Spread Components and Dealer Profits in the Interbank Foreign Exchange Market

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Abstract

This paper studies dealer trading profits, spread components and implications for market making costs for a representative dealer in the foreign exchange market. Though accounting for only about 14% of total trade volume, customer trades generate about 75% of the dealer's gross trading profits. Inter-dealer trades have negligible profit implications for the dealer who maintains his function as a liquidity provider by taking inter-dealer trades and subsequently offsetting the trades at other dealers' quotes. The FX dealer engages in very limited speculation (less than 5% of total volume) and seems to profit from his brief informational advantage upon observing order flows. This contradicts with the popular conjecture that attributes high inter-dealer volume and short term market volatility to FX dealers' excessive speculation .

Dealer trading profits are analyzed from another perspective by decomposing the spread components as in Glosten and Harris (1988). This study extends the existing approach to account for lagged quote adjustments to order flows facilitated by the low market transparency of FX markets. The FX dealer is found to bear only about one-third of the adverse selection costs as a result of risk sharing among market participants arising from the existing FX market structure. Moreover, inventory control costs are estimated to account for at least 70% of the profits that the dealer would have made in a naive model where a dealer collects half of the quoted spread on each trade.

1. Introduction

In a financial market, market makers play a pivotal role in servicing customers and providing liquidity. Their market making behavior in response to asymmetric information and inventory shocks has been the research focus of market microstructure literature. However, few studies examine directly market maker profits that are likely to be an important element in shaping a dealer's trading strategy. In this paper, I study the trading profits of a representative dealer in the world's most active financial market, the interbank foreign exchange (FX) market.

In this study, I emphasize two questions. First, what are the major sources of a FX dealer's profits? In particular, how much do customer business, interbank dealing, and speculative positioning contribute to the dealer's overall trading profits? This question, especially the relative importance of speculative trading activities and profits, is important because of the controversy surrounding the role of FX dealers as major speculators in light of the high inter-dealer volume and short-term market volatility[1]. Second, from a different perspective, how does a dealer's market making behavior impact his trading profits? Specifically, how much is a dealer's loss from trading against informed traders? And what are the costs, in terms of foregone profits, of inventory control?

When asked about trading profits, most dealers in various markets would attribute their profits to positioning, which is speculative in nature. However, academic studies in the literature suggest otherwise. Hasbrouck and Sofianos (1993) analyze the NYSE specialist trading profits and find that overall gross trading profits are not significantly different from zero. By further decomposing the total profits by time horizons, they find that short and median term components (up to 100 trades) are positive even after adjusting for bid-ask spread. On the other hand, the

[1] The concern about short-term speculation and its effect on market volatility has prompted some economists to propose securities transaction tax (STTs) to drive short-term speculators out of the market. The STT tax is sometimes called "Tobin Tax" since James Tobin was one of the first to endorse it. See Tobin (1978).

long-term component of trading profits is indistinguishable from zero with a negative median profit. This leads them to conclude that "NYSE specialists are good short-term traders but undistinguished long-term speculators." In a study of dealer profits on the London Stock Exchange, Hansch and Neuberger (1994) use a different approach to decompose trading profits into order-matching and position-taking. They develop a synthetic dealing strategy that hinges upon a dealer position limit. Trades taken by a dealer that result in positions within the trade limit are considered order-matching, while those trades that breach such a trade limit are consider position-taking. They find that order-matching trades are consistently profitable whereas position-taking trades lose money on average.[2] In a study of futures scalpers, Silber (1984) finds that scalper's earnings stem from liquidity-providing services and that any trades held open for longer than 3 minutes (indicating speculation) produce losses on average.

This paper examines FX dealer profits by studying the complete trade records of a representative dealer. The completeness of the dataset, such as information regarding counterparty identity, allows for identifying different types of trades, such as customer versus inter-dealer trades. One major finding is that customer trades, though accounting for only 14% of total trade volume, represent over 75% of the dealer's total trading profits. This is consistent with a market survey of over forty trading desks around the world by Braas and Bralver (1990) suggesting that these desks generate between 60 and 150 percent (in which case positioning loses money) of their total profits from customer business. While speculative trading profits by the dealer in this study are positive indicating the dealer's brief informational advantage, their relatively small significance is in line with results in the literature.

[2] However they also find that the more such money-losing positioning trades dealers make, the higher his overall trading profits are. They propose two explanations for this. First, such trades carry information that is valuable to

I also examine the magnitude of FX dealer speculation and shed light on the well publicized notion that FX dealers engage in excessive speculation (see Frankel and Froot, 1990; Krause, 1991; among others) because of the high inter-dealer trade volume. According to recent Bank of International Settlements (1993, 1996) surveys, inter-dealer trades account for 85-90% of total trading volume for the market as a whole, whereas customer-dealer trades account for only 10-15%. However, identifying FX dealer speculative trades is difficult because they take place intra-day as almost all FX dealers close their trading days flat and hence have the same time horizon as inventory control trades. Lyons (1995) proposes a inventory decomposition method based on projections onto a dealer's information set to disentangle the FX dealer's speculative inventory component. Unfortunately, such an approach can not address the trade quantity of FX dealer speculation.

In this study, the FX dealer's accumulating outgoing trades at other dealers' quotes that are not followed by incoming orders are treated as speculative trades. Such trades are found to account for less than 5% of the dealer's total volume and provide little evidence for excessive speculation at the dealer level. My analysis lends support to the alternative view of "hot-potato trading" as a explanation for the high inter-dealer trade volume[3].

Dealer profits can also be studied from a different perspective by examining two inherent market making costs associated with adverse selection and inventory control. In a naive market making model, order flows arrive randomly, and market makers set quotes which bracket the expected value of the security. As a result, his profit from each trade equals one half of the bid-ask

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dealers and can be exploited in subsequent trades. Second, such trades breed customer loyalty which will deliver more profitable trades in the future.

[3] The major alternative view is that the large inter-dealer trade volume results from the decentralization of the FX interbank market (e.g. Burnham, 1991). An idiosyncratic trade shock at a dealer would set off a string of inter-dealer

spread. However, Garman (1976) shows that such a passive strategy results in an infinite inventory accumulation over a long period of time, and that a dealer has to adopt an inventory strategy to prevent accumulation. Two major inventory control strategies are quote shading (lower/raise both bid and ask prices when the dealer is long /short relative to his desired inventory level) in hope of eliciting offsetting order flows (see Amihud and Mendelson, 1980; Ho and Stoll, 1983; among others) and outgoing active trades at other dealers' quotes in a decentralized competitive dealership market, such as NASDAQ and the interbank FX market (see Yao 1997). Both of these two inventory control strategies represent a cost to the dealer, in the form of foregone profits compared to the naive model. Quote shading results in an effective spread that is much tighter than the quoted spread. Active trading implies that a dealer, just like a customer, would have to *pay* the spread to trade. In the meantime, even in a world without inventory costs, a dealer loses money to traders with private information due to adverse selection (Bagehot,1971 and Glosten and Milgrom,1985), and therefore has to set spreads to protect himself from such transactions. In Glosten and Milgrom's model, the bid and ask quotes are "regret-free" in the sense that they are the expected value of the security given the current trade.

In reality, a dealer confronts both adverse selection and inventory control problems. As a result, both problems represent a drain on the dealer's profits that would have been earned in a naive model. The market making costs through the two different channels can be estimated by decomposing trade price impacts into these two effects (see Madhavan and Smidt, 1991 among others). Neuberger (1992) uses this approach to study directly trading profits of market makers on the London Stock Exchange. However, his results are quite disappointing and counter-intuitive. (For example, he finds that inventory control *increases* profits.) The poor results reflect the

trades until desired inventory positions are reached. This is the so called "hot-potato" trading. A computer generally stringent and unrealistic assumptions of most microstructure models of price impacts, as well as his simplifying assumption which ignores inter-dealer competition in a decentralized market structure. Glosten and Harris (1998) use a slightly different approach of spread decomposition with a particular focus on the adverse selection component. Similar approaches have been applied to options markets (Choi, Salandro and Shastri, 1988) and London Stock Exchange (Neuberger and Roell, 1991).

This study adopts Glosten and Harris' (1998) spread decomposition approach and extends it in two important ways. First, since the dealer's daily actual profits are given, it is shown that an lower bound of inventory control costs can be calculated. Moreover, if estimates of speculative profits are used, the inventory costs (not just a lower bound) can be estimated. Second, the model extends the Glosten and Harris framework to account for the FX dealer's lagged quote adjustments to order flows facilitated by the unique low market transparency (see Yao (1997) for a dynamic analysis of price impacts). The result is a risk-sharing process in the inter-dealer market in which a dealer can quote prices far lower than suggested by the full information impact of a trade, and in turn bears only part of the adverse-selection costs. Specifically, the quoted adverse-selection component is estimated at only about one third of the full permanent price impacts. Of the total spread for a $9.3 million trade (the average trade size in my sample), the adverse selection component accounts for only about 17%. Inventory control activities cost the dealer about 70% of the total profits that he would have earned in a naive model.

