Different Counterparties, Different Foreign Exchange Trading? The Perspective of a Median Bank

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Abstract

This study examines all transactions of a bank in Germany in USD/EUR-trading over a four-month period. It is the first such data set from a medium-sized bank complementing earlier findings from large banks. Furthermore, our data allows the differentiation of trading information between other dealers, commercial customers and the increasingly important financial customers. Our results show that these differences matter. Moreover, order flows of financial customers are informative even at the low frequency and restricted order volume of a median bank, highlighting the explanatory power of the order flow approach.

JEL-Classification: F31, G15
Keywords: foreign exchange markets, market microstructure, flow analysis, financial customer orders

March 26, 2003

* We are deeply indebted to the bankers who provided and discussed the data with us.

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1. Introduction

The microstructure research in foreign exchange is largely motivated by the failure of traditional exchange rate modeling (see e.g. Frankel and Rose, 1995, Taylor, 1995). In particular, the analysis of order flows has become a promising avenue of studies which follow two directions. One direction analyzes aggregated flows and aims at explaining exchange rates, such as Evans and Lyons (2002, 2002a), Osler (2002) or Froot and Ramadorai (2002). A second approach aims at better understanding the decision-making of dealers. This latter literature is very scarce, as more complete and private information from banks on the single transactions is necessary. We analyze a new data set of this kind from a medium-sized bank in Germany which is the first in differentiating trading information between other dealers, commercial customers and the increasingly important financial customers. Our results show that these differences matter. Moreover, order flows of financial customers are informative even at the low frequency and limited order volume of a median bank, highlighting the explanatory power of the order flow approach.

The pioneering researcher in this field is Lyons (1995), who examined the trading behavior of a very large US dealer over one week in 1992. He established the existence of an inventory and an information effect in accordance with the Madhavan and Smidt (1991) model. This single dealer, however, is particular, as he trades only with other banks. Yao (1998) is thus the first study analyzing customer dealing separately from interbank dealing, finding smaller differences. Bjønnes and Rime (2001) introduce two facts into the literature: diversity in trading style found from their analysis of four dealers and the consideration of the new electronic brokerage systems. Separating traditional deals from electronically brokered deals reveals that the latter bring about a full disappearance of the two effects in the form detected by Lyons (1995). Related effects can be found in a new form, however. This raises some questions which are organized according to the different counterparties:

First, does the change in trading systems systematically impact the dealer's behavior in interbank trading in the sense that the findings can be reproduced at another place, bank and time? Second, do electronic brokers used in the interbank market influence the dealing with customers and how is this trading conducted? Third, is the dealers' behavior towards the increasingly important financial customers the same as towards the traditional commercial customers? These three research questions are addressed in this study, which is built on a new data set.

According to our knowledge, there are only the three above-mentioned earlier data sets to analyze bank deal-by-deal transactions. Yao (1998) is the first who differentiates between dealers and customers as counterparties. His results stem from 1995, however, which is a time when electronic brokerage was in its infancy. The major study being conducted in the now dominating world of electronic brokerage in 1998, i.e. Bjønnes and Rime (2001), does not consider customer business. Bjønnes and Rime (2001a) analyze in a companion paper customer trades in an event study manner for a comparatively small sample. We have therefore collected data which are characterized in three respects: first, the data are recent, i.e. from the electronic brokerage environment of the year 2001. Second, they cover a very different dealer, i.e. a medium-sized participant in Germany, and, third, they differentiate between three trading counterparties: we examine interbank versus customer business and we differentiate between commercial and financial customers.

Our findings support the result of Bjønnes and Rime (2001) that the new electronic trading systems have changed the dealers' behavior in interbank trading away from the Lyons (1995) and Yao (1998) results. Inventory control still exists, as can be recognized from the strong mean reversion in trades, but the mechanism works by steering outgoing trades. There is also an information effect from order flows in the sense that the cumulative order flow informs about the exchange rate development. In a next step, the information effect examinations are extended to customer trading, confirming the findings for the interbank trading. In contrast to earlier studies, the "information effect" in our sample has an unexpected sign, as larger orders receive a smaller spread. This can be interpreted as a simple cost effect due to the comparatively small trades of our median bank. Finally, we split up the customer orders into commercial and financial customers and find that only financial customers' orders are informative on the short-term price movements covered here. Moreover, the spread for this group does not become more attractive for larger trades to the same extent as it does for commercial customers, cautiously indicating a kind of information effect.

Overall, the results suggest that different counterparties play different roles in the foreign exchange market. In particular, financial customer order flows are informative even at the low frequency and comparatively low volume characterizing our median bank. Thus, our disaggregated and high-frequency data are consistent with the finding by Fan and Lyons (2002; see also Lyons, 2001), that financial customers matter most for understanding shorter-term exchange rate movements.

The paper proceeds as follows: Section 2 develops three hypotheses based on a selective literature review, which are going to be tested later. Section 3 describes the data. Examination results are reported in Section 4 and Section 5 presents conclusions.

2. Literature and hypotheses

The empirical literature on foreign exchange market microstructure received a most important impulse by Lyons' (1995) study on transaction determinants of a large US dealer in the spot DEM/USD market. This study was the first to show the importance of order flows for decision making in foreign exchange trading and thus to introduce a new category of "order flow information". Several studies have demonstrated the usefulness of this concept: Ito, Lyons and Melvin (1998) or Covrig and Melvin (2001) use flows in an event study environment. Questionnaire surveys, such as Cheung and Chinn (2001) and Cheung, Chinn and Marsh (2000) show some importance of flows for FX dealers, Gehrig and Menkhoff (2002) test more detailed hypotheses on the character of flow information confirming Lyons' view. Finally, recent work aims to apply flow information for exchange rate explanation, e.g. Evans and Lyons (2002, 2002a), Evans (2002), Killeen, Lyons and Moore (2001) or Froot and Ramadorai (2002), or uses order flow characteristics to explain forecasting power of technical analysis (Osler, 2002).

Whereas these kinds of studies show the power of "order flow information" in understanding foreign exchange markets, studies directly following Lyons' approach are comparatively rare (see Lyons, 2001, and Sarno and Taylor, 2001, for surveys on FX microstructure). Their focus is on grasping the dealers' decision-making, which requires a command of the relevant pieces of information. This information has, of course, proprietary nature and is thus difficult to get. There are early studies on transaction data in foreign exchange, such as Goodhart and Figliuoli (1991), using indicative quotes, and from this perspective it is a step forward to have a data set with real transaction data (see also Danielsson and Payne, 2002). However, these transaction data are not comprehensive enough – and thus not used – to analyze dealers' behavior. For this purpose, one needs more information, for example about the inventory position of the dealer or about all sources of FX business.

In this line of research, there are to our best knowledge the three earlier studies mentioned above, i.e. Lyons (1995), Yao (1998) and Bjønnes and Rime (2001) (related aspects based on the same data sets have been analyzed e.g. in Lyons 1998, Yao, 1998a, Bjønnes and Rime, 2001a). Their common theoretical background is the trading model of Madhavan and Smidt (1991) which postulates that trading decisions will be influences among other things from two interesting effects: first, an asset's own inventory will influence price setting by promoting deals, leading to a mean-reversion of the inventory, in short the *inventory effect*. Second, dealers acknowledge asymmetric information among market participants in the sense that they assume higher private information when they set prices for a larger potential deal. They protect themselves against this assumed information disadvantage by setting larger spreads for larger orders, in short the *information effect*. The examination of the existence of these two effects is at the core of the earlier studies. We motivate our research questions by reviewing these literature results.

