that dealer's rating on a number of different client service dimensions.

3. Information and Bank Size

The nature of information differs between equity and currency markets. In currency markets, much of the relevant asset-specific information concerns a country's aggregate macroeconomic conditions and is therefore revealed publicly in macro statistics.^{iv} A casual observer might wonder whether private information is even a well-defined concept in currency markets. Substantial evidence now shows, however, that private information is not only an important influence driver, but perhaps the single most important driver of returns on a high-frequency basis (Berger et al. 2008). Dealers appear to aggregate information from the customer trades and then profit from that information in their interdealer trading (Osler et al. 2009). If this is true, then the larger banks would presumably be best informed, since they have more customers from whom to gather information.

Foreign-exchange dealers claim that large dealing banks are better informed than others (see e.g. Cheung and Chinn, 2001). We asked the three foreign exchange dealers studied here to rank their interbank counterparties on a scale of 1 – best informed – to 5 – uninformed. Our dealers strongly agreed with each other, as indicated by the fact that the three correlations among their individual rankings were all 0.90 or higher and statistically significant. These information rankings are also strongly related to bank size, which we measure using estimates from *Euromoney*: the Spearman rank correlation between the average of the three dealers' informativeness ratings and the banks' *Euromoney* size ranks is 0.82.^v

To search for information asymmetries in the foreign exchange market we therefore group the banks into four size categories according to the *Euromoney* size estimates. The “Immense” banks are among those ranked from 1 to 20, inclusive. The “Big” group includes banks ranked from 21 to 50. We refer to the Immense and Big banks jointly as “larger banks.” The “Medium” group includes banks ranked from 51 to 100; the “Small” group includes banks ranked higher than 100 or not ranked at all. We refer to banks in the two lowest size categories as “smaller” banks.

A more concrete description of the banks in each size group may be helpful. In *Euromoney*, the Immense banks include such household names as Deutschebank and Citibank, along with slightly less familiar names such as Standard Chartered Bank. Euromoney’s Big banks include Dresdner Bank, Lloyds Bank, and Sumitomo. Euromoney’s Medium banks include ANZ (Australia and New Zealand Bank), Bank of Nova Scotia, and Mitsubishi Trust Bank. According to a market insider unconnected to our bank, the Small bank group could include such institutions as the Landesbank of Rheinland, Moscow Narodny Bank, or the Maruitius Commerce Bank.^{vi}

Our own bank would be a Big bank in this ranking. The same bank is studied in de Jong, Mahieu and Schotman (1998), which documents that during the mid 1990s it was among the nine most active banks in posting indicative quotes on Reuters. While this is a noisy signal of size in today’s market, during that period it was fairly reliable. Further, we have been told informally that our dealing bank ranked among the largest ten users of one electronic foreign exchange broker and among the fifteen largest users of the other.^{vii} Since our results largely measure performance *relative to our bank*, the important quality for inference is that our bank is neither extremely large nor extremely small.

Table 1A provides descriptive statistics for electronic trades between our bank and the other banks in these four size categories. The mean number of trades per bank is monotonically related to size: during the 1999 sample our bank traded on average 148 times

with each immense bank but only 12 times with each small bank.^{viii} Table 1B shows that trade sizes are fairly consistent across banks of all sizes. The median trade size is 1 million for all bank groups in both sample periods (trades were denominated in US dollars in 1998 and in euros in 1999), confirming earlier evidence that trade size is fairly standardized. Mean trade size generally rises modestly with bank size: the Immense banks' mean trade is only 16 percent larger than the Small banks' mean trade in the 1998 sample and 27 percent larger in the 1999 sample.

Table 1A also reveals how little concentrated the foreign exchange market was during this period (it is more concentrated today). There were more banks in the Smallest category than the total number of banks in the larger three categories combined.

4. Standard Order-Flow Regressions

To show that our data reasonably represent the entire interbank market we run standard order-flow regressions, in which returns are regressed against contemporaneous order flow. Returns are measured as log changes in mid-quotes.^{ix} Order flow is measured as net aggressive buys against our bank (i.e., net purchases at our bank's quoted prices). We choose a half-hour time horizon, though this is immaterial: the results barely change if we choose an hourly time horizon.^x In Table 2, Panel A, all order flow is aggregated into a single variable; in Panel B, order flow from each bank category is included separately.

The results confirm that our data display the same positive relation between returns and contemporaneous order flow documented elsewhere (e.g., Evans 2002; Evans and Lyons 2002; Hau, Killeen and Moore 2002; Payne 2003). We also replicate the typical finding that order flow can explain sizable amount of the variation in return. The estimated coefficients suggest that every additional net market buy order – each of which is typically worth between €1 and €2 million – strengthens the euro by one-half to one basis point.

We also run regressions in which order flow from different-sized banks is included separately (Panel B). These indicate that order flow of Immense and Big banks has a strong and significant relation with contemporaneous returns while order flow from Medium and Small banks does not. The negative coefficient on the Medium (1998) and Small (1999) banks can be interpreted as a liquidity-providing role for these banks. Though these regressions suggest that bigger banks are relatively informed, their support for this hypothesis is weak since it is difficult to discern causality at half-hour intervals. A half-hour is a very long time in currency markets, where trading exceeds \$4.0 trillion daily (B.I.S. 2010) and euro-dollar is traded on average more than once per second in the interbank market. With half-hour time intervals, any causal relation between returns and order flow could be masked by feedback effects. To identify structural relations it is necessary to tease out lead-lag relations for individual transactions, and this in turn requires data on individual trades. The next section undertakes such an analysis.

2. Information and Bank Size

This section examines post-trade returns and structural VARs to show that large banks have an information advantage relative to their smaller peers in interbank currency trading.

1. Post-Trade Returns

We calculate average signed post-trade returns (positive if the counterparty bank buys, negative otherwise) for banks in each size category. This is inspired by the analysis of Anand et al. (2005), though there are some noteworthy methodological differences. First, we measure returns as the log change in the bid (ask) quote if a trade is settled at the bid (ask) while Anand et al. measure returns as the change in the mid-quote. More critically, we only calculate returns to realized trades while Anand et al. include returns to all submitted limit orders. Since limit orders are subject to picking-off risk this adjustment can have significant

impact on measures of returns, as documented in Linnainmaa (2010). Finally, Anand et al. focus on returns at the five-minute horizon while we focus on returns at the one-minute horizon. This choice is motivated by the fact that dealers at our bank close their positions within thirty seconds on average (Bjønnes and Rime 2005).

We first carry out this analysis for all trades with our bank; we then repeat the analysis separately for other banks' aggressive trades against our bank and other banks' passive trades against our bank. The independent variable is always coded one (negative one) if a bank buys from (sells to) our bank.

The average signed returns following all trades, shown in Table 3A, rise strongly with bank size. Indeed, the Immense banks' net purchases against our bank tend to be followed by price increases while the smallest banks' net purchases against our bank tend to be followed by price decreases. The difference between the Immense- and Small-bank coefficients exceeds one-half basis point and is highly statistically significant in both samples. Using the 1999 sample, we find that if an Immense-bank dealer trades €2 billion per week (our dealers traded an average of €1.6 billion per week in the 1999 sample), it would earn an extra €7.3 million per year for its bank compared to its earnings if it traded the same amount at a small bank.

Table 3A shows that larger banks typically place more aggressive trades, as a share of all trades, which further supports our hypothesis that banks with the more customer business are better informed. The literature shows that when traders have short-lived information their optimal strategy is to trade aggressively, thereby increasing the chance that they can exploit the information before it becomes embedded in price (Kaniel and Liu 2006). Banks that have access to more information, on average, should thus rely more heavily on aggressive trades, and indeed, the share of aggressive trades among all trades varies positively with bank size. In the 1999 figures, for example, the share of aggressive trades exceeds 60 percent for Immense banks, and falls below one-third for Small banks.