The study is organized as follows: Section 2 describes various dealer activities in the foreign exchange market. Section 3 describes the data and reports some descriptive statistics. Section 4 discusses the methodology of profit decomposition, and presents empirical evidence on

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simulation of the interbank FX market in Flood (1994) supports this alternative view.

dealer trades and profits based on my unique dataset. Section 5 presents a simple model of dealer market-making behavior with lagged quote adjustment to order flows, and estimates dealer costs due to asymmetric information and inventory control. Finally section 6 concludes.

2. Dealer Activities in the Interbank Foreign Exchange Market

Foreign exchange dealers play a pivotal role in the interbank market. Their major activities usually fall into three categories: servicing customers, providing liquidity through inter-dealer trades, and speculating. For a particular dealer, the relative importance of each type of activities, in terms of contribution to his revenue, depends on several factors such as a dealer's customer base and his trading style. Among these factors, a dealer's customer base plays an important role since customer business represents a major source of asymmetric information as well as the most consistent source of revenue for a FX dealer.[4]

2.1 Customer Business

The Bank of International Settlements (BIS 1993, 1996) estimates that customer-dealer trades account for about 15% of total turnover in the interbank FX market. Wholesale customers of dealer services in the interbank FX markets include industrial corporations, non-dealer financial institutions (such as mutual funds) and professional speculators. Because they lack access to FX broker markets, customers must go through banks' sales staff (also called "corporate traders") to trade with dealers. Customer business, built through a capable sales staff, is important to dealers in two ways. First, a dealer with customer order flows usually has a brief informational advantage over other dealers because of his knowledge of such order flows. Unlike the NYSE, the CME and many other financial markets, there is no consolidated tape or centralized public record of the prices and quantities of all FX transactions. Thus, the FX market has low transparency.

Moreover, through the sales staff and via trade negotiations, the dealer learns valuable information beyond the order size and final trade price, such as the customer identity and the motivation behind the trade. Although it is rare that customers have private information regarding the fundamental value of a currency, such order flows may reflect different expectations based on a common public information set (e.g. Harris and Raviv, 1993), or, even if liquidity-based, may still have price impacts as long as the market demand is not perfectly elastic.

Second, and related to low FX market transparency, dealers are usually able to quote a wider spread to customers than in inter-dealer trades. Such price mark-ups represent a reliable source of rents for dealers with customer order flows. In their survey, Braas and Bralver (1990) shows that major FX dealing banks' trading profits are positively related to their respective customer market shares.

2.2 Inter-dealer Trades

FX dealers rely on the liquidity in the inter-dealer markets to lay off inventory shocks originating from their proprietary order flows. Inter-dealer trades take place through two major channels, the interbank direct and brokered markets. The interbank direct market links FX dealers through the Reuters 2000-1 computerized dealing system. Such a system is based on reciprocity among dealers; a dealer provides quotes on demand, and expects others to do the same as well. Major dealers often maintain $10 million relationship among themselves, and can

[4] Lyons (1995) depicts the behavior of a FX dealer without any customer business.

transact very large amount within seconds. In contrast, brokered markets, both voice-brokered and electronic matching, often handle deals with an average size of $3-5 million. The brokered markets are characterized by (ex ante) anonymity so that it provides a level play field for both small and large dealers. However, in volatile market times, dealers usually shun submitting quotes to brokers. Figure 1 lists some major differences of these inter-dealer trading channels.

Figure 1 Here

A particular dealer utilizes these different channels according to his preference and market conditions. A major market player is expected always to make fast quotes with reasonable spreads. His strategies for managing inventories shocks from such inter-dealer trades, mainly quote shading vs. outgoing trades at other dealers' quotes, depend on several factors such as execution certainty, transaction costs in terms of spread retention, and the relative informativeness of the dealer. Yao (1997) suggests that a representative dealer with customer flows will "scratch" (meaning offset) trades by hitting other dealers' posted quotes to reverse incoming trades. Such a strategy is preferred to the alternative of quote shading because the dealer is concerned about revealing his position and further his information from his order flows via shading quotes. Also in the highly liquid FX market with tight spreads, the cost of paying a spread is small relative to the execution uncertainty associated with quote shading.

In a similar study, Lyons (1995) describes the quote shading behavior of a "jobber" style dealer who has no customer trade. Since the dealer in Lyons' study has somewhat lower degree of private information due to the lack of customer business, his concern of revealing information that other dealers can capitalize on is greatly mitigated. A jobber will then shade quotes in hope of offsetting order flows, and will resort to outgoing trades at other dealers' prices only when his inventory drifts to his position limit.

The choice of different inventory control strategies may have profit implications for the dealer. A dealer who "scratches" inter-dealer trades should have on average zero profits/losses from such trades; on the other hand, a jobber's profits depend on the volume of his average trading day and how often he is able to retain his spreads.

2.3 Dealer Speculation

It is widely believed that FX dealers engage in speculation that ultimately results in high price volatility in the foreign exchange market (e.g. Frankel and Froot, 1990), especially in light of the fact that 80-90% of total FX trading volume involve only dealers. However, there is no study in the literature that looks directly at dealer's speculative activities. One important aspect of FX dealer speculation, is that it mostly takes place intraday, since almost all dealers close their trading days flat (Lyons, 1995 and Yao, 1997). Like market makers in other markets (Hasbrouck and Sofianos, 1993 and Silber, 1984), FX dealers speculate to take advantage of short-term (intraday) informational advantage arising from their order flows.[5] Since the FX dealers' speculation has virtually the same time horizon as inventory control trades, traditional methods for characterizing speculation (Hasbrouck and Sofianos, 1993 and Hansch and Neuberger,1994) are not applicable. Lyons (1995) proposes a method that decomposes a FX dealer's inventory into speculative components based on projections onto his information set. However such an approach can not address the extent and profitability of FX dealer's speculative activities. In this study, speculation is identified as the dealer's outgoing active trades not followed by anticipated incoming orders.

[5] Note that the rationale for this speculation does not rely on beliefs regarding the fundamental value of a currency pair which is the conventional notion in many newspaper account of daily FX trading and many academic discussions.

3. Data

The dataset employed in this study consists of complete trading records of a spot $/DM dealer[6] at a major New York City commercial bank over the 25 trading day period from November 1 to December 8, 1995. Each trading day of the dealer in my study starts informally at 12:30 Greenwich Mean Time (GMT) and ends at around 21:00 GMT (corresponding to 7:30 EST and 16:00 EST, respectively). My dealer is one of the most active $/DM market makers with substantial customer order flow. His average daily volume of $1.5 billion puts him among the top five $/DM dealers. More importantly, as I will show below, the composition of his trades is representative of the industry as depicted in market-wide surveys by BIS (1993, 1996).

The quality and scope of my dataset is similar to the proprietary dealer dataset in Lyons (1995).[7] However the dataset in this study provides a more complete description of dealer behavior since the sample here includes customer trades while Lyons' does not. While customer trades represent the major source of asymmetric information, they are particularly important in this study that examines dealer profits from such order flows. The sample also spans a much longer period of 25 trading days, as opposed to Lyons' 5 trading days.

The raw data consists of two components: the dealer's trade blotters and copies of the dealer's conversations (including trades as well as non-dealt quotes) over the widely-used Reuters 2000-1 interbank direct dealing system.

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[6] My dealer makes market only in *spot* $/DM (transactions for delivery in two business days). Like most other banks, my dealer's bank has a separate dealer making markets in $/DM outright forwards and swaps. Unlike spot currency dealers, the major price exposure for forward dealers is not the direction of a currency pair, but rather the differential of the two interest rates involved. Outright forward and swap transactions account for 53.2% of the total volume of all FX transactions (including spot, futures and options) in April 1995 (BIS 1996).

[7] Such dealer datasets provide several advantages over other FX data alternatives, mostly Reuters indicative quotes (see Goodhart and Gigliuoli, 1991; Bollerslev and Domowitz, 1993). The advantages are transactable prices, tighter

3.1 Dealer's Trade Blotters

Trade blotters are hand-written records of all trades done by dealers. A dealer starts a blotter with his overnight open position (mostly close to flat in my sample), and enters his deals as the day goes along. With an average daily turnover of about 180 deals, my dealer has about 8 - 10 blotters per day. Each entry on the trade blotter includes the following information:

(1) The counterparty of each trade;

(2) Trade channel by which the trade is executed, e.g. Reuters 2000-1 dealing system ("direct"), voice broker, electronic broker, or bank's sales staff (by name);

(3) The quantity traded;

(4) The transaction price;

(5) Dealer's inventory immediately after the transaction.