Several important differences between the studies can be directly recognized from obvious design features. Starting with Lyons (1995) as the benchmark, he analyzes one very large US dealer in the DEM/USD spot market over one week. Yao (1998) also focuses on a large US dealer but the coverage is over five weeks and this dealer is not only concerned with interbank trading but has a customer share of his trading volume of 13.9%. Bjønnes and Rime (2001) observe foreign exchange dealing at a Norwegian bank which is characterized as a major player in these markets. They analyze four dealers over one week of trading: dealer 1 mostly resembles Lyons' dealer as he is the bank's main spot dealer in DEM/USD, although the volume is clearly smaller compared to Lyons' or Yao's market leaders. The Norwegian dealer is a "medium-sized market maker in DEM/USD". Dealer 3 is the "largest market maker in NOK/DEM". Dealers 2 and 4, by contrast, command smaller volumes and are mainly active in the DEM/USD market. More information on characteristics of the core DEM/USD dealers and their trading activity as well as market wide "benchmarking" information from the survey of the BIS (2002) is compiled in Table 1. Our own study is mentioned there for comparative purposes.

The BIS data for the year 2001 show that worldwide turnover in foreign exchange on a gross basis is about 1,860 bn. USD. Taking double counting into consideration, this goes down to 1,200 bn. USD. Of this, 387 bn. USD is in spot trading and about 35% of all spot trading is in USD/EUR. Assuming that all 2,530 participating banks trade in this leading currency pair, the mean daily USD/EUR spot trading per bank in net terms is then at least 50 mill. USD. Accounting for the fact that the transaction data of banks refer to gross figures and that not all banks may be active in the particular currency pair, the maximum mean value for comparative purposes with our study here may be about 150 mill. USD. The resulting range of 50 – 150 mill. USD is given in Table 1.

Due to the high concentration in this market, however, the median is much below the just discussed mean. Some qualified estimation on the turnover of a median bank can be given for the German case. In Germany, the Deutsche Bundesbank approached for the compilation of the BIS (2002)-study 33 "reporting dealers" which are assumed to cover at least 95% of the foreign exchange market. These dealers report a net spot trading of 26 bn. USD of which roughly 50% is in the USD/EUR market. Adding 50% to receive a gross figure, the mean turnover of a German bank in the market of interest is about 600 mill. USD. However, the BIS information on concentration says that 75% of the volume is made up by the 5 largest banks. Their mean is then almost 3 bn. USD per bank (although not per individual dealer), whereas the remaining 28 banks trade about 174 mill. USD on average. Using additional information provided by the Deutsche Bundesbank on the distribution of turnover on these remaining banks, the relevant median figure for the 33 reporting banks is roughly 50 mill. USD. The "true" median is even lower, as the statistic does not cover the whole German market. Gehrig and Menkhoff (2002) mention e.g. 43 banks conducting their own account foreign exchange trading in 2001 and there are many more banks in the market intermediating what are essentially customer orders.

In summary, taking a median of below 50 mill. USD turnover per bank as a reference, it becomes obvious that previous studies on transaction data focus on extremely large dealers trading about 10 to 30 times of the median dealer. Our bank with a relevant volume of 39 mill. USD is tiny by contrast but appears to be a reasonable case for a median bank. The same applies on the structure of counterparties, where the earlier covered dealers focus on interbank trading, whereas our bank has a customer share which is more normal when compared to the total market.

Seen from this angle, our study – covered in Table 1 for comparative purposes – thus provides hitherto missing evidence of a median bank, complementing earlier work.

This difference between our sample and earlier studies thus motivates the first research objective, i.e. to replicate earlier findings. In his seminal study Lyons (1995) tests the explanatory power of several price determinants derived from the Madhavan and Smidt (1991) model of a market maker's behavior. He finds indeed that price setting for incoming non-brokered interdealer trades, in the sense of a price change in relation to the earlier trade Δp_{it}, is systematically influenced by three determinants: first, there is an inventory effect as the dealer shows a clear mean reversion of his open position over time by "quote-shading", that being the terms I_{it} and I_{it-1}. If he has, for example, a large open long position in foreign currency, he sets prices more attractive to other buyers than to sellers in order to balance his portfolio. There is thus a larger probability of reducing the open position. Second, the dealer shows an information effect in the sense that he reacts carefully to large orders as he may suspect superior knowledge – private information – on the other market-side. The order volume is the term Q_{jt}. Third, in order to earn a spread from his transaction there is an asymmetry in price-setting as the price for purchases is slightly lower than for sales, i.e. the "direction" expressed by the terms D_t and D_{t-1} matters. Whereas this third determinant seems to be a necessary ingredient of trading, and is thus regularly found in empirical studies, the two other determinants – I and Q – are open to discussion.

$$\Delta p_{it} = \beta_0 + \beta_1 Q_{jt} + \beta_2 I_{it} + \beta_3 I_{it-1} + \beta_4 D_t + \beta_5 D_{t-1} + \varepsilon_{it}$$

Yao (1998) only confirms the information effect but not the inventory effect and Bjønnes and Rime (2001) do not find any of them. Yao argues that his dealer has a large customer business which provides him with an information advantage that the dealer does not want to signal unintentionally to others by quote shading. The Bjønnes and Rime study provides evidence that the changing market structure plays a role. In 1992, when Lyons' data were compiled, interbank trading was mainly executed by direct interdealer communication and to a lesser extent by voice brokered trades, whereas nowadays electronic broker systems dominate. The latter systems, such as EBS and Reuters Dealing 2000-2 or its successors offer convenient ways for inventory control and are much more transparent than the former interbank market. Thus, we do not expect our median bank which effectively trades in the electronic brokerage world to behave as a Lyons' dealer would. However, the economic tasks of inventory control and coping with asymmetric information still exist. Bjønnes and Rime (2001) have proposed new ways to test for the existence of these effects. As they perform the only study conducting these tests in the now relevant institutional environment, it seems interesting to see whether their findings will be reproduced. The median bank can be expected to perform inventory control in the same way as a market maker but the informative situation may be different.

H1 Interdealer trading: Inventory control and private information exist in foreign exchange trading as can be detected by the ways suggested in Bjønnes and Rime (2001).

The discussion has so far focused on interdealer trading although latest research indicates that customer orders may be the relevant force driving exchange rates. We will thus explore other market participants in the following. It is in particular Yao (1998, Table 7) who examines customer order flow. He found no information but an inventory effect. The inventory effect in customer trading mirrors the discussion of the missing inventory effect in the interdealer market as quote shading does not matter in the customer business. The coefficient of the information effect is rightly signed and comes with a t-value of 1.63. Yao argues that the insignificance may be due to the fact that the full price impact of a large customer order develops over several periods.

Thus, in the case of Yao's dealer the price determination in interbank and customer business differs mainly with regard to the inventory effect. For our median bank in the modern trading environment we do not expect such a difference to exist as quote shading does not occur. However, with respect to information effects, the small customer base of a median bank does not really promise any useful private information.

H2 Customer trading: Inventory control works as for interdealer trades but there is no measurable private information from customer business.

Finally, the growing market share of customer business and in particular the gain of financial customers in relation to commercial customers and interdealer trading justify differentiating two groups of customer business. Another motivation is provided by Lyons (2001) and Fan and Lyons' (2002) finding that financial customer orders are highly correlated with shorter-term exchange rate movements. Both studies use the data of a large bank which is aggregated per day for all the trading of three differentiated customer groups each. The information on customer groups at a transaction level provided here is thus new in the literature. As we are studying high-frequency data, the Fan and Lyons finding would imply that a disaggregation into financial and commercial customers provides another reason to expect that commercial customer trading at a median bank is not informative. If there is any effect it could show up in the financial customer deals but, again, there is the disadvantage to our study of comparatively few and small trades.

H3 Customer groups' trading: If customer orders provide information for a median bank, there is a tendency for financial customer orders to be more informative than commercial customer orders at the high frequency.

In summary, the new data allow us to test three hypotheses as motivated above. Regarding hypothesis 1 the case is to confirm the Bjønnes and Rime findings at a different kind of bank. Regarding hypothesis 2, we expect in the new environment, as also for the median bank, a difference between interdealer and customer business as Yao did, although in a new manner. Finally, the so far unavailable disaggregation of customer trades could be useful as financial customers are expected to provide more information to the bank than commercial customers in the shorter-term. The data to test these hypotheses are described in the next section.