We next calculate post-trade returns separately for the other bank's aggressive and passive trades, with the results shown in Table 3B. Post-trade returns tend to be much higher after aggressive trades than passive trades, consistent with the hypothesis that banks rely relatively heavily on aggressive trades when they are informed. Indeed, average returns after aggressive trades are positive and significant for banks of all sizes in the 1999 sample and for the three largest sizes in 1998; by contrast, average returns after passive trades are negative and significant for banks of all size categories in both samples. We interpret the negative returns to other bank's passive trades as indicating that our own bank – who is the aggressive counterparty on every such trade – tends to use aggressive trades when it is informed. We note that even smaller banks are sometimes informed: post-trade returns associated with aggressive trades are positive and statistically significant in both samples for Medium-sized banks and in the (larger) 1999 sample for Small banks.

Average-post trade returns remain broadly consistent with the idea that the trades of larger banks carry more information, on average, since post-trade returns are significantly higher for immense banks than small banks for both types of trades (aggressive, passive) and in both sample periods. The fact that larger banks lose less than smaller banks following our bank's aggressive trades indicates that larger banks use their information in structuring their passive trades and are therefore better protected vis-à-vis our bank when it is informed.

Since bigger banks tend to make bigger trades, one might wonder whether the bigger banks' higher average post-trade return to aggressive trades is due solely to larger trade sizes. However, the size differential for trades is a small fraction of the size differential for price impact. Immense-bank trades are only about 20 percent bigger than Small-bank trades while the proportionate price impact of Immense-bank trades is at least twice as large as that of Small-bank trades. Since price impact has a concave relation with trade size (Hasbrouck 1991, Osler and Vandroych 2009), we infer that trade size is unable to account for the higher price impact of the Immense-bank trades.

The foreign exchange literature has generally focused on the information content of order flow, which means it focuses on aggressive trades. While the broader microstructure literature initially assumed that informed trades were always aggressive (e.g., Glosten 1994), it is now understood that limit orders can be a rational choice for informed traders. Informed banks might rationally place limit orders when they expect their information to affect prices slowly (Kaniel and Liu, 2006). Alternatively, they might serve as liquidity providers – hoping to capture the spread – when their information indicates that the market is fairly priced and picking-off risk is relatively low (Bloomfield, O’Hara, and Saar 2004). Our evidence complements existing evidence emerging from stock markets that there is information in limit orders (Linnainmaa 2010) and limit-order books (Härdle et al., 2009; Payne and Latza 2010).

2. VARs

The post-trade returns examined in the previous subsection correspond to very short time horizons, leaving open the possibility that they reflect inventory or liquidity pressures rather than information. For example, if the larger banks are splitting large orders, they themselves may follow up a given trade with another in the same direction, generating their own positive post-trade returns. To examine more carefully whether the exchange-rate impulse from individual dealer trades is transitory or permanent we next examine how returns respond to order flow using Structural Vector Auto Regressions (SVAR). For banks in each size group we measure order flow once again as aggressive purchases from our bank and run two SVARs, one for each sample period.

Each SVAR has a structure with exchange rate return ordered last, hence responding to shocks to all of the four order flow measures.^{xi} The four groups of order flow are treated symmetrically, so they only respond to their own shocks and to lags of all variables.^{xii} The SVARs have two lags, with lag length chosen according to the Schwartz criterion. Following the recommendation of Hasbrouck (1991) and consistent with Payne (2003), every trade is

one observation, so order flow for a specific bank group is always +1 (aggressive buy), -1 (aggressive sell), or 0 (no transaction). If information is the source of the larger banks' higher post-trade returns, their higher initial price impact will be sustained indefinitely.

The impulse-response patterns revealed by these regressions, shown in Figures 1A and 1B, are quite similar across our two sample periods, though the confidence intervals are narrower for the large 1999 sample. Consistent with previous results, returns respond positively to order flow from banks of all sizes. The response is initially small but rises quickly – usually within five transactions – to its sustained level. Since our bank trades roughly once per minute, on average, this suggests that the exchange rate responds fully to information within about five minutes. Reassuringly, in all cases the response of returns to order flow appears to be sustained indefinitely. This suggests that the information included in order flow is fundamental.

Consistent with our maintained hypothesis of information asymmetries in the FX interbank market, the strength of the response rises monotonically with bank size.^{xiii} In the more-reliable 1999 sample, an unexpected one-standard-deviation positive shock from the Immense banks increases the mid-quote by 0.4 basis points while a one-standard-deviation shock from the Small banks increases the mid-quote by only 0.1 basis point. Differences across bank size groups are generally statistically significant.

These regressions provide further supports for earlier results in the literature indicating that information helps explain the contemporaneous correlation between interbank order flow and returns (Payne 2003; Evans 2002; Evans and Lyons 2002; Hau, Killeen and Moore 2002). The standard alternative hypothesis is that the contemporaneous correlation stems only from liquidity effects, in which case the dynamic relation between order flow and returns would be the same for banks of all sizes. If information asymmetries are important, as suggested by the literature, the relation would be stronger for better-informed banks. These regressions also

provide a clue as to whether the information involved here is fundamental: if order flow carries fundamental information these relations should be sustained over time.

The relevance of information for passive trades, including limit orders, is indicated yet again by a second SVAR analysis, where the focus this time is the other banks' passive trades or, equivalently, our own bank's aggressive trades (Figure 2). As noted earlier, if the relation between order flow and returns is driven solely by liquidity the responses to these trades should be similar across bank size groups. We find, however, striking differences across bank size groups. When our bank trades against Immense banks our bank is typically left with a net loss after the price stabilizes. When our bank trades aggressively with other Big banks it comes out even, on average, after the price settles down. When our bank trades against Medium or Small banks it comes out ahead, on average. This indicates that our bank, which fits in the "Big" category, is about equally informed as the other Big banks. It also provides further evidence that banks' limit-order strategies are influenced by their information.

In Figure 3 in the appendix we present similar results for the 1999 sample when shocks are of unit size rather than one-standard-deviation shocks. Large banks' orders are typically 27 percent larger than small banks' orders. Figure 3 show that results are similar using unit shocks. For market orders of a given size Immense banks have a bigger cumulative effect on prices than Small banks.^{xiv}

3. Correlated Trading and Position-Taking

We finish this section by examining two extensions of the hypothesis that large banks are better informed than smaller banks. The first concerns correlations between the net purchases of our four bank groups, using an half-hourly time horizon, and the second concerns price dynamics when banks take positions.

Trading Correlations: If bank size and information vary positively, then purchasing patterns should vary predictably across bank size groups. To fix ideas, suppose two banks

learn that the euro is likely to appreciate while all other banks remain uninformed. The informed banks will try to buy euros and will also try to avoid selling euros. The uninformed banks, in their ignorance, will continue both buying and selling. The informed banks would be unlikely to trade with each other and would be more likely to trade with uninformed banks. If the size differences do not reflect information then there is no reason these correlations would be anything but zero.

The hypothesis that larger banks are better informed than smaller banks has three predictions for trading correlations, all of which are confirmed by the actual correlations across groups (Table 4).^{xv} These patterns are most pronounced for the banks in the extreme size categories.

1. *Implication: Net purchases of informed bank groups should be positively correlated with each other.* Finding: The correlation between the Immense and Big banks is positive and statistically significant in both samples.