Figure 2 provides an example of a typical trade blotter by my $/DM dealer.

Figure 2 Here

This component entails transaction prices and trade quantities needed for estimation of dealer profits. Moreover, customer trades can be easily identified by counterparty identities. However, this component alone is not enough to determine whether a Reuters trade or a brokered trade is incoming passive or outgoing active (i.e. "signing" a trade), and to identify, in turn, the liquidity-providing and speculative trades. To sign a Reuters or brokered trade using quote-based methodology (Lee and Ready, 1991) requires prevailing quotes, which are obtained from the second data component.

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spreads and realistic prices when trading intensity is high. Also dealer inventories would allow a direct test of

3.2 Reuters 2000-1 direct quotes and trades

The Reuters 2000-1 dealing system is the most widely used electronic dealing system among FX dealers. This direct dealing system is based on trading reciprocity; what a dealer expects, and is expected to provide in turn, is a fast quote with a tight spread. All Reuters conversations, including trade confirmations, are printed out on hardcopy, which is the source of the second component of my dataset. For each Reuters direct trade, the following information is obtained from the hardcopy record:

(1) The time the conversation is initiated (to the minute);

(2) The counterparty;

(3) Which of the two dealers is seeking the quote;

(4) The quote quantity;

(5) The two-sided quote;

and if the quote results in a trade,

(6) The quantity traded;

(7) The transaction price.

Figure 3 provides an example of a Reuters dealing 2000-1 communication. Since a Reuters conversation is usually very short, transaction time to the minute is virtually the same as the time the conversation is initiated.[8]

Figure 3 Here

inventory models and the investigation of trading strategies.

[8] The exception occurs when the counterparty is requesting a transaction of large size (e.g. over $100 million). The communication will remain open while the dealer is working (to get an average price) to fill the order. This working process could take as long as 1-2 minutes, and therefore in this case the transaction time cannot be pinned down exactly. Also, in some trades of large size, the requesting dealer might identify himself as a buyer or seller (of US$), and hence only one-sided quote is given.

A Reuters trade can be signed easily. A Reuters passive buy (sell) is an incoming buy (sell) initiated by my dealer's counterparty and effected at my dealer's offer (bid) price. Reuters records also provides prevailing dealt and non-dealt quotes to sign the brokered trades [9] using quote based methodology. Specifically, a brokered trade is classified as a buy if the price is greater than or equal to the prevailing ask, or closer to the ask than the bid, and as a sell if the price is less than or equal to the prevailing bid, or closer to the bid than the ask. Next, if a trade is signed as initiated by a buyer (seller) and if it is a buy (sell) by my dealer, it is classified as an active trade, and if it is a sell (buy) by my dealer, it is classified as a passive trade. Finally, I determine whether an active trade is accumulating or decumulating. By definition, when the dealer is long (short), if the trade is a buy (sell) by my dealer, it is classified as an accumulating active trade; if the trade is a sell (buy), it is classified as a decumulating active trade. (See Yao (1997) for more details.) The distinction between accumulating and decumulating active trades is important here because accumulating active trades that are not followed by incoming orders are identified as the dealer's speculative trades.

3.3 Descriptive Statistics

Table 1 reports some statistics on my $/DM dealer's daily activities over the sample period.[10] There are considerable daily variations in turnover. The busiest day has as much as three times the turnover in the slowest day in the sample. The average daily volume of about $1.5

[9] Except for brokered trades, electronic and voice, all other trades can be classified as active (in which my dealer initiates the trade) or passive (in which the counterparty initiates the trade) by examining their counterparties and/or the channels by which the trades are executed. Active trades include IMM trades and Reuters outgoing trades. Passive trades include customer trades, limit and stop loss orders, Reuters incoming trades and internal deals.

[10] The sample covers an otherwise continuous trading period for the dealer, except for (1) weekends and (2) Thanksgiving Day (11/23) when the U.S. operation is closed, and the day before (11/22) and after (11/24), both days on which the dealer, like many other dealers in the United States, did not quote or trade in the interbank direct (i.e.

billion puts this dealer among the top five $/DM dealers in the North America. The dealer is representative in terms of the composition of different types of trades such as customer flows and inter-dealer trades. Table 2 presents descriptive statistics about my dealer's different types of trades, as well as the market-wide statistics based on BIS (1996) surveys. For example, over the entire sample period, customer trades account for 13.9% of total volume, compared with about 16% for the market as a whole. Voice and electronic brokered trades combined account for 43.3% of total volume, compared with around 39% for the market as a whole. Interbank direct trades conducted via Reuters 2000-1, including Reuters incoming, outgoing and aggregate[11], account for 23.3% of total volume, compared with a market-wide 25%.

<u>Table 1 and 2 Here</u>

Figure 4 presents the transaction price for all passive trades over the entire 25-day sample period, Nov. 1 -- Dec. 8, 1995. Note that there is a price discontinuity surrounding the Thanksgiving Day (Nov. 23). In figure 5, the top graph plots the dealer inventories at the time of all incoming passive trades. The maximum long position is $198 million, and the maximum short position is $158.7 million. The bottom graph, using the same scale, plots the dealer's daily closing positions, which are fairly small compared to his intraday inventories.

<u>Figure 4 and 5 Here</u>

Table 3 presents the results of classification of incoming passive versus outgoing active trades for all trades in the sample, including brokered trades. Statistics are quite similar in terms

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Reuters 2000-1) markets. Dealers at other financial centers, such as London and Frankfurt, did quote in the direct market during their hours overlapping with the U.S.

[11] Reuters aggregate trades are outgoing trades by nature. They take place when the dealer's inventory is significantly in imbalance from his desired level, most often resulting from large trades above $50 million. In this case, aside from requesting quotes (recall that the Reuters 2000-1 enables the handling of four quotes at a time) himself, the dealer also asks other dealers such as $/Stg and $/Aus dealers on the desk to call out as well for $/DM quotes. Deals done by various dealers are fed into a computer that figures out an average price. On the $/DM dealer's blotter,

of number of trades or volume. In volume terms, passive trades constitute 60% of total volume, decumulating active trades 30% and accumulating active trades 10%.

<u>Table 3 Here</u>

4. Methodology and results of profit decomposition

4.1 Methodology

4.1.1 Calculating customer trade profits

Because the identity of counterparty in each trade is given by trade blotter, customer trades can be separated out from other types of trades. In reality, a bank manager supervising the dealer would separate out the customer trades revenue by marking them to the market price in the inter-dealer markets at the time of transaction. This will essentially capture any mark-up by the dealer on customer trades. For the estimation here, prices in the inter-dealer market at the time of customer trades are unavailable because they were not recorded by the dealer. The approximation I make is to use the average price of unwinding trades. This is equivalent to the following computing algorithm for profits from *i*th customer trade:

$$\Pi_{i,C} = \sum_{j=1}^{n} (Q_{i,j}\, p_{i,j}) + Q_{i,C}\, p_{i,C} \qquad (1)$$

where I denote the trade quantity and price pair as ($Q_{i,c}$, $p_{i,c}$) and those for unwinding trades as ($Q_{i,j}$, $p_{i,j}$), j = 1, 2, ..., *n*, where *n* is the number of unwinding trades. A computer program identifies the *n* offsetting trades, active or passive, and verifies that $Q_{i,C} + \sum_{j-1}^{n} Q_{i,j} = 0$.[12]

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though, all these deals are recorded as one trade, with the rate equal to the average price. Note that the average and median trade size of Reuters aggregate trades are $75.3 and $70.0 millions, respectively.

[12] In the few cases in which there are substantial position buildup (greater than 50% of the customer trade size), the algorithm searches for offsetting trades ahead of the customer trade as well.

The question then arises whether the unwinding trades are close enough in (trade) time to the customer trade so that their average transaction price represents a good approximation for the unobserved inter-dealer market price. Table 4 presents evidence supporting this approximation.

Table 4 Here

Table 4 shows that inventory shocks from customer trades are laid off quickly and by the end of the third trade subsequent to a customer trade, the dealer is almost flat again.[13] Since the estimated inter-transaction time is only about 2 minutes (see Yao 1997), this suggests that the dealer is able to layoff inventories from customer trades within approximately 6 minutes in clock time. In case of customer trades of very large sizes, inventory management is not any slower because the dealer would then “line-up the banks” via Reuters aggregate trades. For example, I find that for each of twelve largest customer trades with an average size of $77 million, there is a subsequent Reuters aggregate trade within 1-2 minutes offsetting 87% on average of the original customer trade. The evidence suggests that the dealer is laying off inventories without much delay following customer trades. As a result, the transaction prices of those inventory lay-off trades are reasonably good approximates for prices in the inter-dealer markets at the time of customer trades.