3. Data

The data set employed in this study consists of the complete USD/EUR trading record of a medium-sized bank in Germany. The record covers 87 trading days, beginning on Wednesday, the 11th of July 2001, and ending on Friday, the 9th of November 2001.[1] Compared with the other microstructure data sets mentioned, this is the longest observation period so far. Due to the size of the bank as a non-market making participant with a limited customer base, the transaction frequency is comparatively low. The bank realizes about 40-50 USD/EUR trades per day considering all kinds of transactions, whereas the market makers covered earlier perform about five times as many transactions per day. The data set includes transaction prices, quantities, information about the initiator of each trade and a time stamp. The infor-

[1] We could not find any enduring change in trading behavior due to a possible "September-11th-effect".

mation on the bank's inventory position can be designed by cumulating the successive transactions. These kinds of calculations are performed for the bank and not for a single dealer. However, due to the comparatively small size of our institution, there is only one dealer responsible for the banks' USD/EUR inventory position and trading policy – although he may be supported by other dealers when required – so that there is no de facto difference to earlier studies covering dealers.

In order to obtain a broad data set we include outright-forward trades in an adjusted manner, i.e. by correcting for the forward points. In our opinion these trades should not be disregarded, as we especially focus on customer trading, and outright-forward trades account for a large portion of customer business. Moreover, outright-forward trades influence the inventory position in "our" median bank as this trading is also conducted by and accounted for by the same dealer as the spot trading. However, to make our findings better comparable to the literature, we have also performed the examinations without these outright-forward trades. Results mostly do not differ much from each other and are thus not reported, although statistical measures tend to be better when more data are considered.

3.1 Deals blotter

The FX dealings of the bank are split into two segments: (i) trading with other dealers takes place on the "trading floor", and (ii) customer trades are transacted by the "sales staff". While dealers on the trading floor can choose between different trading channels, the sales staff generally communicates by telephone with the customers and their colleagues from the trading floor respectively. Each member of the sales staff is responsible for a certain group of customers, e.g. financial institutions or commercial customers. The dealers are notified about customers' requests by the sales staff via voice-box or phone. Because they are not informed about the direction of the upcoming trade (buy or sell) they always place bid/offer quotes at market conditions. Figure 1 illustrates the communication structure and the process of FX trading. Dealers told us that they almost solely use EBS, because communication and transactions require less time than in any other interdealer trading channel. Moreover, spreads are very advantageous – around one or two pips only.

The data set consists of all trades, including indirect trades executed by voice-brokers or electronic brokering systems such as EBS, direct trades completed by telephone or electronically, internal trades and customer trades. All trades are entered manually into the "deals blotter" by the back-office without differentiating between the several trading channels of each transaction. Bid-offer quotes at the time of each transaction are not recorded, either, but we can easily identify bid-offer prices afterwards by means of the trade-initiating party. For each trade, the following information is obtained from the hardcopy record:

(1) the type of each trade;
(2) the date and time of the trade[2];
(3) the counterparty;
(4) the quantity traded;
(5) the transaction price;
(6) the forward points if applicable[3];
(7) the initiator of the trade.

Identifying the initiator of each trade allows for distinguishing between incoming (passive) and outgoing (active) trades. Similar to the finding by Yao (1998, Table 3b) approximately 53% of all trades are signed as incoming or passive.

3.2 The inventory position

The bank performs a clearly risk-averse policy regarding its open USD/EUR inventory position. The maximum long position is EUR 73.1 million, and the maximum short position is EUR 49.1 million. These extreme values are misleading, however, as the average absolute open position during the day is just 3.3 million USD. The day always ends with a position close to zero. As we have no information about a possible overnight position change, we follow Lyons (1995) and set the daily starting position to zero. Figure 2 presents this inventory position measured in EUR.

The finding on our bank's inventory policy is consistent with Lyons (1995), Yao (1998) and Bjønnes and Rime (2001). Also, the absolute size of the inventory does not differ crucially from those observed in the three former studies, which is noteworthy as our bank trades less often and with less volume. Obviously, the balancing of the inventory position is an important feature of dealers' behavior regardless of the bank's size.

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[2] The time stamp indicates the time of data entry and not the moment of trade execution which will differ slightly. Nevertheless there is no allocation problem because all trades are entered in a strict chronological order.

3.3 The types of trade

Table 2 presents some statistics about the different types of trade. The structure of the interdealer trades is very similar to the ones observed by Bjønnes and Rime (2001, Table 2). Mean, median and standard deviation indicate that most transactions are in fact executed via EBS, as the dealers told us.[4]

Of more interest are the customer trades. The share of customer trading volume amounting to nearly 40% (23% spot trades only) is striking. Moreover, our data set allows us to distinguish between three different groups of customers according to the bank's classification: financial business, commercial business and preferred commercial business. Whereas preferred and commercial customers mostly trade small positions in foreign exchange, financial customers transact larger amounts. The latter, however, trade less often with our bank than commercial customers. Outright-forward trades seem to play a major role in customer business where they make up for 30 to 40% of all trades. Despite their numerical importance they do not have an effect on the statistical structure of the data set (see Panel A and B in Table 2). The share of outright-forward trades does not differ too much between the three customer groups, either.

3.4 Descriptive statistics of regression variables

Descriptive statistics for the relevant variables used in the estimations and inter-transaction times are reported in Table 3. According to the above reasoning we will include outright forward transactions when it comes to the regression analysis. We will neglect, however, the preferred commercial business in the following as these customers are attended to individually, each with specific conditions, possibly reflecting cross-selling arrangements. Moreover, some cases are deleted from the final data set due to extreme price changes of more than 100 basis points or tiny volumes of less than 1,000 USD as both characteristics may overly influence the relations of interest.

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[3] On the basis of the forward points it is possible to transform each outright-forward trade into a "spot-like" trade. This requires that the covered interest parity holds, which is a stylized fact for the market under consideration.

[4] When working with the EBS system dealers can only transact trades of the size of one, two or five million EUR/USD. Trades of the size of 10 million EUR/USD are pretty uncommon. There is only one single trade above that.

The final data set is thus composed of all incoming and outgoing spot and outright-forward trades of the interdealer and the financial and the commercial customer business (see Table 3). When reproducing Lyons' (1995) baseline model we only consider incoming trades. It might be interesting to compare the absolute values of these variables with the ones of the former studies.

One thing that catches the eye is the absolute change in transaction price between two periods Abs(Δp_{it}). Mean, median and standard deviation are by far higher – though not beyond means – than in the other studies mentioned. This can be explained by the fact that the trading records contain transactions of very different counterparties and by the comparatively long inter-transaction time Δt. Whereas the average transaction time in Lyons (1995) and Yao (1998) is only 1 minute and 46 seconds, and in Bjønnes and Rime (2001) approximately 5 minutes, almost 13 minutes pass by between two trades in our study and as long as 25 minutes between two incoming trades. In the foreign exchange business this is a huge time gap. The question arises whether the regression equation of Lyons' baseline model, which tries to map the dealer's reaction, is still an appropriate way of modeling this kind of trading behavior, as a lot can happen within 25 minutes! We help ourselves by trimming the data set to transactions and price changes of up to five minutes only and we use this "adjusted" data set for confirmatory estimations.[5] Although we lose a lot of observations, explanatory power sometimes tends to increase.

The statistics of the absolute values of order flow Abs(Q_{jt}) and inventory Abs(I_{it}) are very similar to those observed in Bjønnes and Rime (2001, Table 4, dealer 1), but clearly smaller than in Lyons (1995, Table 2) or Yao (1998, Table 4), which is compatible with the differences in the dealers' sizes.