2. *Implication: Net purchases of the informed banks should be negatively correlated with net purchases of the uninformed banks.* Finding: All the correlations between the Medium and Small banks with the Immense and Big banks are negative, and most of these are statistically significant. The negative correlation between banks in the extreme size categories is always statistically significant.

3. *Implication: Net purchases of uninformed banks should be either uncorrelated with each other (since their trades are unrelated to information) or positively correlated with each other (since they will tend to trade against the informed larger banks).* Finding: The correlation between Medium and Small banks is positive and significant in the 1998 sample while in the 1999 sample it is economically and statistically insignificant.

Position Taking: It is also instructive to examine our bank's counterparties when it is most likely to be informed. This analysis (which does consider the likely motivation of each trade, unlike the earlier analysis) assumes that dealers are most likely to be informed when

they expand an inventory position. The basis for this assumption is the fact that FX dealers typically carry zero inventory when they are not speculating, which implies that aggressive interbank trades undertaken to expand an inventory position are more likely to be speculative than aggressive interbank trades to reduce an inventory position.^{xvi} We cumulate the observed trades of our individual dealers to assess their inventory position throughout, on the basis of which we distinguish aggressive trades that are inventory-accumulating or inventory-decumulating. Earlier published research shows that our dealers' inventory-accumulating trades tend to be quite profitable, which suggests that they are informed. (The profitability of such trades is documented for the 1998 sample in Bjønnes and Rime (2005); profitability in the 1999 sample is comparable.)

Suppose our bank has information and makes an aggressive accumulating trade. If all banks are equally informed, the likelihood that it trades with banks of any given size should be the same as that group's share in any other type of trade. If large banks are better informed, by contrast, when our bank is informed it would trade relatively more frequently with smaller banks and less frequently with other large banks.

Table 5 shows the share of each bank group in our own bank's accumulating trades and also, as a point of reference, in our bank's de-cumulating trades. The pattern conforms to the predictions of the hypothesis that large banks are relatively well informed. In 1999, for example, 37 percent of our bank's accumulating trades but only 21 percent of our bank's de-cumulating trades were with Small banks; similarly, Immense banks accounted for only 25 percent of our bank's accumulating trades but for a full 36 percent of our bank's de-cumulating trades. More broadly, the ratio of our bank's accumulating trades to de-cumulating trades is inversely related to counterparty-bank size and the differences are statistically significant.

3. Sources of Private Information in FX

So far this paper has shown that bigger banks have an information advantage relative to their smaller peers when trading in the interbank foreign-exchange market. This raises a fundamental question: Which agents bring private information to the market?

The original papers on private information in financial markets, Kyle (1985) and Glosten and Milgrom (1985), suggest that private information comes from end users, which in the foreign exchange market would be the customers. As this implies, Evans and Lyons (2005) show that customer order flow has predictive power for exchange rates. Evans and Lyons (2007) show that customer order flow also has predictive power for macroeconomic variables. As discussed in Osler et al. (2009), dealers make great efforts to gather information from customer trades, even subsidizing the trades of informed customers with relatively narrow spreads, and our results so far suggest they exploit this information in speculative interbank trades.^{xvii}

At present there is only limited evidence about which customer types bring information to the market. Evans and Lyons (2005) suggest that corporate firms unintentionally bring information to the market because their trades passively reflect the state of the economy. Each individual firm might not be able to generalize from their own situation to that of the economy as a whole, but dealers could do so based on observing a larger set of corporate trades. It seems logical that financial order flow could anticipate upcoming exchange-rate returns since international asset managers have a natural incentive to predict how that value will change. That incentive is intensified by their tendency to trade in large amounts (Osler et al. 2009). Hedge funds and other members of the “active trading community” are known to aggressively seek profitable currency trading strategies, in part by hiring “quants” and members of the academic elite to advise their asset-allocation decisions. Practitioners report, however, that real-money funds tend to ignore the currency component of

their returns. For example, a report on currency management by Taylor and Farstrup (2006) states:

[T]here are key participants in foreign exchange markets ... that are not always seeking profit derived *from their currency positions* [I]n this category are international equity managers. While some managers factor in currency positions as they go about picking foreign stocks, most are attempting to add value through stock, sector, and region bets rather than currency plays (p. 10, italics in original).

The interaction between banks and customers has become technologically more sophisticated during recent years. Most notably, many transactions now take place over multi-bank portals, the advent of which has brought tighter spreads and less loyalty among customers. Nonetheless, the nature of end-users in currency markets, and their relation to information, has been fairly stable. By the mid-1990s currency-focused hedge funds were already a major presence in the market and they have remained so. A bank's customer trades still provide noisy but private signals of any information possessed by the customers, and trading with more informed customers seems likely to improve the precision of the bank's overall information.

To investigate the source of banks' currency-relevant information, we turn again to the *Euromoney* Foreign Exchange Survey. This provides estimates of the dollar value of each bank's business with nine customer types: corporations, governments (including central banks), trusts, mutual funds, insurance firms, pension funds, investment managers, hedge funds, and non-dealing banks. From these we calculate each bank's share of the customer business for each customer type. We then evaluate how the banks' market shares influence their information in regressions where a bank's information is measured by its market-relevant information, which in turn is measured in terms of average one-minute post-trade returns or "price impact." In this context, however, we take an average return across the trades of each individual bank, denoted with a subscript "b": PI_b . After excluding banks with fewer than 20 trades we have a sample of 108 banks.

As shown in Table 6, correlations among market shares tend to be fairly high. Positive correlations among market shares are expected since big banks tend to have higher market shares in all customer segments when compared with small banks. This raises concerns about multicollinearity which lead us to adopt the following estimation strategy. We run a number of regressions, in each of which the dependent variable is the bank's average post-trade returns and the independent variables include market shares for corporate (*CORP*) business and government business (including central bank trades; *GOV*), as shown below:

$$PI_b = \alpha + \beta_1 CORP_b + \beta_2 GOV_b + \beta_3 Type_b + \beta_4 IBK_b + \eta_b . \quad (1)$$

Each regression also includes the market share for one type of financial customer: $Type \in \{\text{Unit Trusts, Mutual Funds, Insurance Firms, Pension Funds, Investment Managers, Hedge Funds, and Non-Dealing Banks}\}$. If the market-share variable is insignificant it seems reasonable to infer that such customers do not bring information to the market. However, inference here is not symmetric: if the market-share variable is significant we cannot assert that such customers do bring information to the market, only that such customers might bring information to the market.

Each regression also includes a variable that allows us to examine the possibility that banks bring their own information to the market. Existing research focuses almost exclusively on the contribution of customers to private information. The one exception of which we are aware is Valseth (2010), which finds that bond dealers in Norway contribute information beyond that provided by their customers. Reasoning that the extent of a bank's own insights will be reflected in the extent to which it trades in the interbank market beyond that required to handle its customer business, we regress the banks' share of total interbank trades (in our sample) on the same customer market-share categories included in Equation (1). We include the residuals from this regression in Equation (1) as IBK_b .

We use weighted least squares, using a bank's total number of interbank trades as weights, with Newey-West HAC-adjusted standard errors and covariance matrix. The weights compensate for the presumably inverse relation between measurement errors in the dependent variable and a bank's total number of trades. The relevant descriptive statistics are presented in Table 7. The banks' market shares naturally average a bit below 1 percent, given our sample size of 108. (The residual interbank market shares change across regressions so the descriptive statistics, which are intended only to be indicative, are taken from the regression in column (8) of Table 8, Panel A).