4.1.2. Estimating profits from inter-dealer liquidity-providing trades

Profits associated with such trades are estimated in the same way as customer trades, except that (1) the incoming orders are from another dealer instead of a customer, and (2) the average size of inter-dealer trades are somewhat smaller. Dealer orders arrive through two

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[13] Table 4 excludes the few incidences in which the dealer builds up substantial inventory ahead of incoming customer trades. In these cases, inventory shocks subsequent to the customer trades are very small relative to the customer trade sizes.

different channels: the direct market via Reuters 2000-1 dealing system and through brokers, both voice and electronic. Here I consider only the incoming dealer orders received through the Reuters direct channel. The reason is that the reciprocity feature of the Reuters direct system requires that a dealer always provide two-way quotes with a decent spread upon request, and hence be ready to take a trade even if he is not willing to. In contrast, a dealer never takes a trade that he is *totally* unwilling to take through brokers. In the brokers channel, the dealer submits his own quote (not necessarily a two-way quote) with a particular depth so that he has a good idea about the exposure from such a quote. The motivation of submitting quotes to a broker is to elicit incoming trades, and is often related to price experimentation or information seeking in a directionless market (see Stigum, 1990). This is particularly true in light of the relative small trade size of brokered trades (median $5 million) relative to Reuters incoming trade (median $10 million). It is possible that a dealer shades quotes submitted to the brokers in hope of eliciting trades to offset inventory imbalance. However, as Yao (1997) suggests, because of execution uncertainty and of the concern over revealing information via quote shading, FX dealers seem to rely on outgoing active trades at other dealers' prices rather than quote shading for inventory control.

Therefore I only look at profits associated with Reuters incoming trades as an estimate of profits from liquidity-providing activities. Like inventory control following customer trades, the dealer lays off inventories following Reuters incoming trades mostly through outgoing Reuters direct trades or brokered trades by hitting other dealers' quotes. As a major player in the market, my dealer wishes to maintain his reputation of always providing liquidity to other dealers, and then "scratches trades" by trading at other dealers' quotes. Therefore, it is expected that the his profits from liquidity-providing trades are close to zero on average, although actual profits may vary from day to day.

4.1.3 Profits residuals as speculative trading profits

First, consider the profits implication for the dealer from the other two types of incoming order flows, inter-dealer brokered incoming trades and internal deals. From the discussions about inter-dealer trades above, incoming brokered trades (the total volume of which is about one-third of all brokered trades) are mostly price experimentation or information seeking in nature. Since the dealer in this study is a major market player, it is reasonable to assume that his information-seeking trades have zero expected profits *on a daily basis*. In an internal deal which involves other in-house traders for hedging options, futures or EMS currencies position, since my dealer always passes along rates obtained in the inter-dealer markets to his colleagues, there is no profit (or zero profit) implication for the $/DM dealer considered here.

Then the profit residual from each day's actual total profits after accounting for customer trade profits and Reuters incoming trade profits must be related to the dealer's third type of major activities, i.e. speculation.[14] Treating speculative profits as profit residuals rather than calculating them directly avoids the relatively difficult task of identifying dealer speculative trades, which occur intra-day and thus have the same time horizon of inventory control trades. Moreover, even if speculative trades can be identified precisely, the cash-flow based algorithm for computing customer trade profits and Reuters incoming trade profits is not applicable here because it is even

[14] If the profits from price experimentation trades via incoming brokered trades are actually *negative* on a daily basis as opposed to zero as assumed, the speculative profits measured as profit residual would actually underestimate the actual speculative profits. In that sense, the speculative profits under the assumption of zero price experimentation trade profits can be regarded as a lower bound of profits from dealer speculation.

harder to determine how long the speculative positions are held open and to further identify the unwinding trades.

However, to provide a measure of the magnitude of speculative activity rather than an alternative to computing speculative profits, I do need to identify speculative trades. As a first order approximation, I estimate the magnitude of speculative trades as the total amount of accumulative active trades that are not immediately followed by incoming orders. This recognizes the fact that some accumulative active trades are building up inventory ahead of incoming trades and thus are indeed inventory-controlling in nature.

4.2 Customer trade profits

Table 5 presents the customer trade profits as estimated based on the algorithm described above for each day of the 25-day sample. It also includes the $/DM dealer's overall actual profits as a comparison. On average, there are about 8 customer trades with a total volume of over $200 million per day, compared with about 181 deals with over $1.5 billion in volume for all trades combined. The average total profits per day are about $13,000 for customer trades only, and about $17,000 for all trades combined.

Table 5 Here

There are several noteworthy results. First, and probably the most striking result, is that although customer trades account for only about 14% of total trading volume over the 25-day sample, it represents more than 75% of dealer's total profits during the sample period. This is consistent with a market survey of forty trading desks around the world by Braas and Bralver (1990) which finds that these desks generate between 60 and 150 percent (in which case other trades such as speculative trades lose money) of total (gross) profits from customer business.

Second, on a profit-per-deal basis, each customer trade earns about $1,500 on average for the dealer, over 16 times more than the profit per deal for all trades combined. Not only are the customer trades more profitable than other trades combined (actually, it is shown later that customer trades are indeed the most profitable trades for the dealer), their profits are also more consistent, measured as lower daily variations relative to their average daily profits. The *t*-statistic based on average daily profits and their standard deviations over the 25-day sample is 2.0 for customer trade profits, and only 1.2 for all trades combined.

The source of customer trading profits, as evidenced by the algorithm used here, is the mark-up on such trades relative to prices in the inter-dealer market. Yao (1997) estimates that the dealer quotes a 1.1 pip (or 0.00011 DM/$) higher fixed spread (representing fixed transaction costs, such as order-processing costs) in customer trades than in inter-dealer trades. Using a back-of-the-envelope calculation, such a 1.1 pip fixed spread mark-up on a total customer trade amount of $5.3 billion translates into about $410,000 profits (assuming the spot rate of DM 1.4183/$, the median closing price) over the 25-day period. This is close to the $322,000 total customer trade profits estimated using the algorithm described above.

Customer trade profits also exhibit variations over the sample, and it would be interesting to see what factors contribute to such variations. While there is no ready economic models that relate particular factors to customer trade profits, I experiment with various regression specifications and find that daily exchange rate price ranges have particularly strong association with the dealer’s profits on customer trades. Specifically, I find that (*t*-statistics in parentheses)

$$\text{Profits (\$K)} = \underset{(-1.88)}{-27.9} + \underset{(2.71)}{0.27}\, x_1 + \underset{(0.99)}{90.1}\, x_2, \qquad R^2 = 0.10$$

where total profits are measured in thousands of dollars, x_1 is the daily spot price range in pips between a day's high and low rates, and x_2 is the customer trade volume as a percentage of a day's total volume as an indication of customer participation on that particular trading day. Since the daily price range between high and low prices can be a proxy for volatility of a trading session (Garman and Klass, 1980), the results indicate that a FX dealer demands higher profits for providing services to customers in volatile markets. The low regression R^2 reflects high random variations of daily customer trade profits. It is possible that other factors also play an important role.

To further exploit the data, I examine whether customer trades involving an industrial corporation versus a non-dealer financial institution (such as a mutual fund) are different in terms of trading profits. It is possible that the dealer's trade can be less profitable against a non-dealer financial institution because of the latter's possible information advantage and bargaining power. Table 6 presents the break-down of customer profits between industrial corporations and non-dealer financial institutions.

<u>Table 6 Here</u>

Table 6 shows no major difference in dealer profitability (such as profit/deal or profit per million dollar in trade volume) between these two different types of customers. This is partly because in the foreign exchange market private information in the usual sense, i.e. regarding the currency fundamental value, is rare. Since dealers observe more order flows overall, which are the most important form of private information in this market, they are often better informed about not only demands from particular customers but also market-wide flows. Although the average size of a trade involving a non-dealer financial institution is about twice that of an industrial corporation ($32 million versus $15 million), the order of difference and the absolute magnitude of either type of trades are not likely to generate significant difference in bargaining powers against a $1.5 billion-a-day currency dealer in a $1.2 trillion-a-day market.

Finally, although not reported in the tables above, I find that average number of trades used to lay off inventory shocks from customer trades is three.[15] This is consistent with the information in table 4 that the dealer returns to a flat position after about three trades subsequent to a customer order.

4.3 Profits from liquidity-providing trades

Table 7 presents the dealer's trading profits in interbank direct "passive" trades via Reuters 2000-1 dealing system, in which the counterparties initiated the trades and dealt at my dealer's quotes. As discussed above, such trades best represent the situations in which the dealer provides the liquidity to the interbank dealer market by always being ready to quote two-way prices with reasonable spreads.