4. Results

This section presents results in the order of the three hypotheses derived above. They are organized according to different counterparties in foreign exchange trading, starting with the so far best researched interdealer trading in Section 4.1. Section 4.2 examines effects in aggregated customer trading, thus deepening the work of Yao (1998) which has been the first source in this subfield. In Section 4.3 we

[5] We also cut down the data set after a 10, a 15 and a 20 minutes interval. The results do not differ significantly. As a tendency one can recognize that the smaller the time interval, the better the fit of the model.

concentrate on the two major groups in customer business, i.e. commercial and financial business, and their different information effects which have never been separated before in this type of study.

4.1 Interdealer trading: inventory control and information effect

The examination of microstructure effects in foreign exchange interdealer trading was pioneered by Lyons (1995). However, the different trading environment and to some degree also different positioning of traders makes the earlier findings look rather more specific than general as Bjønnes and Rime (2001) show. For the purpose of comparison we have nevertheless repeated Lyons' regressions but do not find any interesting effects. What can still be recognized is a slight "bounce" effect but neither inventory nor information effect – just as expected (see Annex 1).

The picture becomes very different when we turn to the methods suggested by Bjønnes and Rime (2001) for the new environment. One approach to test inventory control is to regress the inventory position in t-1 on the change in inventory from t-1 to period t. The coefficient of interest would be zero if inventory changed randomly. If there were inventory control, however, the expected mean reversion in inventory would be revealed by a negatively signed coefficient. Table 4 gives a "correctly" signed and statistically significant coefficient showing that inventories tend to be reduced in the next trade by 21%. The size of this coefficient indicates a higher risk aversion in holding inventories than for the market maker examined by Bjønnes and Rime (2001) with a parameter size of 11%. However, the holding period is longer, so both effects tend to compensate each other.

Regarding a possible information effect in interbank dealing, we have learned that dealers do not regard this as an issue anymore as the electronic brokerage system provides sufficient liquidity to square incoming trades. The empirical examination is consistent with this view as well as with Bjønnes and Rime's (2001) argument that possible information advantages can be counterbalanced by easily closing unwanted positions (see Annex 1). In another attempt to find out a possible information effect they suggest to re-estimate the Madhavan and Smidt equation for electronically brokered deals but without the insignificant inventory terms. Calculations show that the size of an incoming trade is no statistically significant determinant of the bank's pricing behavior, independent of considering all trades or only incoming spot trades within a 5-minute interval, which is close to the data of Bjønnes and Rime (2001)(see Annex 2).

Although the information effect in the form found by Lyons (1995) does not exist in our data, there is information in the interbank trading deals. As has been suggested by Evans and Lyons (2002), the cumulative interbank order flow is positively related to the exchange rate movement. This can be seen from the cointegration test documented in Table 5 as well as from the graphical presentation in Figure 3. What seems to be trivial from a demand and supply perspective is a challenge for any asset market view. Traditional macro-models of foreign exchange markets consider fundamentals, possibly a risk premium and assume that any news is instantaneously incorporated in prices. Information contained in order flow may be thus seen as a vehicle of time-consuming information flows, either about news or risk perceptions. The case of the order flow view of foreign exchange is thus not self-evident and needs empirical support. Our data fit into the new literature but are remarkable in the respect that they stem from a median bank. A smaller bank does not by definition receive so many and large flows as a market maker. That a median bank can recognize anything at all from incoming orders indicates that orders are widely and quickly disseminated in the market. The foreign exchange market is in this sense an efficient means of distributing "information" and the order flow view gains support from our study.

In summary, interbank trading in foreign exchange seems to be influenced by inventory and information effects as suggested by Bjønnes and Rime (2001) for the electronic brokerage world. Hypothesis 1 is thus supported by our study. Moreover, the order flow view gains further credibility as flows are informative even at a median bank with much less exposure to the markets than the market makers earlier examined, not to mention studies aggregating daily flows for the market. We now turn from the interbank to the customer business.

4.2 Effects in the aggregated customer trading

The individual customer trades of a bank have only been examined by Yao (1998) in the above motivated framework so far. He found somewhat different effects in comparison with the interbank business. Repeating his approach – which is methodologically the same as Lyons' – neither gives an inventory nor information effect in the new environment (see Annex 3). This strengthens the claim by Bjønnes and Rime (2001) that electronic brokerage has changed trading behavior.

However, if we apply the above introduced approach to measure an inventory effect by observing systematic adjustments in inventory, we do find that inventories are basically adjusted in the same way as when considering interbank business alone (see Panel A in Table 6). An instrument to perform this adjustment is outgoing trades. Panel B in Table 6 shows that the choice for an outgoing trade is independent of the inventory size Abs(I_{it-1}), negatively related to the trade size Abs(Q_{jt}) but positively determined by the fact that a customer trade was foregoing.

Testing for the information effect provides a seemingly surprising result as the coefficient is significantly negative, indicating that larger customer orders receive better prices (see Table 7). The explanation is straightforward, however: in contrast to earlier studies, our median bank is characterized by several small-sized orders below one million USD, which were unimportant in other studies. These small orders are handicapped by two effects. First, banks have to cover fixed administrative costs for each deal and, second, small orders are more often given by small customers who can be expected to be less informed. If we consider for the same empirical approach only orders of one million USD and more, the coefficient becomes insignificant (not reported here). The same reason as argued before should be responsible for the fact that the coefficient does not turn significantly positive as our bank mostly deals in the 1 to 10 million USD range where no size-related information effects are to be expected.

Finally, examining the relation between exchange rate development and the cumulative customer order flow of our bank reveals a statistically significant negative coefficient (Table 8). This indicates that not only interbank but also customer orders may be informative although in reverse manner to the exchange rate movement. Our hypothesis 2 is therefore not fully supported. The obvious issue of interest is then whether all customers have the same effect or whether a particular group is more important than another. This is the research question of the following section.

4.3 Customer trading: information effect of different counterparties

This section enters thus far unknown territory as there is no earlier study where customer groups could be differentiated on a deal-by-deal basis. The study by Fan and Lyons (2002) is related in its intention as it differentiates between three customer groups of a large US bank over many years. The relative shortcoming of their data is that deals are aggregated per day, possibly to protect the customer business of the unknown bank. Our data set, by contrast, covers a shorter four-month period for a median bank but it allows us to analyze trading with two different customer groups on an individual deal basis. The customers have been identified as being either commercial customers – essentially firms with some foreign trade business – or financial customers, which are mostly institutional investors such as fund managers or insurance companies.

We repeat the exercises conducted in Section 4.2 for all customers here for two separated customer groups each. The findings are similar for both groups regarding the inventory effect and thus not reported again (see Table 6). Examining the information effect indicates that there is always a negative and statistically significant coefficient for commercial business (see Table 9, Panel A). This does not apply to financial customers. Their coefficient is somewhat smaller and insignificant and when we come close to the Bjønnes and Rime (2001) data set by considering only spot trades with less than 5 minutes transaction time, the coefficient becomes positive and significant, although for a sample of 37 cases only (see Panel B). The findings are thus consistent with the view that the bank possibly treats large trades by financial customers more carefully, i.e. with a wider spread, than commercial customers.

What is interesting, moreover, is the relation between exchange rate development and cumulative order flow. Whereas commercial customers are the group that causes a negative relation in the overall customer relation (see Table 8), financial customer orders are positively related (Table 10). This different relation for both groups can be also easily seen from Figure 4. This finding indicates support for our hypothesis 3.

Furthermore, it fits nicely with the Fan and Lyons (2002) study, which reports that their daily aggregated data of order flows show a shorter-term relation of financial orders with price and only a longer-term relation of commercial orders with price. The latter cannot be observed by our data, so our findings are consistent with the Fan and Lyons (2002) study, although we use a different kind of data set.