The results, provided in Table 8A, indicate strongly that corporate and government trades do not bring information to the market. Coefficient on these market shares are economically and statistically insignificant in almost every regression. The results also indicate that the trades of certain financial customers, specifically unit trusts, mutual funds, and insurance firms, likewise do not carry information. This seems inconsistent with standard models of asset managers, which assume perfect rationality, and it could conceivably reflect imperfect rationality at such institutions given the strong evidence for irrationality among the forecasts of professional exchange-rate watchers (MacDonald 2000). Alternatively, it could reflect a superior rationality, given the literature's robust finding that the major exchange rates are well-approximated as a random walk.

The regression coefficients are positive and significant for pension funds, investment managers, hedge funds, and non-market-making ("non-dealing") banks, consistent with the hypothesis that these agents bring information to the market. Because of the high correlations among market shares of financial customers shown in Table 6, however, we cannot conclude that all these groups bring information to market. We suspect, in particular, that pension funds and non-dealing banks bring little information to the market, and their coefficients are significant because the market shares of these groups are strongly correlated with the market shares of hedge funds and investment managers. Our suspicion is based on the observation

that the regressions' explanatory power is around 0.43 for hedge funds and investment managers while it ranges only between 0.30 and 0.34 for the other financial customers. Market participants suggest that the information brought to the market by investment managers would essentially be an extension of the information brought by hedge funds, since some significant hedge funds trade through the broker dealers included in the category of investment managers.

The final regression in Table 8A includes all customers, but groups them into four categories: corporate customers, governments, previously-insignificant financial customers (*NO-INFO-FIN*) and previously-significant financial customers (*INFO-FIN*), which we interpret as potentially informed. This regression confirms that corporate customers, governments, unit trusts, mutual funds, and insurance firms do not bring information to the currency market, and confirms that some of the remaining four financial-customer groups – pension funds, investment managers, hedge funds, and non-dealing banks – are informed.

To get a sense of the economic magnitude of the information brought to the market by customers, consider a dealer that raises its market share among informed financial customers by one percentage point (roughly half of a single standard deviation). Column 8 in Table 8A indicates that returns in the first minute after its interbank trades are 0.12 basis points higher, on average, which implies the bank would earn an extra €12 per €1 million traded. During our 1999 sample, our bank's three euro dealers traded an average of €4.8 billion per week in the interbank market (together). Thus, an extra €12 per €1 million traded would have meant additional profits of roughly €57,120 per week or €3 million per year.

To assess the value of bank-originated information we examine the coefficient on the residual portion of the interbank market share in the comprehensive regression (column 8). This suggests that a one-percentage-point increase in this residual market share is associated with an additional 0.23 basis points per trade, which would be associated with an estimated €5.7 million in extra profits annually at our bank. We hasten to qualify this figure in two

ways. First, the standard deviation of residual interbank market shares is roughly half as large as that of the potentially-informed customers. Second, care needs to be taken when inferring causality. While it seems reasonable to think that customer market share causes higher trading profits, it seems unlikely that residual interbank market share causes trading profits. Instead, residual interbank market share and trading profits seem likely to be jointly caused by higher bank-generated information.

It could be argued that big banks might have a larger average price impact because they place more market orders (Table 3A) and market orders have bigger average price impact (Table 3B). We view the larger impact of market orders as an implication of their additional information value, which justifies our interpretation of the results. If the larger impact of market orders has an origin distinct from information value, however, our results might be distorted. We therefore re-calculate post-trade returns, subtracting from each aggressive trade the average price impact of all aggressive trades and subtracting from each passive trade the average price impact of all passive trades.

The results from running Equation (1) with adjusted returns are shown in Table 8B. The coefficients on all market-share variables drop noticeably, as one would expect, but our qualitative conclusions are unchanged. The coefficients for corporate customers, governments, unit trusts, mutual funds, and insurance firms remain statistically insignificant, indicating that these groups do not bring information to the market. The coefficients for pension funds, investment managers, hedge funds, and non-dealing banks remain positive and significant, marking these financial customers as potential sources of information. As before, the explanatory power is roughly 10 percentage points higher for hedge funds and investment managers, suggesting that they bring more information to the market than pension funds and non-dealing banks. The comprehensive regression in column (8) suggests that a bank with an extra 1 percentage point market share for potentially-informed customers would bring extra returns of 0.06 basis points per trade, on average. At our bank this implies additional profits of

€1 million annually. A bank with an extra one-percentage-point residual interbank market share would earn an extra 0.12 basis points on its trades, on average, and an additional €3 million annually.

We next look for evidence of information in the frequency with which a bank makes aggressive trades. If aggressive trades tend to be placed when banks are informed, then a given bank's share of aggressive trades should rise with the extent of its information sources. We run the same set of regressions just described but with the share of aggressive trades in a bank's total trades as the dependent variable. We rely once again on weighted least squares with Newey-West HAC-adjusted standard errors and covariance matrix:

$$ShrAgg_b = \alpha + \beta_1 CORP_b + \beta_2 GOV_b + \beta_3 Type_b + \beta_4 IBK_b + \eta_b$$

The results of these regressions, shown in Table 8C, continue to indicate that corporate customers, governments including central banks, and many real-money asset managers do not bring information to the currency markets. (Though the corporate-customer market share is often significant when some other customer categories are excluded, it becomes insignificant when all customers are included.) These results are also consistent with our conclusion that banks bring their own original information to the market. Consistent with the R^2 s of the previous regressions, the regression coefficients suggest that, among financial customers, only investment managers and hedge funds bring information to the market. A one-percentage point increase in the bank's share of potentially-informed customer business (defined, as earlier, to include pension funds and non-dealing banks) is estimated to raise a bank's tendency to place aggressive orders by 1.7 percentage points relative to the overall average of 50 percent. A similar increase in the bank's unexplained share of interbank trading would raise the bank's tendency to place aggressive orders by 4.3 percentage points.

This final section has examined the sources of information for currency-market dealing banks. One approach to this analysis focused on the banks' average price impact; the

other focused on the strength of the banks' tendency to place aggressive orders. These two approaches direct us to similar findings. First: Non-financial corporations, governments, and certain financial customers – specifically unit trusts, mutual funds, and insurance firms – do not bring private information to the market, on average. Second: Other financial customers do bring private information to the market; included in this category could be hedge funds and investment managers. Third: The banks themselves bring substantial private information to the market.

4. Conclusion

This paper examines sources of information advantage in the foreign-exchange market. It first shows that large banks have an information advantage, relative to small banks, in the foreign exchange interdealer market. It then traces that advantage to two sources of private information: the larger banks' more extensive network of hedge funds and other relatively aggressive financial customers, and the large banks' own ability to generate market insights.

Our data comprise the complete record of interbank transactions at a big Scandinavian bank during four weeks of 1998 and 1999. Using the methodology of Anand et al. (2008), we document the information advantage of large banks by comparing average post-trade returns to banks of different sizes. We also use structural VARs, as in Hasbrouck (1991), to show that the big banks' larger post-trade returns are sustained indefinitely, which suggests that the returns are indeed driven by information and their is fundamental.

We evaluate the information content of order flow from nine types of customers, using cross-sectional regressions in which the dependent variable is each bank's average post-trade return and the key independent variables are its customer market shares. We find that at least five customer types do not bring information to the market, namely non-financial corporations, governments, unit trusts, mutual funds, and insurance firms. Information comes

from a group of financial customers that includes hedge funds, investment managers, pension funds, and non-dealing banks. Private information in the foreign-exchange market also seems to be originated by the banks themselves.

We are able to quantify the information advantage from different sources. The results suggest that if an average bank examined here were to increase its market share with informed customers by one percentage point, its euro traders would each earn an extra 0.12 basis points per trade or about €12 per million. Our bank's three euro dealers traded an average of €4.8 billion per week. An extra €12 per million would earn an extra €3 million per year. A one-standard-deviation rise in the banks' own residual market share would be associated, at our bank, with extra profits of €5.3 million per year.