Table 7 here

Such Reuters passive trades account for about 13.7% of total trade volume during the 25-day sample period, comparable to that of customer trades. Reuters passive trades average about $16.9 million, greater than the average size of $8.4 million for all types of trades combined but less than the $27.6 million average size for customer trades. Total trading profits for the 25-day sample period are just - $18,600, or -4.4% of the dealer's total profits. The average daily profits

[15] This result may underestimate the actual number of trades that the dealer make to lay off inventories because he tends to lump together unwinding trades (brokered and Reuters outgoing) following a large customer trades. Recall that the dealer can deal with four other dealers simultaneously through Reuters 2000-1 dealing systems. Also he can access both voice and electronic brokers market at the same time. However, in either case, the algorithm for profit calculation won't be affected since it will pick up the average price for either type of aggregated trades as reported on the dealer's blotter. Such average price should be particularly good indication of prevailing price in the inter-dealer markets at the time of a customer trade.

are only -$743 (indicating losses), compared to $12,866 of customer trade profits and to $16,949 of profits for all trades combined. The standard deviation of daily profits is only 28% of the standard deviation of daily profits for all trades combined, and 68% of the standard deviation of daily customer trade profits. Profitability measures, in terms of both profit per deal and profit per $10-million trade volume, are statistically indistinguishable from zero.

The overall picture that emerges from table 7 is that although the dealer incurred profits or losses from day to day on Reuters passive trades, these daily profits/losses are small and tend to offset over time. As a result, the dealer is virtually breaking even on these liquidity-providing trades. This is not surprising since the dealer usually offsets Reuters incoming trades by hitting other dealers' prices (also called "scratching trades"). Although customer trades are a major source of trading revenue for a dealer with a good customer base, the dealer must still maintain his reputation of always being ready to provide inter-dealer liquidity. By doing this, the code of reciprocity among dealers in Reuters direct markets ensures that he will be provided liquidity in return when needed.

Although the dealer in this study is representative of major market players with both customer and inter-dealer flows, caution is warranted to generalize the findings of "scratching inter-dealer trades" to all types of FX dealers. In particular, dealers who don't have much customer business and who mainly provide liquidity in the inter-dealer markets are likely to adopt a "jobber" style of trading. They manage their quotes to elicit as many incoming trades effected at their prices as possible, and resort to outgoing trades (as in "scratching trades") only when incoming orders push their inventories beyond certain position limits (Lyons 1995). For an experienced jobber with large turnovers, trading in such a way can indeed be profitable. However, it is unclear whether jobbers as a whole group can earn significantly positive profits.

4.4 Speculative trading and profits

To identify FX dealer's intra-day speculative trades which have the same time horizon of his inventory control activities, I separate out accumulative active trades that are not followed by incoming orders as a measure for speculative trades. As mentioned above, daily speculative trading profits are profit residuals by subtracting the dealer's customer trade and Reuters direct trade profits on a particular date from that date's actual profits. Results are reported in table 8.

Table 8 Here

Speculative trades amount to only about 11 trades, or about $64 million per day, with an average trade size of about $5.6 million. This translates into only about 4.2% of the dealer's total trading volume of the sample period, and contradicts the common belief that FX dealers engage in excessive speculation (e.g. Frankel and Froot 1990). Speculative profits account for about 28.5% of the total profits during the 25-day sample period. Although quite substantial, such profits have much wider daily variations, from a maximum daily loss of $127,000 to a maximum daily profit of $121,000. On a profit per deal basis, speculation profits average about $770 with a daily standard deviation of about $6200, comparing to an average of $1500 and standard deviation of $3700 for customer trade profits. Therefore, speculation profits are not only much smaller but also much more volatile that those of customer trades.

Since FX dealers are well known for NOT betting on long-term economic fundamentals[16], intraday (because FX dealers almost always close their trading days flat)

[16] Charles C. Coombs, a former foreign exchange expert at the Federal Reserve Bank of New York, has the following observation of FX traders: (cited from Michael Moffitt, 1983, *The World's Money*, Simon and Schuster.)

"Foreign exchange traders for better or worse, are not a bunch of scholarly Ph.D.s searching reams of statistical evidence for proof that a certain currency rate is becoming over or under valued and thereby triggering their decision to buy or sell. Anyone who has ever spent any time in the foreign exchange trading room knows only speculative profits seem to arise from the short-term information advantages of the dealers with informative order flows in a market characterized by low transparency. Superior information about market order flows not only allows a dealer to refine his quotes but also make it possible for him to aggressively build up a position to take advantage of expected price movement before the information is widely disseminated. Using volume of large trades as a proxy for informational flow, a regression of speculation profits on large trade volume yields a positive relationship (although not statistically significant at the conventional confidence level). However, private information regarding order flows is often short-lived and lasts less than 30 minutes (see Yao 1997) partly because of information revealed during the inventory adjustment and risk-sharing process.

Many discussions in international finance attribute short-term FX market volatility to dealer speculation, citing the high (80-90%) volume of inter-dealer trades in this market. The results on FX dealer speculative trades and profits in this study do not support this view. As I have measured it in this sample, I find that speculation is not a large share of volume at the market maker level. As for the high volume of inter-dealer trades in the FX market, it seems to be closely related to inventory management through the inter-dealer channels following order flow shocks. This is consistent with the view of "hot-potato trading" as discussed in Flood (1994) and Lyons (1994). As a simple model in the next section shows, such cascading rounds of inter-dealer trading following a order innovation also has much to do with the low transparency of this market.

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too well that traders focus primarily on short run developments. Foreign exchange traders have been taught by harsh experience that betting on the longer term fundamentals is an excellent way of losing your shirt."

On the other hand, FX dealers could anticipate and act on *short-term* macroeconomic news. However, examination of my dealer's trade records finds little evidence that he has substantial inventory positions around news

5. Spread Components and Market Making Costs

5.1 A simple model with lagged adjustment to order flow

First, I consider a simple model of FX dealer spreads. As in Glosten and Harris (1988), dealer spreads are broken into two components. First is the *transitory* component related to fixed transaction costs (such as trade clearing) and inventory costs. The second is the adverse-selection component related to trading against market participants with private information. The model differs from the standard Glosten and Harris setup by including a lagged quote midpoint adjustment to order flows. This is motivated by the finding in Yao (1997) that FX dealers strategically delay their quote revision to take advantage of the low market transparency in the joint management of inventory shocks and information impacts from order flows. Specifically,

$$m_t = m_{t-1} + w_t \qquad (2)$$

$$w_t = u_t + \sum_{i=1}^{n} b_i Q_{t-i} \qquad (3)$$

$$p_t = m_t + aQ_t + cD_t \qquad (4)$$

where m_t is the time-t mid quote, Q_t the signed transaction size, D_t the trade sign indicator with +1 for an incoming buy and -1 for an incoming sell, and p_t the transaction price. The timing is important in this setting: at the beginning of a trade period (defined as the occurrence of an incoming order), a public signal u_t arrives, then the quote with a midpoint of m_t is set. A trade occurs at a price of p_t. The quote midpoint revision according to eq. (3) includes the public information u_t, and the adjustment to past order flows. The spread consists of a adverse selection component linear in signed trade size, and a constant order processing cost component.

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announcement. Even when speculative positioning is involved, my analysis suggests that such positions are small

The framework is close in spirit to Glosten and Harris's (1988) model because the dealer in this model also sets spreads to take into account his expectations about current trade. As a result, order flow has a contemporaneous effect on transaction prices. What is new here is that the dealer's quoted midpoint also factors in an additional lagged price adjustment to past orders.[17] This setup reflects the findings in Yao (1997) that FX dealers only adjust quotes gradually in response to order flows. Intuitively, following an incoming order, because of the low market transparency, a FX dealer will adjust prices slowly while he is working off inventory shocks mostly through outgoing active trades at other dealers' prices. Not quoting prices immediately that impounds all the information of a trade avoids the free-rider problems in a decentralized dealership market structure. Once he substantially cuts off the inventory shocks, the dealer will adjust price fully to incorporate the complete information content of a trade.

As for the spread components for time-*t* trade, the model suggests that it includes two components, an information component proportional to trade size and a fixed transaction cost component. Although the fixed transaction cost component could include an inventory-related cost, inventory does not enter the model directly to affect the placement of the spreads as in most inventory control models. This simplified approach draws upon the results in Yao (1997) that there is little evidence that a representative FX dealer shades quotes to elicit trades of designed sign. To avoid revealing inventory imbalance and proprietary order flow information while shading quotes, the dealer lays off the majority (80-90%) of inventory shocks through outgoing active trades at other dealers' prices.

From eq. (2) - (4), the price return series with the assumption of a 8-lag structure follows,

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relative to overall order flow.

[17] Specifically, the lagged price adjustment refers to the terms in eq. (3) for Q_{t-i}'s, where $i > 1$. In a traditional model, the midpoint update based on order flows would include only the Q_{t-1} term.

$$\Delta p_t = a(Q_t - Q_{t-1}) + b_1 Q_{t-1} + \cdots b_8 Q_{t-8} + c(D_t - D_{t-1}) + u_t \qquad (5)$$

Eq. (5) can be estimated directly using the data described above. Table 9 presents the results.