5. Conclusions

This study examines all single transactions of a bank in Germany in USD/EUR-trading over a four-month period. The purpose is to learn about the behavior of this bank and about possible differences of the counterparties in the trading process. We complement and extend the rare earlier literature in three respects: first, we examine inventory and information effects for interbank trading in the new environment of electronic brokerage. We confirm the findings of Bjønnes and Rime (2001) that both effects exist, although not in the same way as found by Lyons (1995) and Yao (1998). Second, we newly apply the same approach to customer business. In contrast to Yao (1998) – applying Lyons' methodology – we cannot detect a difference regarding the inventory effect. What is surprising from our point of view is, however, the fact that a slight information effect seems to exist even at the low business frequency and low trading volume of a median bank. This motivates us, thirdly, to search for the first time in this literature for possible differences in customer groups. We find, indeed, that financial customer orders are positively related to exchange rate movements whereas commercial customer orders are not.

Overall, the order flow approach as pioneered by Lyons (1995) proves to be a fruitful avenue (see early Goodhart, 1988). It is comforting that the advances made by Bjønnes and Rime (2001) hold at a different time and for a different type of bank, too. It is encouraging, moreover, that the findings for the interbank business can be mostly extended to customer business. Finally, the microstructure approach's supposition that heterogeneity matters is confirmed by the different roles played by financial and commercial customers.

In particular the last finding on the differences in customer groups motivates us to speculate on possible links with the macro exchange rate literature. Our findings strengthen the hypothesis that the theoretically and empirically hardly explainable shorter-term exchange rate movements are connected to the behavior of financial market participants. Moreover, the analysis of order flows may provide a useful approach to studying the behavior of this group in particular and thus to learning about the true dynamic forces in the foreign exchange market. As these results point in the same direction as the study of Fan and Lyons (2002), but by applying a different approach, further research along these lines may promise high rewards.

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Table 1 Daily spot USD/EUR (USD/DEM) trading volumes, average number of trades per day and customer share for several studies

Study	Lyons (1995)	Yao (1998)	Bjønnes/Rime (2001), Dealer 1	This paper	BIS (2002) per bank
Data period	08/03/92 – 08/07/92, 5 trading days	11/01/95 – 12/08/95, 25 trading days	03/02/98 – 03/06/98, 5 trading days	07/11/01 – 11/09/01, 87 trading days	April 2001
Volume per day (mill. USD)	1,200	1,529	443	39 (52)*	50 - 150 (mean)
Trades per day	267	181	198	40 (51)*	-
Volume per trade (mill. USD)	4.5	8.4	2.2	1.0 (1.0)*	-
Customer share	0%	13.9%	3.3%	22.5% (39.2%)*	25.0% GER
					32.5% world

*The values in parentheses refer to the data set including outright-forward transactions.

Figure 1 Participants and trade channels in the FX market

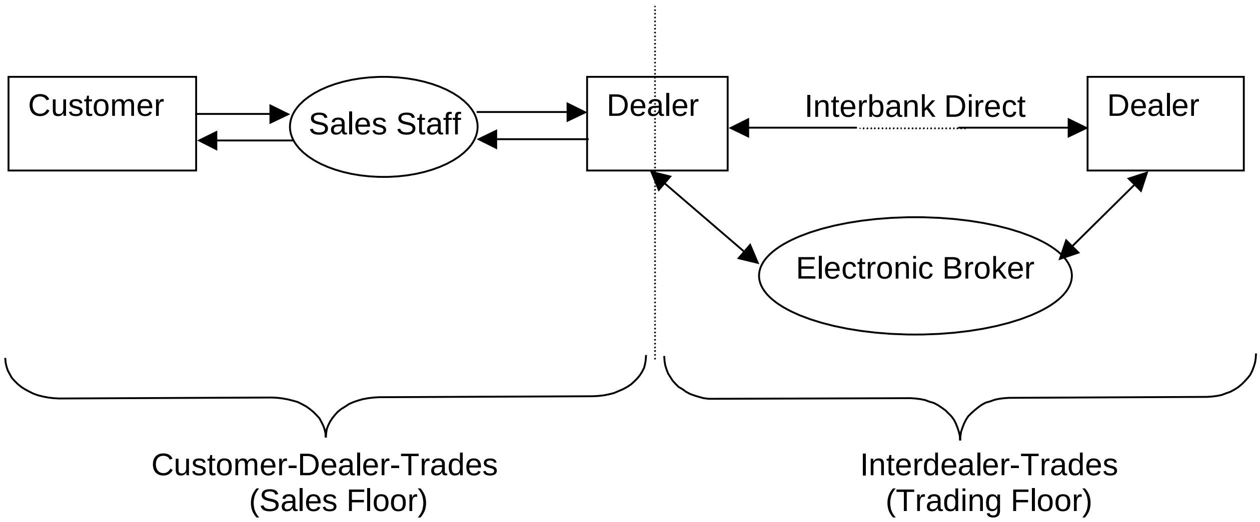
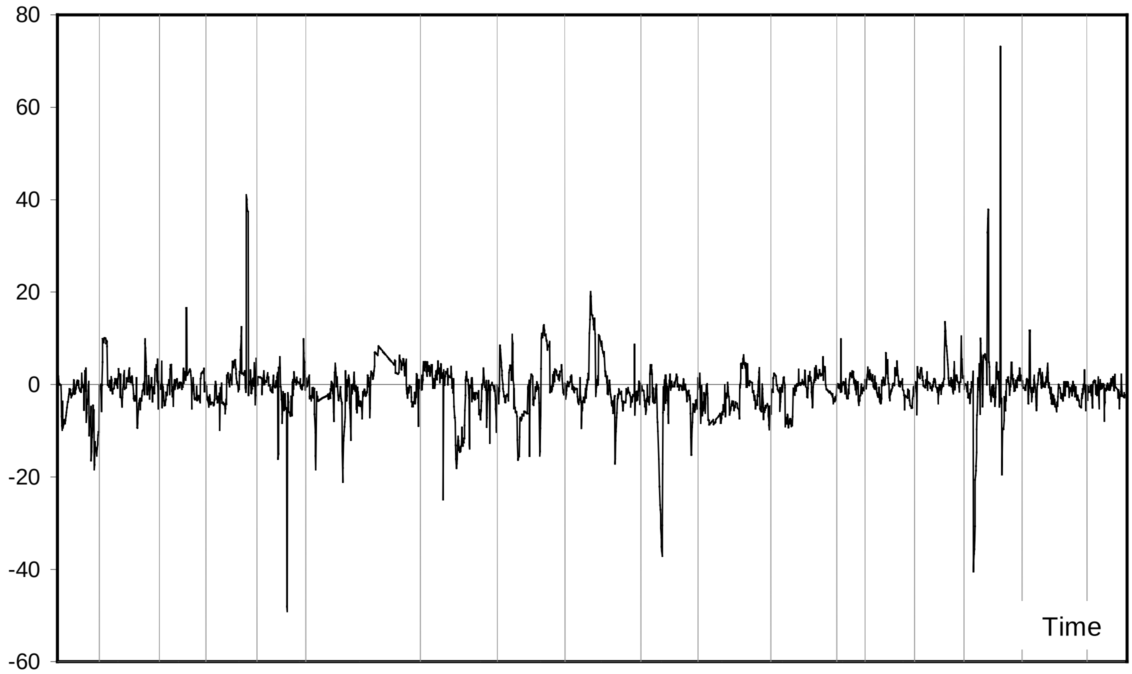


Figure 2 Overall inventory position (in EUR millions)



The graphic shows the dealer's overall inventory position in millions of EUR at the time of each trade over the whole 87-day period. Vertical lines indicate the end of each week.