We are the first to suggest that currency banks bring their own information to the market. The literature uniformly assumes that all private information in currency markets originates with end users. Valseth (2010) provides evidence that bond dealers in Norway bring information to the market, but otherwise the literature generally assumes that dealers are simply conduits for information brought to the market by end users.

Our conclusions have implications for many current questions in the microstructure of currency markets. First, they show that private information is one of the forces driving short-run exchange-rate dynamics. Though there is a consensus that macro-based exchange-rate models have not successfully identified these forces so it is fortunate that close scrutiny of the market's microeconomics is proving fruitful. This microstructure approach, pioneered by Goodhart (1988) and Evans and Lyons (2002), shows that one important force driving returns is contemporaneous order flow. Among the three prominent explanations for the relation between order flow and returns— inventories, liquidity (or finite elasticity of demand), and information – only the information hypothesis is consistent with our finding that there is a stronger relation between order flow and returns for some banks than others.

Our results are also relevant to understanding the price discovery process in currency markets. The price discovery mechanism proposed in Osler et al. (2009) implies that banks that trade most heavily with informed customers tend to rely most heavily on aggressive trades, consistent with our results. Finally, our results are relevant to ongoing investigations about the extent to which information influences liquidity provision or, more prosaically, the placement of limit orders. We find that limit-order placement is strongly influenced by information: the biggest banks have the most positive post-trade returns to limit orders as well as aggressive orders.

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Table 1. Descriptive Statistics, Banks in Four Size Categories

Table shows descriptive statistics for the complete dollar-mark and euro-dollar interdealer trading record of a Scandinavian bank during one week in 1998 and three weeks in 1999. The larger 1999 sample is highlighted in bold. Ranks are from *Euromoney* in 1998 or 1999.

Table 1A. Number of trades

	Num. Banks	Trades/Bank	Num. Trades
1998 Sample			
Immense (Rank 1-20)	18	26.3	473
Big (Rank 21-50)	21	17.0	357
Medium (Rank 51-200)	23	21.3	491
Small (Rank > 100)	197	3.7	722
Total	259	7.9	2,043
1999 Sample			
Immense (Rank 0-20)	20	147.8	2,955
Big (Rank 21-50)	30	76.8	2,303
Medium (Rank 51-200)	37	43.3	1,601
Small (Rank > 100)	200	12.2	2,447
Total	287	32.4	9,306

Table 1B. Trade sizes (1998: \$ millions; 1999: €millions)

	1998 Sample			1999 Sample		
	Mean	Median	Std. Dev.	Mean	Median	Std. Dev.
Immense	1.77	1.00	1.20	1.80	1.00	1.86
Big	1.65	1.00	0.95	1.53	1.00	1.24
Medium	1.55	1.00	1.01	1.54	1.00	1.17
Small	1.52	1.00	0.89	1.42	1.00	1.09

Table 2. Standard order-flow regressions

Table shows coefficients and *t*-statistics (in parentheses) from a regression where the dependent variable is the half-hourly exchange-rate return (log change, measured in basis points) and the independent variable(s) are other banks' net aggressive trades with our bank over half-hour intervals. Other banks' net aggressive trades are largely other banks' market orders that hit our bank's limit orders at electronic brokers. Results for the 1999 sample are shown in bold. An entry of unity implies that one net buy order brings a currency appreciation of one basis point. Symbols *** indicate significance at 1% level. Data comprise the complete dollar-mark and euro-dollar interdealer trading record of a Scandinavian bank during one week in 1998 and three weeks in 1999.

	1998 Sample	1999 Sample
Panel A		
All banks	0.97***	0.50***
Adj.R2	0.20	0.09
DW Stat	1.95	1.96
Panel B		
Immense (Rank 0-20)	1.11***	0.92***
Big (Rank 21-50)	1.25***	0.69***
Medium (51-100)	-0.07	0.07
Small (Rank>100)	0.56	-1.10***
Adj.R ²	0.22	0.22
DW Stat	1.94	1.90

Table 3. Returns immediately following a trade with our bank

Table shows average (log) returns in the 1-minute period immediately following trades. Since we can identify the trade initiator, we measure returns as the (log) change in the bid (ask) quote if a trade is settled at the bid (ask). All returns are multiplied by 10,000, so “1.0” represents one basis point. “Share Aggressive” is the share of aggressive trades as a percent of all trades between our bank and banks of that size group. Data comprise the complete dollar-mark and euro-dollar interdealer trading record of a Scandinavian bank during one week in 1998 and three weeks in 1999. The 1999 sample is in bold.

3A: Other banks’ net purchases (aggressive or passive) from our bank

	A: 98 Sample			B: 99 Sample		
	Avg. return	<i>t</i> -stat.	Share Aggressive	Avg. return	<i>t</i> -stat.	Share Aggressive
<i>1-Minute Horizon</i>						
Immense	0.25	2.71	66.1	0.23	5.60	61.8
Big	-0.09	-0.78	51.4	0.16	3.22	57.3
Medium	0.00	0.01	53.6	-0.04	-0.61	51.3
Small	-0.63	-7.20	37.7	-0.47	-10.84	30.4
Immense-Small	0.88			0.70		
<i>p</i> -value	0.00			0.00		

3B: Other banks’ net aggressive purchases and net passive purchases

	Other banks’ aggressive trades				Our bank’s aggressive trades			
	1998 Sample		1999 Sample		1998 Sample		1999 Sample	
	Avg. return	<i>t</i> -stat.	Avg. return	<i>t</i> -stat.	Avg. return	<i>t</i> -stat.	Avg. return	<i>t</i> -stat.
<i>1-Minute Horizon</i>								
Immense	0.54	4.83	0.54	11.00	-0.30	-1.97	-0.51	-6.94
Big	0.36	2.20	0.55	9.17	-0.52	-3.66	-0.62	-7.59
Medium	0.62	3.64	0.38	5.29	-0.66	-3.78	-0.69	-7.24
Small	-0.01	-0.05	0.24	3.69	-0.99	-8.37	-0.92	-17.11
Immense-Small	0.55		0.30		0.69		0.42	
<i>p</i> -value	0.00		0.00		0.00		0.00	

Table 4. Net purchases: Correlation across bank groups

The table shows how net purchases for each group is correlated with net purchases of other groups. Net purchases is measured as the number of purchases minus the number of sales for over 30-minute intervals. Data comprise the complete dollar-mark and euro-dollar interdealer trading record of a Scandinavian bank during one week in 1998 and three weeks in 1999. The 1999 sample is shown in bold. *, ** and *** indicate significance at the 10%, 5% and 1% level, respectively.

	Immense (Rank 1-20)	Big Rank (21-50)	Medium (Rank 51-100)
A. 1998 Sample			
Big	0.31 ***	1.00	
Medium	-0.62 ***	-0.28 ***	1.00
Small	-0.71 ***	-0.36 ***	0.36 ***
B. 1999 Sample			
Big	0.12 **	1.00	
Medium	-0.02	0.00	1.00
Small	-0.45 ***	-0.22 ***	0.01

Table 5. Position-taking against other banks

“Accumulating trades” are aggressive trades through which dealers at our bank build speculative position, while “decumulating trades” are trades through which these dealers reduce speculative positions. “Percent of trades” shows the percent of trades with the different categories of counterparts. “*P*-Value: Accumulating-Decumulating” tests whether the percentage of accumulating trades is significantly different from the percentage of decumulating trades. Data comprise the complete dollar-mark or euro-dollar interdealer trading record of a Scandinavian bank during one week in 1998 and three weeks in 1999. The 1999 sample is shown in bold. Ratios in *italics* are statistically different from unity.