Table 9 Here

The contemporaneous information component coefficient *a* is about 0.302 pips/$10mm and is statistically significant. The fixed transitory component is 1.358pips/$10mm. For a $10 million trade, the estimated spread would be about 3.32 pips (two times the sum of 0.302 and 1.358), very close to the 3-pip quoted spreads found in Yao (1997) and in Lyons (1995). For a $9.3 million trade, i.e. the average incoming order size, the percentage of the adverse-selection component of the total spread is about 17% (i.e. 0.281/(0.281+1.358), where 0.281 = 0.93*0.302), compared with 35% for 1000-share equity trades as reported in Glosten and Harris (1988).

Another important result is that there is indeed evidence that there are lagged price adjustments to order flows. For example, the lag-3 trade coefficient b_3 is 0.171 pips/$10mm and the lag-4 trade coefficient b_4 is 0.189 pips/$10mm. Both of them are economically and statistically significant. The results of lagged price adjusts are consistent with the dynamic vector-autoregression analysis in Yao (1997), which further points out that the significance at 3- and 4- lags reflects the fact that by then about 90% of the inventory shocks from trade innovations have already been laid off.

The total price impacts from a signed order flow Q_t are captured by the product of Q_t and $\sum_{i=1}^{8} b_i$ (with an eight-lag structure), estimated at 0.879 pips/$10mm with a *t*-statistics of 3.37. To the extent that the full price impacts can be interpreted as the permanent information effects free of any transient effects, a total impact of 0.879 pips/$10mm is also the dealer's rational expectation facing an incoming order. The fact that the quoted information spread component of 0.302 pips/$10mm is only about one-third of his belief seems somewhat surprising when first meets the eye and contradicts directly the "regret-free" notion as in Glosten and Milgrom (1985). In the Glosten and Milgrom (1985) world, the dealer quotes prices that are ex-post regret-free in the sense that he believes the prices to be fair given the trade observed. This is true when it is assumed that the dealer's expected profit is zero on *each and every* trade. Glosten and Milgrom (1985) admit that this may not be a realistic assumption and that such an assumption implies a market closure if the degree of private information is high. In a study of price experimentation in various different market structures, Leach and Madhavan (1993) relax this assumption and impose only zero expected profits over a series of trade by a dealer. As they show, price averaging that induces information revealing is possible with a monopolistic specialist, but impossible in a competitive dealer structure because of "free-rider" problems.

However, in a dealer market with *low market transparency* like the foreign exchange market, departures from "regret-free" quotes in the sense of Glosten and Milgrom and price averaging are possible, although they are quite different from the mechanism for price experimentation in the Leach and Madhavan model, where the *specialist* incurs a loss first but makes up in later trades by refining his quotes. In a setting such as the FX market, thanks to low transparency, the dealer can quote prices lower than full information impacts because upon taking the trade, he can lay it off at quotes of other dealers who are less well-informed. Such a task is made particularly easy in the FX market where dealers' search costs are low and where an experienced dealer can "line up the banks" and hit each with a piece of the original trade. Hence, the dealer would make money initially, but face the risk of valuing the residuals that he is not able to lay off in time at full information impact prices. The initial quoted price only needs to satisfy price averaging or zero expected profits over the initial and subsequent laying-off trades. The following example illustrates this intuition.

5.2 Price Averaging and Inter-dealer Volume: An Illustration

To illustrate price averaging in the setting of low market transparency, consider the following simple example of an incoming dollar buy order (the case of an incoming sell is similar given the symmetry of the problem). A representative dealer, like all other competing dealers, has a *common* linear quote schedule of $c+aQ$, where c is fixed transaction cost spread, and his prior conditional expectation is assumed to be zero only for simplicity (trivial to extend to the non-zero case). Suppose that the dealer takes on a incoming dollar buy of size Q unobservable to other dealers. The initial trade price is $c+aQ$. Assume that the dealer lays off resulting inventory shocks only through outgoing trades at other dealers' quotes. Because of low market transparency and the linear price schedule, he can achieve best prices by breaking down the original trade (a common practice known as "lining up the banks"). For the *i*th of the total n laying-off trades, he lays off x_iQ amount at the price of $c+a(x_iQ)$, where x_i is the percentage of initial trade size. He has a residual of $(1-x)Q$, where $x = \sum_{i=1}^{n} x_i$ is the percentage of inventory shock laid off before being exposed to the full information price of $BQ+(c+a(1-x)Q$, where BQ is the full information mid-quote, and $B = \sum_{i=1}^{8} b_i$ as before. The dealer can lay off the inventory residual at the full information price, or equivalently mark it to market at that price[18]. The zero (expected) profit condition imposed in this competitive dealer market yields:

$$(c + aQ)Q - \sum_{i=1}^{n} (c + ax_i Q)x_i Q - (BQ + c + a(1 - x)Q)(1 - x)Q = 0 \qquad (6)$$

where the first-term on the left-hand side is the DM inflows by taking the original dollar buy order, the second term is the DM outflows related to laying off the short inventory in dollars, and the third term is the DM outflows if the dealer were to lay off the residual at the full information price. Eq. (6) can be simplified as

$$1 = \sum_{i=1}^{n} x_i^2 + (B / a)(1 - x) + (1 - x)^2 \qquad (7)$$

Then the lower bound of *x*, i.e. the percentage of inventory shocks being laid-off in inter-dealer trades, can be obtained from

$$1 > (B / a)(1 - x) + (1 - x)^2 \qquad (8)$$

or, $x > 69.0\%$, given the parameter estimation in section *5.1*.

From the behavior of this representative dealer, one can get a sense of trade volume (or "hot-potato" trading) for the market as a whole as follows. A trade innovation (such as a customer trade) of a unit size arrives. The dealer taking the trade immediately lays off 69% of it in the inter-dealer markets. The dealers who get hit with his laying-off trades start the second round of inter-dealer trading, laying off 69% of their own inventory shocks. The process goes on until dealers all reach their new optimal inventory levels. As a result, one unit of customer trade triggers an aggregate inter-dealer trade amount of 2.23 units (or, $0.69 + 0.69^2 + 0.69^3 + \cdots = 0.69/(1-0.69)$). For the market as a whole, inter-dealer trading amounts to a lower bound of 69%

[18] It is helpful to think that the dealer holds the inventory residual as his share of the original order flow. In this simple example, each dealer would ultimately hold an identical share of the original trade, and feel indifferent

of total market volume compared to the BIS survey findings of 80-90%. Essentially, there is a direct correspondence between the inter-dealer volume for the market as a whole and the percentage of inventory shocks a representative dealer immediately lays off following a trade innovation.

Figure 6 presents a finer estimation of the inter-dealer trading volume as a percentage of total market volume. The parameter values for quote schedule and full information impact are the same as above. An additional simplifying assumption is made that all laying-off trades have the same size $x_i = y$, and hence $ny = x$. According to eq. (7), the inventory being laid off (x), and in turn the resulting inter-dealer volume, depends on the size of laying-off trade (y). Figure 6 plots such a relationship between x and y based on the zero expected profits constraint as in eq. (7).

<u>Figure 6 Here</u>

As discussed earlier, the inter-dealer volume has a lower boundary of 69% of total volume and rises with the size of unwinding trades. Given the linear quote schedule, the size of unwinding trade simply reflects the price impacts of such trade. The higher unwinding price then implies that the dealer has to lay off more inventory shocks to maintain zero expected profits. It is therefore optimal for the dealer to break the initial trade into smaller unwinding trades both to minimize the price impact and to better camouflage the initial trade. In the limit case where y = 100%, the dealer passes on the initial trade to another dealer in a single unwinding trade. The plot suggests that unless the dealer quotes full information impact prices as in a structure with complete transparency, inter-dealer trades always dominates market turnover.

According to figure 6, for a customer trade of $27 million (the mean size of customer trades in the sample), if the unwinding trade size is $5 million (the typical size in the brokers

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between holding his share and laying it off at the full information price.

markets) or 19% (*y*) of the customer trade size, the dealer has to lay off about 73% of the original customer trade amount. In comparison, for a really large trade of $100 million, if the dealer lays off by trading $10 million (typical size in Reuters direct markets) each with other dealers, he has to unwind at least 71% of the original $100 million trade. Note that the total percentage of inventory shocks to be laid off may not differ by much in these two examples, but the estimate is more likely to have a downward bias for a large trade that requires more laying-off trades and hence potentially higher searching costs. In this case, information is more likely to get disseminated during the inventory management process so that the assumption of an identical unwinding trade price used above is more likely to be violated. As the dealer faces rising prices quoted to him, he has to lay off more inventory shocks (as a higher percentage of initial trade size) rather than valuing them at the full information price to maintain zero expected profits.