Table 2 Types of trades

A Spot and outright forward trades

	Interbank	Customers	Preferred commercial business	Financial business	Commercial business	Total
No. of trades	1,919	2,491	801	171	1,519	4,410
% total	43.51%	56.49%	18.16%	3.88%	34.44%	100.00 %
Volume	2,726	1,755	146	405	1,204	4,481
% total	60.83%	39.17%	3.25%	9.04%	26.87%	100.00 %
Average size	1.42	0.70	0.18	2.37	0.79	
Median size	1.00	0.08	0.05	0.76	0.08	
St. dev.	1.42	3.50	0.74	4.92	4.08	
Min.	0.00	0.00	0.00	0.02	0.0	
Max.	16.42	76.43	7.29	41.68	76.43	

B Spot trades only

	Interbank	Customers	Preferred commercial business	Financial business	Commercial business	Total
No. of trades	1,805	1,703	545	111	1,047	3,508
% total	51.45%	48.55%	15.54%	3.16%	29.85%	100.00 %
Volume	2,639	767	70	179	518	3,406
% total	77.49%	22.51%	2.04%	5.25%	15.22%	100.00 %
Average size	1.46	0.45	0.13	1.61	0.49	
Median size	1.00	0.06	0.05	0.43	0.07	
St. dev.	1.43	2.80	0.49	4.40	3.22	
Min.	0.00	0.00	0.00	0.02	0.00	
Max.	16.42	76.32	7.06	41.68	76.32	

The table shows the trading activity of the three different types of counterparties over the sample period, i.e. interbank, preferred commercial, financial and commercial business respectively. All volume and trade size statistics are in EUR millions. Panel A contains spot as well as outright forward trades, whereas Panel B contains spot trades only.

Table 3 Descriptive statistics on regression variables
A Spot and outright forward trades

	Δp_{it}	Abs(Δp_{it})	Q_{jt}	Abs(Q_{jt})	I_{it}	Abs(I_{it})	Δt
Mean	-0.05	10.71	0.02	1.18	-0.92	3.47	0:12:56
Median	0.00	6.00	0.05	0.61	-0.66	2.17	0:03:47
Maximum	99.70	99.70	76.43	76.43	73.12	73.12	3:47:49
Minimum	-91.00	0.00	-76.32	0.00	-49.10	0.00	0:00:00
Std. Dev.	17.30	13.58	3.32	3.10	5.84	4.79	0:20:31
Observations	3449	3449	3449	3449	3449	3449	3449

B Spot trades only

	Δp_{it}	Abs(Δp_{it})	Q_{jt}	Abs(Q_{jt})	I_{it}	Abs(I_{it})	Δt
Mean	-0.09	10.95	-0.06	1.11	-0.87	3.30	0:15:44
Median	0.00	7.00	0.04	1.00	-0.60	1.97	0:05:55
Maximum	91.00	91.00	16.46	76.32	73.12	73.12	3:47:49
Minimum	-91.00	0.00	-76.32	0.00	-49.10	0.00	0:00:00
Std. Dev.	17.19	13.25	2.68	2.44	5.85	4.90	0:23:02
Observations	2808	2808	2808	2808	2808	2808	2808

Δp_{it} is the change in price between two successive trades in pips. Abs(Δp_{it}) is the absolute value of this change. Q_{jt} is the quantity transacted in millions of EUR from the perspective of the dealer's counterparty, positive for a purchase and negative for a sale. Abs(Q_{jt}) is the absolute value of Q_{jt} . I_{it} is the inventory at the end of period t, and Abs(I_{it}) is its absolute value. Δt is the inter-transaction time between two successive trades. Panel A contains spot as well as outright forward trades whereas Panel B only shows spot trades.

Table 4 Interbank trades: inventory control
Mean reversion in dealer's inventory, results for $I_{it} - I_{it-1} = \alpha + \beta I_{it-1} + \varepsilon_t$

EUR/USD	Interbank
β	-0.21
Test statistic	***(-10.52)
Implied half-life (mean)	0:38:58
Implied half-life (median)	0:11:24
Observation	1875

The dependent variable is the change in dealer's inventory between two successive interbank trades. The explanatory variable is lagged inventory. The first row reports the mean reversion coefficient β. The second row shows the test statistic from a Augumented Dickey-Fuller unit root test. "***" indicate that the null hypothesis of a unit root is rejected at the 1%-significance level. The implied half-life is calculated as mean or median inter-transaction time multiplied with ln(2)/ln(1+β) (see Lyons 1998, p.109). The regression contains spot and outright forward interbank trades. Results for β and the significance remain stable if we use spot trades only.

Table 5 Test of cointegration between price and cumulative interbank order flow

EUR/USD	Interbank
Constant	0.888
Cumulative flow (cum Q_{jt})	0.104
Trend	0.017
ADF-test	**(-1.99)
PP-test	**(-2.26)
Observations	1753

The parameters are estimated using ordinary least square. Since the null hypotheses of a unit root is not rejected when testing for the variables, t-values for each coefficient are not reported here, because they are unreliable as they depend on the sample's size. The dependent variable is price, the exchange rate respectively. Cumulative order flow is created using the direction and size of all executed trades, incoming and outgoing. ADF-test is a standard augmented Dickey-Fuller test on the regression residuals. PP-test is a Phillips-Perron test (Perron, 1988) on the regression residuals. The Phillips-Perron test incorporates the Newey and West (1987) modification procedure. The number of lags included is calculated from the sample size (Newey-West automatic truncation lag selection). The tests do not include a constant since a constant is included in the original regression equation. "***", "**" and "*" indicate significance of the whole model at the 1%, 5% and 10% level respectively. The flow and trend coefficients are multiplied by 10^3.

Figure 3 Price movements and cumulative interbank order flow

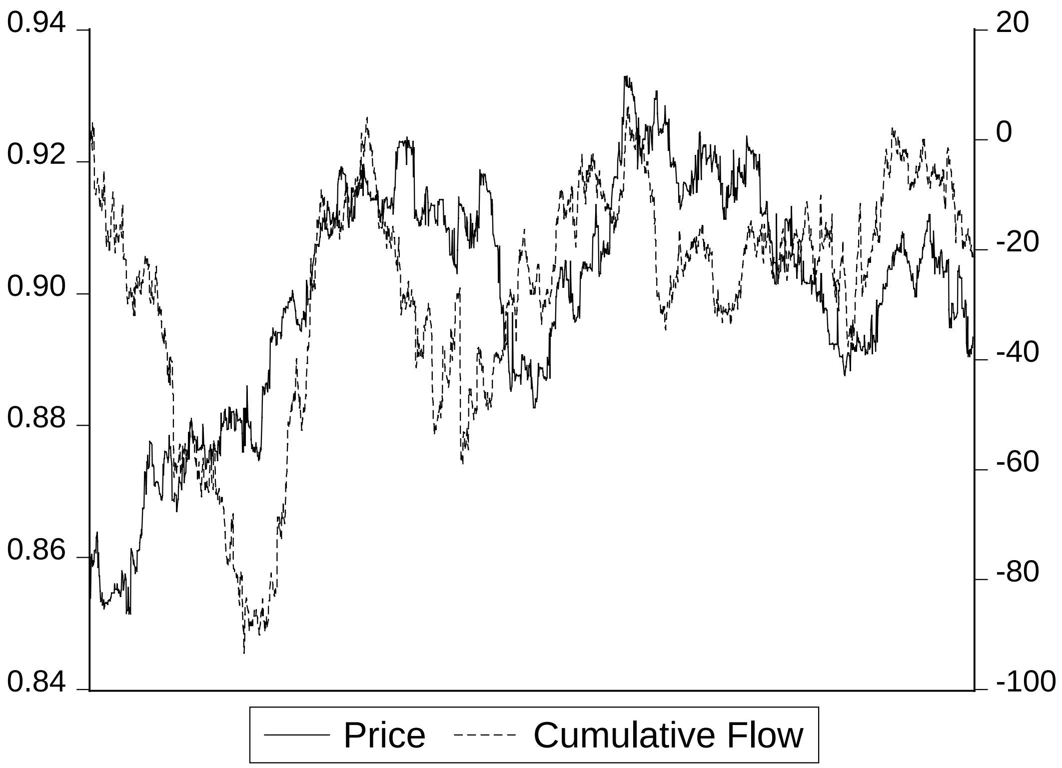


Table 6 Customer trades: inventory control

A Mean reversion in dealer's customer inventories, results for $I_{it} - I_{it-1} = \alpha + \beta I_{it-1} + \varepsilon_t$

EUR/USD	All customers	Commercial customers	Financial customers
β	-0.33	-0.35	-0.47
Test statistic	***(-8.22)	***(-7.99)	***(-4.86)
Implied half-life (mean)	0:22:40	0:20:46	0:14:18
Implied half-life (median)	0:06:38	0:06:05	0:04:11
Observation	1662	1491	170

The dependent variable is the change in dealer's inventory between two successive customer trades, commercial or financial customers respectively. The explanatory variable is lagged inventory. The first row reports the mean reversion coefficient β. The second row shows the test statistic from a Augumented Dickey-Fuller unit root test. "***" indicate that the null hypothesis of a unit root is rejected at the 1%-significance level. The implied half-life is calculated as mean or median inter-transaction time multiplied with $\ln(2)/\ln(1+\beta)$ (see Lyons 1998, p.109). The regression contains spot and outright forward customer trades. Results for β and the significance remain stable if we use spot trades only.