Counterparty Bank	Percent of Accumulating Trades	Percent of Decumulating Trades	<i>P</i>-Value: Accumulating-Decumulating	Ratio: Accumulating Over Decumulating
A. 1998 Sample				
Immense	18	30	0.00	<i>0.62</i>
Big	16	19	0.09	<i>0.85</i>
Medium	21	20	0.52	1.08
Small	44	32	0.00	<i>1.40</i>
B. 1999 Sample				
Immense	25	36	0.00	<i>0.68</i>
Big	22	25	0.00	<i>0.87</i>
Medium	16	18	0.04	<i>0.90</i>
Small	37	21	0.00	<i>1.77</i>

Table 6. Correlations among banks' market shares

Correlations between banks' market shares with nine customer types. If correlation is e.g. 0.7 (such as between Insurance and corp.) this means that banks with a big market share of insurance-customers typically will also have a big market share of corporate customers. Since big banks typically have significant trading with all type of customers, correlations will be positive numbers. Market shares taken from *Euromoney's* 1999 Foreign Exchange Survey. Banks are those included in the complete euro-dollar interdealer trading record of a Scandinavian bank during three weeks in 1999. Banks with fewer than 20 trades excluded.

	Size (\$ bn)	Corp.	Unit Trusts	Mutual Funds	Insurance Firms	Pension Funds	Invest- ment Mgrs	Hedge Funds	Non- Dealing Banks
Governments	138.6	0.02	0.02	0.53	0.12	0.07	0.15	0.12	0.11
Corporations	689.2	1	0.02	0.35	0.73	0.63	0.67	0.41	0.58
Unit Trusts	0.4		1	0.11	0.00	0.02	0.11	0.06	0.10
Mutual Funds	265.6			1	0.56	0.31	0.41	0.29	0.19
Insurance Firms	235.2				1	0.61	0.52	0.34	0.20
Pension Funds	98.0					1	0.62	0.53	0.47
Investment Mgrs	567.7						1	0.65	0.69
Hedge Funds	141.8							1	0.50
Non-Dealing Bks	321.8								1

Table 7. Descriptive statistics: Sources of information analysis

Table shows descriptive statistics for variables in the analysis of the relative information content of trades by different currency market participants. Price impact figures are for interbank trades a Scandinavian bank in euro-dollar (three weeks in 1999). Returns measured in basis points; market shares measured in percent. Market shares for the customer groups are taken from *Euromoney's* 1999 FX survey. Interbank market shares are based on the number of trades in our Scandinavian bank sample.

	Mean	Median	Max	Min	Std.Dev.	Skew	Kurt.
Raw post-trade returns	-0.18	-0.09	1.33	-1.56	0.57	-0.15	2.79
Adjusted returns	0.03	0.06	1.33	-1.29	0.42	-0.05	3.45
Market share							
Corporate	0.87	0.10	10.89	0.00	1.86	3.21	14.45
Government/CBs	0.87	0.00	15.49	0.00	2.73	3.90	18.07
Unit trusts	0.50	0.00	26.18	0.00	3.10	6.74	50.33
Mutual funds	0.91	0.00	19.33	0.00	3.39	4.18	19.86
Insurance firms	0.77	0.00	11.23	0.00	2.15	3.04	11.75
Pension funds	0.85	0.00	15.77	0.00	2.34	3.77	19.82
Investment Mgr	0.88	0.00	12.93	0.00	2.24	3.47	16.09
Hedge funds	0.90	0.00	15.03	0.00	2.26	3.74	19.71
Non-dealing banks	0.79	0.00	7.94	0.00	1.63	2.69	10.11
Excess IB Mkt share	0.00	-0.18	3.72	-0.97	0.64	3.20	16.75
Share aggressive trades	0.54	0.57	0.83	0.03	0.21	-0.52	2.41

Table 8. Who Brings Information to the Market?

Tables 8A and 8B shows results from regression where the dependent variable is each bank's average post-trade return, measured in basis points. In Panel A the dependent variable is the raw return; Panel B the returns to market (limit) orders are adjusted by subtracting average returns to market (limit) orders across all banks. Explanatory variables represent a given bank's market share of different customer segments (except Resid IB). The different customer segments are Corporates; Governments and Central banks; Unit trusts; Mutual funds; Insurance firms; Pension funds; Investment managers; Hedge funds; and Non-dealing banks. Market shares taken from Euromoney FX Survey for 1999. The variable "No-info fin" refers to a bank's market share with respect to unit trusts, mutual funds, and insurance firms. "Info fin" Refers to a bank's market share with respect to pension funds, investment managers, hedge funds, and non-dealing banks. "Resid_IB" is the residual from a regression of the banks' interbank trading shares on these customer market shares. In Table 8C the dependent variable is the share of aggressive trades among each bank's total trades, and the independent variables are the market shares of 8A. Data comprise the complete euro-dollar interdealer trading record of a Scandinavian bank during three weeks in 1999. Only banks that have at least 20 trades in our sample are included. Weighted least squares where the inverse of total interdealer trades is the weight. Adj. R² is from the unweighted regression. All figures E-2.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Raw Returns								
Corporates	3.5**	3.3	2.8	0.7	-0.8	1.4	1.3	-2.2
Gov't/cent. bk	0.4	0.4	0.4	0.4	0.2	0.3	0.3	0.2
Unit trusts	1.2							
Mutual funds		0.4						
Insurance firms			0.8					
Pension funds				3.5**				
Investment Mgrs					5.0***			
Hedge funds						4.6***		
Non-dealing banks							5.6***	
No-info financial								1.5
Info financial								11.9***
Resid. interdealer	15.9***	15.6***	15.9***	15.2***	15.9***	15.9***	16.3***	22.7***
Adjusted R ²	0.32	0.31	0.31	0.34	0.42	0.43	0.36	0.44
Panel B: Adjusted Returns								
Corporates	2.0	2.3	1.4	0.2	-1.5	0.4	0.2	-2.7*
Gov't/central bk	0.2	0.3	0.2	0.2	0.0	0.1	0.2	-0.1
Unit trusts	0.7							
Mutual funds		-0.2						
Insurance firms			0.7					
Pension funds				2.8**				
Investment Mgrs					4.1***			
Hedge funds						3.5***		
Non-dealing banks							4.5***	
No-info financial								1.0
Info financial								6.0***
Resid. interdealer	11.8***	11.3***	11.8***	11.2***	11.9***	11.8***	12.2***	12.1***
Adjusted R ²	0.29	0.30	0.29	0.33	0.43	0.41	0.35	0.44

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel C: Share Aggressive Trades as Independent Variable								
Corporates	1.4***	1.0**	1.3*	0.9*	0.7	0.9**	1.0**	-0.6
Government/Cent. bks	0.1	0.0	0.2	0.2	0.1	0.1	0.1	-0.0
Unit trusts	0.5							
Mutual funds		0.6						
Insurance firms			0.1					
Pension funds				0.7				
Investment Mgrs					0.9**			
Hedge funds						1.1**		
Non- dealing banks							1.0	
No-info financial								1.0**
Info financial								1.7**
Resid. interdealer	3.9***	4.0***	3.9***	3.7***	3.9***	3.9***	3.9***	4.3***
Adjusted R²	0.22	0.22	0.20	0.22	0.22	0.26	0.21	0.26

Notes

ⁱ The market structure has changed somewhat since the time of our sample, but not in ways that challenge our analysis. Selected large, active hedge funds are now permitted direct access to the interdealer market, but their presence has not affected the basic structure of trading. Further, the largest dealing banks have been enlisted to provide liquidity on ECNs (e.g., Hostpot FXi). However, since the banks' role there is primarily to place limit orders they are unlikely to trade much with each other in those settings.