5.3 Market Making Costs

In a naive model, a dealer earns a half spread on each trade. However, he faces costs through two channels: adverse selection and inventory control. The analysis above provides a gauge of the magnitude of these two different market making costs. Consider a typical $/DM incoming trade of $9.3 million (the average trade size in my sample). First, the adverse-selection component is about 17% of a half-spread of 1.639 pips. However, the adverse-selection spread component does not cover the permanent information impact of the trade; the dealer only bears part of the adverse-selection costs while the balance is shared by other dealers through inter-dealer trading in a setting of low market transparency. Second, the FX dealer engages in very active inventory management. Yao (1997) estimates that about 90% of the inventory shocks are laid off through such active trades. Without going into details of the break-down of active trades versus incoming trades used for inventory control, I consider an lower bound for the cost of inventory control.

Specifically, consider first the profits based on the naive model. Using the same pricing schedule as estimated above, for an average trade (average of all trades, active and passive) with $E[Q]$ = \$8.4 million, the half spread is (1.358 + 0.302*Q) pips. Then the naive model profit per average trade is (1.358*$E[Q]$ + 0.0302*$E[Q^2]$)*100/1.4183, or \$1,260, where 1.4183 DM/\$ is the median daily closing rate in the sample and $E[Q^2]$ = 214.0. On average, there are 181 trades per day. Then the total naive model profits per trading day are \$228,000.

The adverse-selection costs accrued to this dealer is 0.0302*$E[Q^2]$*100/1.4183 = \$524 per trade, where expectations are taken over incoming passive trades only and $E[Q^2]$=246.1. With about 99 incoming orders a day, this amounts to \$52,000 adverse selection costs per trading day.

The actual (gross) trading profits per day in the sample are \$17,000. According to the following relationship of profits[19],

actual = naive spread - adverse selection - inventory control + speculation

> naive spread - adverse selection - inventory control

A lower bound on inventory control can be estimated based on the non-negative speculative trading profits per day on average. Such a lower bound is equal to \$159,000 per day, or 70% of the naive model profits. Using the estimated (see section 4.3) speculative trading profits of \$4,800 per day, the inventory control costs are \$163,800 per day, or 72% of the naive model profits.

[19] Note that actual profits here gross trading profits before any fixed transaction costs such as order processing or broker commissions. Therefore any profit components aside from adverse selection and speculation are related to inventory control costs only.

To summarize, the dealer in my study would have made about $228,000 per day if he were able to earn half a spread on each trade as in a naive trading model. However, at least 70% of the naive profits go toward managing the dealer's inventory. About 23% are related to adverse selection costs because of asymmetric information, leaving the dealer making at most only about 7% of the naive model profits. However, the adverse selection costs are vastly underestimated at the single dealer level because of risk-sharing via inter-dealer trading facilitated by low market transparency.

6. Conclusion

The market maker's trading behavior as a profit-maximizing rational agent has not been a focus of traditional market microstructure studies. This study addresses dealer profits by studying the complete trade records of a representative foreign exchange dealer in the interbank market. FX dealers are of particular interests because of the publicity regarding their trading activities and because of the unique decentralized, less transparent market structure they operate in.

FX dealer profits are analyzed from two different perspectives. First, the study separates trading profits from various dealer activities such as customer trades, inter-dealer liquidity-providing trades and speculative trades. Although customer trades account for only about 14% of total trading volume over the 25-day sample, they represent 75% of dealer's total profits. This is consistent with a market survey by Braas and Bralver (1990) which finds that most dealing rooms generate between 60 and 150 percent of total profits from customer business. There is evidence that the dealer profits from customer trades by charging a small mark-up which becomes substantial when applied in the world's most active financial market. In the meantime, the dealer constantly provides liquidity to the inter-dealer market, and subsequently scratches trades by hitting other dealers' quotes. The dealer engages in very limited intra-day speculation and profits mostly form his short-term informational advantage by observing customer order flows. The small scale of speculative trades which are less than 5% of total volume rejects the popular notion that attributes the high inter-dealer volume and short-term price volatility to excessive speculation on the part of FX dealers. In fact, the analysis suggests that the high inter-dealer volume arises from the so-called "hot potato trading" related to rounds of dealers' inventory control trades subsequent to order flow innovations.

Because of my dealer's status as a major market maker and of the representative composition of his trades, his activities accurately characterize market making activities in the FX market. However, this does not suggest that the study here exhausts trading strategies and profit decomposition of all FX market participants. For example, a "jobber" who has no customer flows and only provides liquidity in the inter-dealer markets (see Lyons 1995) derives the majority of his profits from spread retention on as many trades as possible via quote shading. Still, while a complete description of dealer behavior and profits which requires multi-dealer data is not possible, the study here captures the most important and representative aspects of FX dealer activities and their profits distribution among various activities.

Another interesting aspect of dealer profits is the market-making costs reflecting adverse selection and inventory control. Such costs deprive the dealer of most profits he would have earned in a naive world where he collects one half of the quoted spread on each trade. The analysis utilizes a framework of spread component decomposition close in spirit to Glosten and Harris (1988), but modifies the "regret-free" quote setup to accommodate the FX dealer's lagged quote adjustments to order flows. The departure from such "regret-free" quotes parallels Leach and Madhavan's (1993) analysis of price experimentation, but my findings of lagged price adjustments are based on the FX dealer's strategic joint management of inventory shocks and information impacts; because of the unique low market transparency, a FX dealer delays quote revision that would reflect fully the information content of a trade until after he lays off the majority of his inventory shocks. Such behavior results in a spread decomposition suggesting (1) that the dealer bears only part of adverse selection costs (about one-third as estimated) due to risk-sharing through inter-dealer trading and (2) that for a trade of average size ($9.3mm in the sample), the adverse selection spread component accounts for only about 17% of the total quoted spread, reflecting both the aforementioned underestimate of the full information impact and the low degree of private information in the FX market. Finally, as the dealer relies heavily on outgoing trades at other dealers' quotes for inventory control, he forgoes at least 70% of profits he would have earned in a naive model for inventory control. Inventory management is indeed the name of the game in the FX market.

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Table 1

Overview Statistics, Nov. 1 -- Dec. 8, 1995

The overall daily trade data are from trade blotters of a $/DM dealer at a major New York City commercial bank. The sample covers a continuous trading period for the dealer, except for (1) weekends and (2) Thanksgiving Day (11/23) when the U.S. operation is closed, and the day before (11/22) and after (11/24), both days on which the dealer, like most other North American dealers, did not quote or trade on the interbank direct (i.e. Reuters 2000-1) markets. Volume and size of trade are in $US million.

#	date	day of week	#trades	volume	mean size
1	11/01	W	207	1737	8.4
2	11/02	Th	157	1320	8.4
3	11/03	F	195	2253	11.6
4	11/06	M	138	1031	7.5
5	11/07	Tu	147	1244	8.5
6	11/08	W	148	931	6.3
7	11/09	Th	289	2746	9.5
8	11/10	F	198	1406	7.1
9	11/13	M	179	1479	8.3
10	11/14	Tu	223	1928	8.6
11	11/15	W	194	1635	8.4
12	11/16	Th	151	1170	7.7
13	11/17	F	177	1346	7.6
14	11/20	M	174	1624	9.3
15	11/21	Tu	110	841	7.6
16	11/27	M	232	2120	9.1
17	11/28	Tu	165	1188	7.2
18	11/29	W	220	1758	8.0
19	11/30	Th	237	1868	7.9
20	12/01	F	129	1154	8.9
21	12/04	M	120	1038	8.6
22	12/05	Tu	171	1675	9.8
23	12/06	W	117	930	7.9
24	12/07	Th	197	1621	8.2
25	12/08	F	243	2175	9.0
total			4518	38217	
Minimum			110	841	6.3
maximum			289	2746	11.6
average			181	1529	8.4
median			177	1479	8.4

* The median trade size of each and every trading day in the sample is around $5 millions.

Table 2

Descriptive Statistics: Types of Trades

This table lists all different types of trades, in terms of trade venues, of my $/DM dealer over the sample period of Nov. 1 -- Dec. 8, 1995. For definitions of different types of trades, refer to the text of the paper. All volume and trade size statistics are in US$ millions.