B Probit-regression of choice of incoming/outgoing interbank trade

Dependent Variable: Trade-choice		
Included observations: 3533		
Variable	Coefficient	t-Statistic
Abs(Q_{jt})	**-0.006	-2.24
Foregoing customer trade	***0.192	11.19
Abs(I_{it-1})	0.001	0.62
Constant	***0.267	17.05
Trade-choice(-1)	***0.203	12.30
adjusted R^2	0.09	
D-W test	2.01	

Probit regression of incoming/outgoing trade decision in interbank trading, i.e. EBS. Incoming trades (submitting limit orders) are coded 0, while outgoing trades (hitting other dealer's limit orders) are coded 1. The dummy "Foregoing customer trade" equals 1 if previous trade was with a customer.

Table 7 Customer trades: information effect

A All trades

Dependent Variable: Δp_{it}		
Included observations: 1650		
Variable	Coefficient	t-Statistic
Const.	***0.97	2.77
Q_{jt}	***-0.30	-4.14
D_t	***9.35	19.10
D_{t-1}	***-6.72	-14.59
adjusted R^2	0.25	
D-W test	2.26	

B Transaction time less than 5 minutes

Dependent Variable: Δp_{it}		
Included observations: 958		
Variable	Coefficient	t-Statistic
Const.	***0.95	2.59
Q_{jt}	***-0.19	-3.29
D_t	***5.89	9.90
D_{t-1}	***-4.68	-7.96
adjusted R^2	0.21	
D-W test	2.06	

The dependent variable is Δp_{it}, the change in price between two successive trades. In Panel B Δp_{it} is the change in price between trades within a maximum time span of five minutes. Q_{jt} is customer order flow measured in millions, positive for a purchase and negative for a sale of the customer. D_t is an indicator variable picking up the direction of the trade, positive for purchases (at the ask) and negative for sales (at the bid). Estimation uses GMM and variable Newey-West correction. t-values are reported in the third column, and "***", "**" and "*" indicate significance at the 1%, 5% and 10%-level respectively.

Table 8 Test of cointegration between price and cumulative customer order flow

	Customer
Constant	0.883
Cumulative flow	-0.258
Trend	0.014
ADF-test	***(-2.85)
PP-test	***(-3.55)
Observations	1663

The parameters are estimated using ordinary least square. Since the null hypotheses of a unit root is not rejected when testing for the variables, t-values for each coefficient are not reported here, because they are unreliable as they depend on the sample's size. The dependent variable is price, the exchange rate respectively. Cumulative customer order flow is created by using the direction and size of all executed customer trades. ADF-test is a standard Augmented Dickey-Fuller test on the regression residuals. PP-test is a Phillips-Perron test on the regression residuals. The Phillips-Perron test incorporates the Newey and West modification procedure. The number of lags included is calculated automatically from the sample size. The tests do not include a constant since a constant is already included in the original regression equation. "***" indicate significance at the 1% significance level. The flow and trend coefficients are multiplied by 10^3.

Table 9 Information effect in customer trades: commercial vs. financial business
A All spot and forward trades

Dependent variable: Δp_{it}				
Commercial business Included observations: 1480			Financial business Included observations: 169	
Variable	Coefficient	t-Statistics	Coefficient	t-Statistics
Constant	**0.78	2.11	-0.87	-0.70
Customer order flow Q_{jt}	***-0.29	-3.92	-0.19	-0.97
Direction D_t	***10.02	18.55	***4.44	3.24
Direction lagged D_{t-1}	***-6.76	-13.25	0.19	0.15
adjusted R^2	0.28		0.08	
D-W test	2.20		1.93	

B Transaction time less than 5 minutes (spot trades only)

Dependent variable: Δp_{it}				
Commercial business Included observations: 503			Financial business Included observations: 37	
Variable	Coefficient	t-Statistics	Coefficient	t-Statistics
Constant	0.53	0.79	**-5.05	-2.16
Customer order flowQ_{jt}	***-0.25	-4.78	**0.17	2.69
Direction D_t	***4.60	7.33	-0.58	-0.25
Direction lagged D_{t-1}	***-3.86	-5.32	-0.63	-0.35
adjusted R^2	0.22		0.10	
D-W test	1.48		3.04	

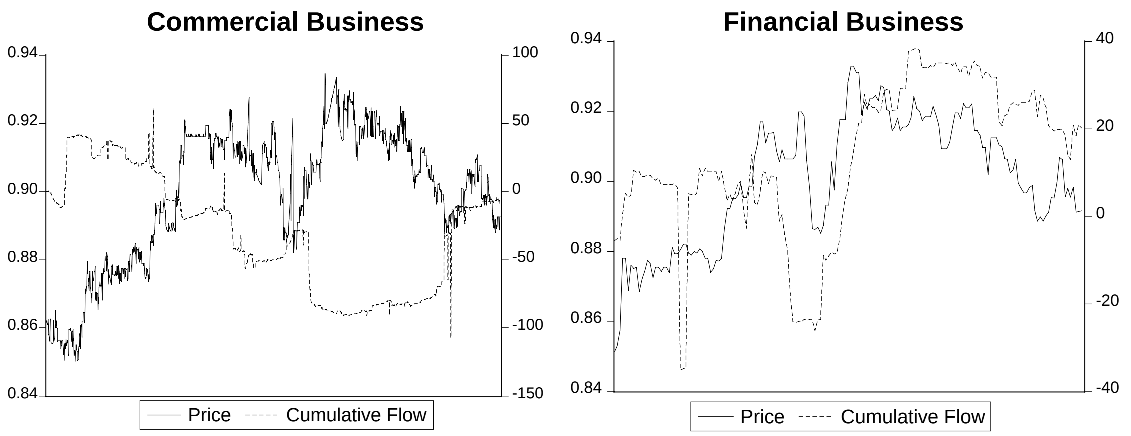
The dependent variable is Δp_{it}, the change in price between two successive trades. In Panel B Δp_{it} is the change in price between trades within a maximum time span of five minutes. Q_{jt} is customer order flow measured in millions, i.e. commercial business and financial business respectively, positive for a purchase and negative for a sale of the customer. D_t is an indicator variable picking up the direction of the trade, positive for purchases (at the ask) and negative for sales (at the bid). Estimation uses GMM and variable Newey-West correction. t-values are reported in the column to the right of the coefficients, and "***", "**" and "*" indicate significance at the 1%, 5% and 10%-level respectively.

Table 10 Test of cointegration between price and cumulative customer order flow: commercial vs. financial business

	Commercial business	Financial business
Constant	0.884	0.884
Cumulative flow	-0.291	0.152
Trend	0.008	0.167
ADF-test	***(-3.02)	**(-2.31)
PP-test	***(-3.77)	**(-2.45)
Observations	1492	171

The parameters are estimated using ordinary least square. Since the null hypotheses of a unit root is not rejected when testing for the variables, t-values for each coefficient are not reported here, because they are unreliable as they depend on the sample's size. The dependent variable is price, the exchange rate respectively. Cumulative order flow is created by using the direction and size of all executed trades, commercial customer trades and financial customer trades respectively. ADF-test is a standard Augmented Dickey-Fuller test on the regression residuals. PP-test is a Phillips-Perron test on the regression residuals. The Phillips-Perron test incorporates the Newey and West modification procedure. The number of lags included is calculated automatically from the sample size. The tests do not include a constant since a constant is already included in the original regression equation. "***" and "**" indicate significance at the 1% and 5% significance level respectively. The flow and trend coefficients are multiplied by 10^3.