ⁱⁱ One of the dealers examined in Bjørnnes and Rime (2005) is not included here because he had only a limited number of dollar-mark trades.

ⁱⁱⁱ Evans and Lyons (2007), Carpenter and Wang (2007), Bjørnnes, Rime and Solheim (2005), and Osler et al. (2009) study customer data disaggregated into different groups, like financial and non-financial.

^{iv} There are minor exceptions, such as inside information that a central bank is about to intervene.

^v To rank a bank's overall size we used the overall assessment of the top 100 foreign exchange banks of 1998 (since our questionnaire was done in 1998), or, if a bank was not ranked in 1998, the 1999 rank.

^{vi} These banks need not be included in our sample; their names are included here purely for illustration.

^{vii} Our bank would still not be counted as an Immense bank since its interbank activity is larger relative to its customer activity than is typical.

^{viii} Individual trader strategies; which are addressed in Bjørnnes and Rime (2005), are not central to our analysis.

^{ix} Our dataset only contains traded prices. In order to create midquotes, to avoid bid-ask bounce in the estimation, we subtract (add) one pip from ask (bid) prices since the interbank quoted spread was between 2 and 3 pips in 1998 and 1999 (see Bjørnnes and Rime 2005; Goodhart *et al.* 2002).

^x These results, suppressed to save space, are available upon request.

^{xi} Overnight-returns are excluded from all samples.

^{xii} Alternatively one could use a block-triangular structure, e.g. with the Immense banks at top, and the Small banks last, but before return. Results, which are very similar, are available on request.

^{xiii} In unreported results we aggregate the banks and estimate just one SVAR between order flow and returns per sample period. The cumulative impact of a positive shock is between 0.4 and 0.5 basis points for both sample periods, which is comparable to the effect of 0.5 basis points found by Payne (2003) for the overall market.

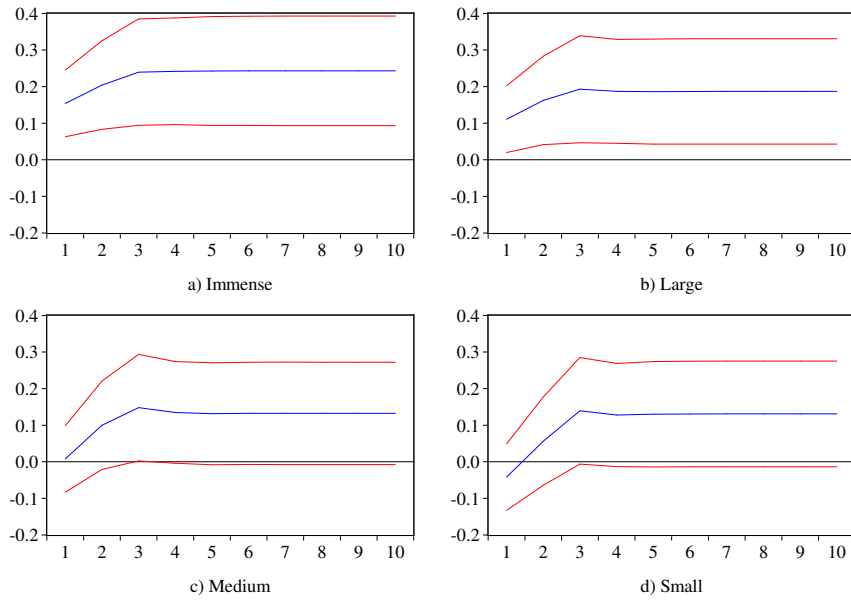
^{xiv} Results are available on request.

^{xv} The strength of these patterns suggests that our sample is indeed representative of the broader market.

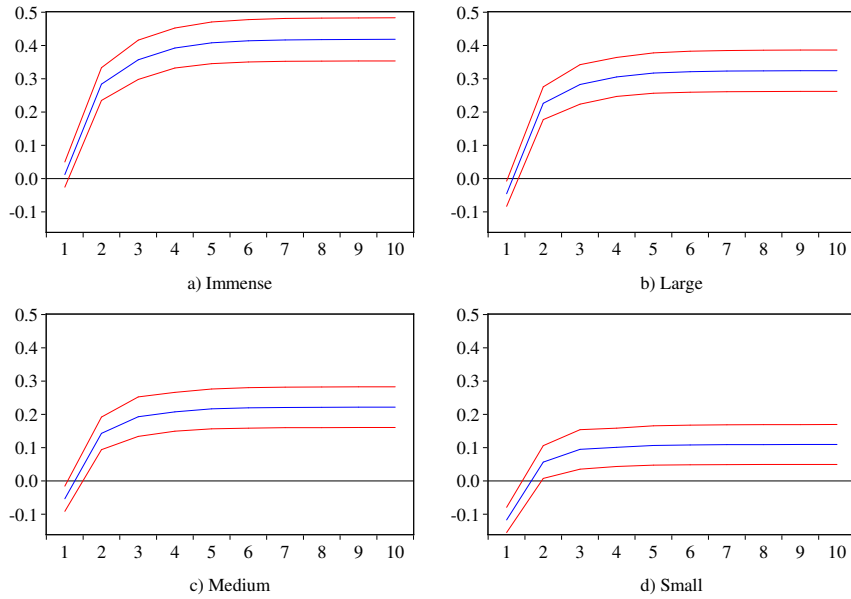
^{xvi} In studying our dealers' accumulating trades, we noticed that occasionally the resulting position is immediately unwound via an offsetting customer trade or direct interbank trade. Since this type of inventory accumulation seems unlikely to represent speculation, we further narrow the set of trades on which we focus to those that are not immediately followed by a customer or direct interbank trade of the opposite sign, though we continue to refer to these as "accumulating" trades.

^{xvii} According to a Citibank manager in the *Financial Times*, April 29, 1991: "if you don't have access to the end user, your view of the market will be severely limited."