Figure 4 Price movements and cumulative customer order flow: commercial vs. financial customer order flow



Annex 1 Lyons' baseline model for interbank trades

A All spot and forward transactions

Dependent Variable: Δp_{it}
Included observations: 1802

Variable	Coefficient	t-Statistic
Const.	***-2.39	-6.17
Q_{jt} (+)	-0.25	-0.96
I_{it} (-)	0.05	0.62
I_{it-1} (+)	-0.12	-1.30
D_t (+)	***3.06	5.20
D_{t-1} (-)	-0.62	-1.55
adjusted R^2	0.00	
D-W test	2.12	

B All spot and forward transactions within 5 minutes

Dependent Variable: Δp_{it}
Included observations: 899

Variable	Coefficient	t-Statistic
Const.	***-1.12	-2.64
Q_{jt} (+)	0.36	1.44
I_{it} (-)	0.14	1.53
I_{it-1} (+)	**-0.23	-2.38
D_t (+)	***2.73	4.43
D_{t-1} (-)	**-0.93	-2.11
adjusted R^2	0.01	
D-W test	2.11	

C All incoming spot transactions

Dependent Variable: Δp_{it}
Included observations: 1087

Variable	Coefficient	t-Statistic
Const.	***-2.66	-5.45
Q_{jt} (+)	0.52	1.51
I_{it} (-)	-0.08	-0.61
I_{it-1} (+)	0.04	0.34
D_t (+)	***1.99	2.85
D_{t-1} (-)	***-1.83	-3.73
adjusted R^2	0.01	
D-W test	2.12	

D All incoming spot transactions within 5 minutes

Dependent Variable: Δp_{it}
Included observations: 508

Variable	Coefficient	t-Statistic
Const.	***-1.38	-2.84
Q_{jt} (+)	0.43	1.33
I_{it} (-)	0.26	1.19
I_{it-1} (+)	-0.26	-1.21
D_t (+)	***2.70	3.61
D_{t-1} (-)	***-1.21	-2.23
adjusted R^2	0.03	
D-W test	2.91	

The dependent variable is Δp_{it}, the change in price between two successive trades. In Panel B and D Δp_{it} is the change in price between two trades within a maximum time span of five minutes. In Panel C and D we use incoming spot trades only. Q_{jt} is order flow measured in millions, positive for a purchase from another dealer, and negative for a sale. I_{it} is inventory at the end of period t. D_t is an indicator variable picking up the direction of the trade, positive for purchases (at the ask) from the other dealer and negative for sales (at the bid). The "+" and "-" in parentheses in the first column indicate the expected sign of the coefficient (see Lyons 1995, p.328). Estimation uses GMM and variable Newey-West correction. t-values in the third column, and "***", "**" and "*" indicate significance at the 1%, 5% and 10%-level respectively.

Annex 2 Interbank trading: information effect

A All spot and forward transactions

Dependent Variable: Δp_{it}		
Included observations: 1802		
Variable	Coefficient	t-Statistic
Const.	***-2.30	-6.10
Q_{jt}	-0.33	-1.30
D_t	***3.04	5.18
D_{t-1}	-0.58	-1.46
adjusted R^2	0.00	
D-W test	2.12	

B All spot and forward transactions within 5 minutes

Dependent Variable: Δp_{it}		
Included observations: 899		
Variable	Coefficient	t-Statistic
Const.	***-0.98	-2.42
Q_{jt}	0.18	0.79
D_t	***2.71	4.39
D_{t-1}	**-0.85	-1.94
adjusted R^2	0.00	
D-W test	2.11	

C All incoming spot transactions

Dependent Variable: Δp_{it}		
Included observations: 1087		
Variable	Coefficient	t-Statistic
Const.	***-2.60	-5.58
Q_{jt}	*0.58	1.69
D_t	***1.97	2.81
D_{t-1}	***-1.81	-3.70
adjusted R^2	0.01	
D-W test	2.12	

D All incoming spot transactions within 5 minutes

Dependent Variable: Δp_{it}		
Included observations: 508		
Variable	Coefficient	t-Statistic
Const.	***-1.37	-2.85
Q_{jt}	0.19	0.65
D_t	***2.70	3.50
D_{t-1}	**-1.16	-2.11
adjusted R^2	0.03	
D-W test	2.91	

The dependent variable is Δp_{it}, the change in price between two successive trades. In Panel B and D Δp_{it} is the change in price between two trades within a maximum time span of five minutes. In Panel C and D we use incoming spot trades only. Q_{jt} is order flow measured in millions, positive for a purchase from another dealer, and negative for a sale. D_t is an indicator variable picking up the direction of the trade, positive for purchases (at the ask) from the other dealer and negative for sales (at the bid). Estimation uses GMM and variable Newey-West correction. t-values in the third column, and "***", "**" and "*" indicate significance at the 1%, 5% and 10%-level respectively.

Annex 3 Lyons' baseline model for customer trades

A All spot and forward transactions

Dependent Variable: Δp_{it}
Included observations: 1650

Variable	Coefficient	t-Statistic
Const.	**0.87	2.51
Q_{jt} (+)	-0.10	-0.58
I_{it} (-)	0.16	0.95
I_{it-1} (+)	-0.27	-1.62
D_t (+)	***9.48	19.32
D_{t-1} (-)	***-6.76	-14.63
adjusted R^2	0.26	
D-W test	2.26	

B All spot and forward transactions within 5 minutes

Dependent Variable: Δp_{it}
Included observations: 958

Variable	Coefficient	t-Statistic
Const.	***0.96	2.66
Q_{jt} (+)	0.14	0.83
I_{it} (-)	*0.32	1.92
I_{it-1} (+)	**-0.39	-2.25
D_t (+)	***5.85	9.57
D_{t-1} (-)	***-4.63	-7.90
adjusted R^2	0.22	
D-W test	2.07	

C All incoming spot transactions

Dependent Variable: Δp_{it}
Included observations: 1131

Variable	Coefficient	t-Statistic
Const.	**1.08	2.02
Q_{jt} (+)	**-0.39	-2.24
I_{it} (-)	-0.15	-1.12
I_{it-1} (+)	0.03	0.24
D_t (+)	***10.08	15.58
D_{t-1} (-)	***-7.16	-13.27
adjusted R^2	0.24	
D-W test	2.24	

D All incoming spot transactions within 5 minutes

Dependent Variable: Δp_{it}
Included observations: 540

Variable	Coefficient	t-Statistic
Const.	0.11	0.18
Q_{jt} (+)	-0.39	-1.24
I_{it} (-)	-0.19	-0.64
I_{it-1} (+)	0.18	0.56
D_t (+)	***4.71	8.25
D_{t-1} (-)	***-3.82	-5.48
adjusted R^2	0.21	
D-W test	1.44	

Estimated by GMM and variable Newey-West correction. t-values and probabilities in the second and third row, and "***", "**" and "*" indicate significance at the 1%, 5% and 10%-level respectively. The dependent variable is Δp_{it}, and is the change in price between two incoming trades. In Panel B Δp_{it} is the change in price between two incoming trades within a time span of five minutes and below. Q_{jt} is signed incoming trade measured in millions, positive for a purchase from dealer j, and negative for a sale. I_{it} is inventory at the end of period t. D_t is an indicator variable picking up the direction of the trade, positive for purchases (at the ask) from dealer j and negative for sales (at the bid). We use all incoming trades. The "+" and "-" in parentheses in the first row indicate the expected sign of the coefficient.