Figure 1: SVAR Analysis of Price Response to Banks' Aggressive Trades



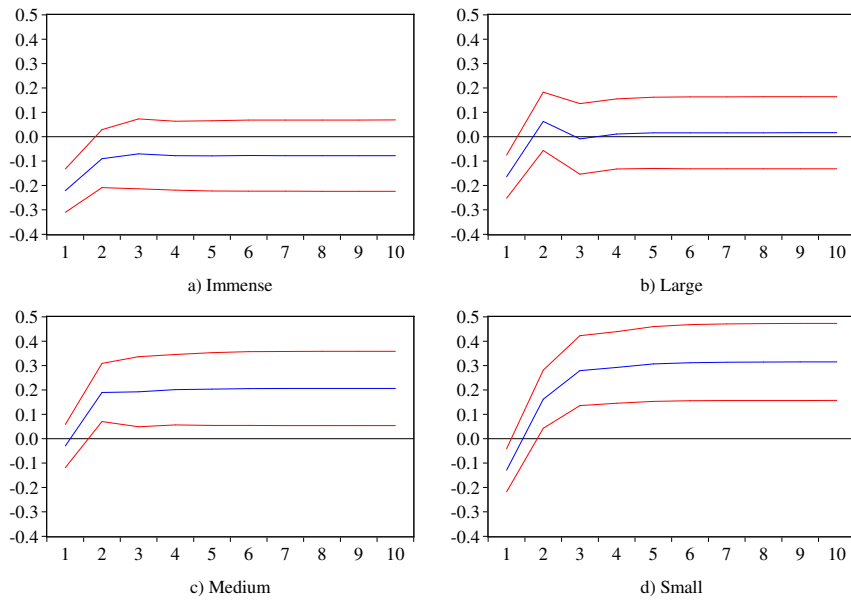
(a) 1998 Sample



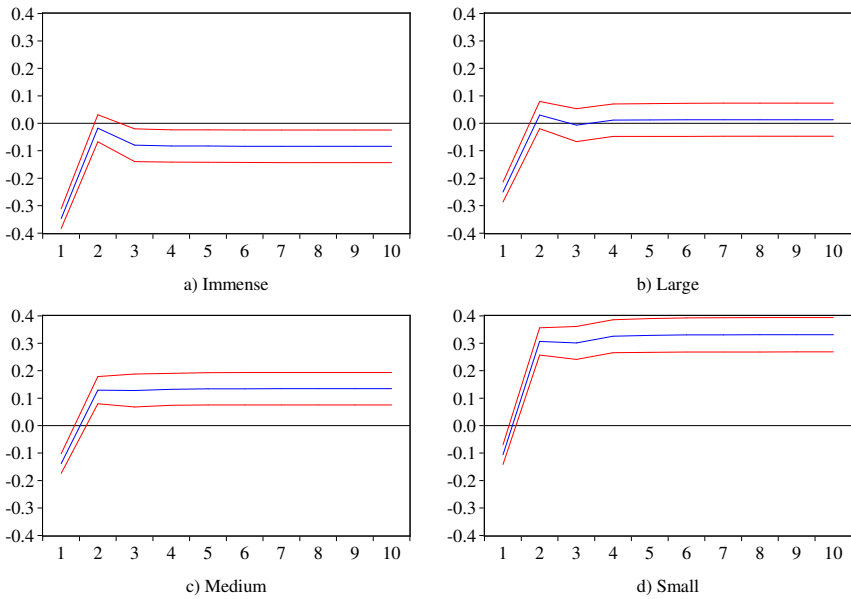
(b) 1999 Sample

Note: Accumulated impulse response of price to one standard deviation innovations in aggressive trades of counterparty banks, together with two-standard-deviation bands. The four order flows are treated symmetrically in the VAR: They only respond to own shock and lags of the other variables. Return (measured in basis points) is ordered last in the VAR and respond to contemporaneous shocks to all of the order flow variables. Data comprise entire trading record for major Scandinavian bank over one week in 1998 and three weeks in 1999. Individual banks are disaggregated into size groups according to contemporaneous Euromoney size rankings. Vertical axis shows returns in basis points. Horizontal axis is event time (transactions), approximately minutes.

Figure 2: SVAR Analysis of Price Response to Our Bank's Aggressive Trades



(a) 1998 Sample

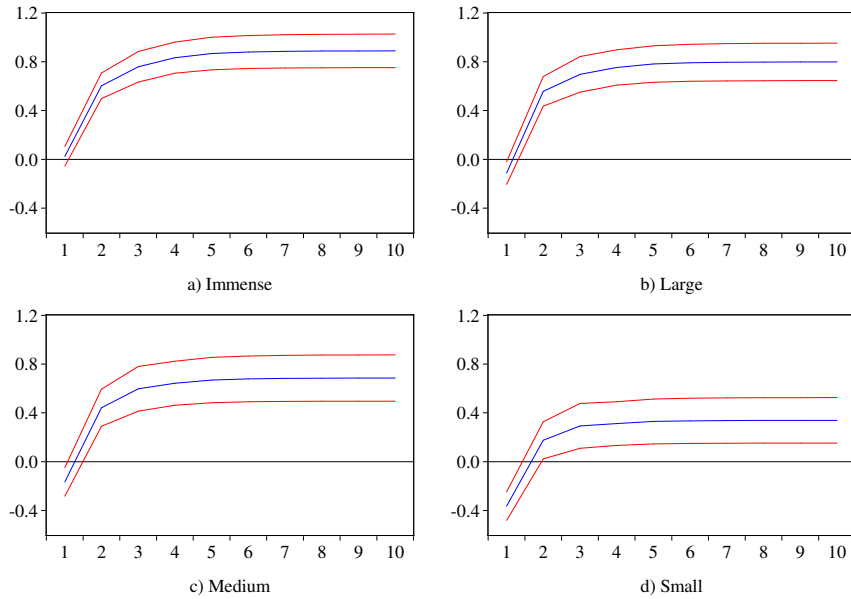


(b) 1999 Sample

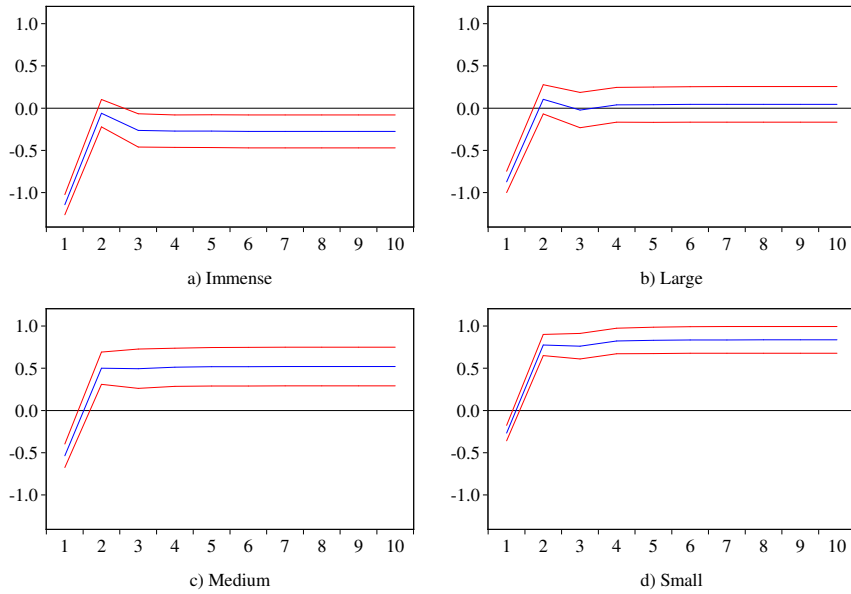
Note: Accumulated response of price to one standard deviation innovations in aggressive trades of our bank, together with two-standard-deviation bands. The four order flows are treated symmetrically in the VAR: They only respond to own shock and lags of the other variables. Return (measured in basis points) is ordered last in the VAR and respond to contemporaneous shocks to all of the order flow variables. Data comprise entire trading record for major Scandinavian bank over one week in 1998 and three weeks in 1999. Individual banks are disaggregated into size groups according to contemporaneous Euromoney size rankings. Vertical axis shows returns in basis points. Horizontal axis is event time (transactions), approximately minutes.

A Robustness

Figure 3: SVAR Analysis of Price Response to Banks' Trades: Unit shocks



(a) Incoming trades (1999)



(b) Outgoing trades (1999)

Note: Accumulated impulse response of price to one-unit innovations in aggressive trades of counterparty banks (panel a), and to our bank's aggressive trades (panel b), together with two-standard-deviation bands. The four order flows are treated symmetrically in the VAR: They only respond to own shock and lags of the other variables. Return (measured in basis points) is ordered last in the VAR and respond to contemporaneous shocks to all of the order flow variables. Data comprise entire trading record for major Scandinavian bank over one week in 1998 and three weeks in 1999. Individual banks are disaggregated into size groups according to contemporaneous Euromoney size rankings. Vertical axis shows returns in basis points. Horizontal axis is event time (transactions), approximately minutes.