	(1) customer	(2) voice broker	(3) electronic broker	(4) Reuters incoming	(5) Reuters outgoing	(6) Reuters aggregate	(4+5+6) Reuters direct	(7) internal	(8) IMM	(9 limit/stop order	(10) misc.	total
# trades	194	1480	1283	312	130	29	471	928	101	54	7	4518
% total	4.3%	32.8%	28.4%	6.9%	2.9%	0.6%	10.4%	20.5%	2.2%	1.2%	0.2%	100.0%
volume	5299	9913	6649	5248	1500	2185	8933	6169	516	678	59	38217
% total	13.9%	25.9%	17.4%	13.7%	3.9%	5.7%	23.3%	16.1%	1.4%	1.8%	0.2%	100.0%
market-wide*	16%	21%	18%				25%	-	-	-	-	
average size	27.6	6.7	5.2	16.9	11.5	75.3		6.6	5.1	12.6	7.4	
median size	20	5	4	10	10	70		5	4.3	10	4	
25% size	12.25	5	2	10	10	40		3	2.6	8.5	0.5	
75% size	40	8.5	6	19	10	100		9.7	8.5	12	10	

***** Sources for market-wide statistics: Bank of International Settlements surveys, 1993 and 1996.

Table 3

Determining Active vs. Passive Trades

(all trades, Nov.1 -- Dec. 8, 1995)

This table presents the results of determining the aggressor of all types of trades. Most trades are classified as passive or active simply by trade channels. Passive trades thus classified include customer trades, internal deals, limit and/or stop-loss orders, and Reuters incoming trades. Active trades thus classified include Reuters outgoing trades and IMM trades. Brokered, both voice/traditional and electronic (EBS, etc.), trades and miscellaneous trades (such as trades done over the phone) are classified using quote-based methodology (details see text of the paper). Sample period: Nov. 1 -- Dec. 8, 1995.

	accumulating active trades	decumulating active trades	Subtotal: active trades	passive trades	total
number of trades	617	1429	2046	2472	4518
% of total number of all trades	13.7%	31.6%	45.4%	54.7%	100%
volume ($mm)	3842.8	11452.4	15295.2	22921.6	38216.8
% of total volume of all trades	10.0%	30.0%	40.0%	60.0%	100%

Table 4

The Speed of Inventory Control: Customer Trades

This table presents evidence on average inventories, net of cumulative laying-off trades, at trade time +1, +2 and +3 as a percentage of inventory shock immediately following customer trades at trade 0. Sample: 194 customer trades with an average size of $27 million (excluding cases in which the dealer builds up substantial inventory ahead of customer trades). Nov. 1 -- Dec. 8, 1995.

	trade +1 (2 min.)	trade +2 (4 min.)	trade +3 (6 min.)
Top two quartiles (size>=$20mm)	44.6%	18.4%	6.9%
Top quartile (size>=$38mm)	51.9%	18.6%	-10.0%

Table 5

Customer Trade Profits

This table presents estimated customer trade profits as compared to actual profits for all trades combined. Sample period: Nov. 1 -- Dec. 8, 1995.

	<------------ Customer Trades Only -------------->					<------- all trades --------->		
date	#deals	vol ($mm)	profits cust.($)	prof/ deal($)	prof/vol ($/mm)	profits all ($)	prof/ deal($)	prof/vol ($/mm)
1101	4	265	-3864	-966	-15	19375	94	11
1102	8	264	67318	8415	255	36414	232	28
1103	5	109	6608	1322	61	103760	532	46
1106	2	85	-6440	-3220	-75	-82043	-595	-80
1107	6	147	-18973	-3162	-129	-25143	-171	-20
1108	3	37	339	113	9	-50346	-340	-54
1109	16	498	56978	3561	114	150120	519	55
1110	7	128	-947	-135	-7	-2702	-14	-2
1113	4	107	9145	2286	85	29039	162	20
1114	7	242	7282	1040	30	46258	207	24
1115	5	272	9775	1955	36	134664	694	82
1116	6	86	18065	3011	209	12028	80	10
1117	9	210	8406	934	40	19058	108	14
1120	8	208	26933	3367	129	-142003	-816	-87
1121	5	169	14116	2823	83	3923	36	5
1127	23	435	13520	588	31	-44053	-190	-21
1128	8	160	-44593	-5574	-279	-38566	-234	-32
1129	6	150	5570	928	37	22034	100	13
1130	12	352	3702	309	11	16252	69	9
1201	13	231	72033	5541	313	72616	563	63
1204	5	71	-4755	-951	-67	49305	411	48
1205	8	293	12512	1564	43	15132	88	9
1206	5	81	64111	12822	796	91410	781	98
1207	10	316	7059	706	22	-30011	-152	-19
1208	9	383	-2262	-251	-6	17208	71	8
Total:	194	5299	321638			423729		
Customer trades as % of all trades	4.3%	13.0%	75.9%					
Average	7.8	212	12,900	1,500	69	17,000	89	9
Std.			27,000	3,700	192	65,000	376	44
t-statistic:				2.0	1.8		1.2	1.0

Table 6

Customer Trade Profits:
Industrial Corporations vs. Financial Institutions

Sample period: Nov. 1 -- Dec. 8, 1995.

		Industrial Corporation	Financial Institution
Trade data	# of trades	53	141
	volume($mm)	795	4504
	profits($)	62,000	260,000
profit/deal ($/deal)	average	1,900	1,600
	std	5,800	4,600
	t-statistic	1.47	1.74
profit/volume ($/$mm)	average	82	66
	std	295	187
	t-statistic	1.24	1.72

Table 7

Profits from Inter-Dealer Liquidity-Providing Trades:
Reuters Direct Incoming Trades

Liquidity-providing trades considered here include only inter-dealer *direct* trades arrived through Reuters 2000-1 dealing system. Trading profits on incoming *brokered* trades are excluded. See text for detailed discussions. Sample period: Nov. 1 -- Dec. 8, 1995.

Date	#deals	vol ($mm)	profits($) dealer	profits($) all trades	prof/deal ($)	prof/vol ($/mm)
1101	17	210.0	-18137	19375	-1067	-86
1102	10	190.0	-14211	36414	-1421	-75
1103	9	541.4	12681	103760	1585	34
1106	6	140.5	15665	-82043	3133	130
1107	6	225.0	18443	-25143	3074	82
1108	6	61.0	10361	-50346	1727	170
1109	19	250.0	25865	150120	1990	136
1110	13	132.0	-17236	-2702	-1326	-131
1113	10	174.0	785	29039	71	4
1114	23	340.0	33941	46258	1476	100
1115	13	156.5	3764	134664	290	24
1116	8	208.0	-9354	12028	-1169	-45
1117	7	101.0	-3857	19058	-551	-38
1120	15	325.0	-42418	-142003	-2828	-131
1121	11	109.6	4228	3923	384	39
1127	20	321.0	-38653	-44053	-1933	-120
1128	10	120.0	-1284	-38566	-117	-10
1129	13	278.0	2842	22034	178	9
1130	22	250.2	-8059	16252	-366	-32
1201	8	160.0	10007	72616	1430	71
1204	16	269.0	-13968	49305	-931	-53
1205	18	295.0	21422	15132	1190	73
1206	6	80.0	9763	91410	1627	122
1207	12	140.0	-10816	-30011	-832	-72
1208	14	171.0	-10342	17208	-796	-61
Total	312	5248.2	-18567	423729		
% all trades:	6.8%	13.7%	-4.4%			
average			-743		193	6
std.			18,000		1,500	88
t-statistic					0.63	0.32

Table 8

Speculative Trades and Profits

This table presents speculative trade profits estimated as residuals of actual profits nets of customer trade profits and liquidity-providing trade profits. The speculative trade activities are measured as the daily total amount of accumulative active trades not followed by (anticipated) incoming orders. Sample period: Nov. 1 -- Dec. 8, 1995.

date	#deals	vol ($mm)	% tot vol	profits ($)	prof/deal ($)	prof/vol ($/mm)
1101	13	80.5	4.6%	41375	3183	514
1102	9	42.3	3.2%	-16693	-1855	-395
1103	12	72.0	3.2%	84470	7039	1173
1106	10	57.9	5.6%	-91268	-9127	-1576
1107	16	88.7	7.1%	-24613	-1538	-277
1108	17	73.4	7.9%	-61045	-3591	-832
1109	23	155.1	5.6%	67276	2925	434
1110	16	98.5	7.0%	15481	968	157
1113	11	56.0	3.8%	19109	1737	341
1114	17	97.6	5.1%	5035	296	52
1115	16	95.0	5.8%	121125	7570	1275
1116	9	53.0	4.5%	3317	369	63
1117	12	56.0	4.2%	14510	1209	259
1120	13	56.0	3.4%	-126519	-9732	-2259
1121	10	51.5	6.1%	-14421	-1442	-280
1127	6	41	1.9%	-18920	-3153	-461
1128	5	29.0	2.4%	7311	1462	252
1129	18	109.0	6.2%	13622	757	125
1130	15	68.0	3.6%	20609	1374	303
1201	5	30.0	2.6%	-9424	-1885	-314
1204	3	28.5	2.7%	68028	22676	2387
1205	10	55.0	3.3%	-18801	-1880	-342
1206	8	57.3	6.2%	17536	2192	306
1207	5	33.0	2.0%	-26255	-5251	-796
1208	6	21.1	1.0%	29812	4969	1413
total	285	1605		120659		
% all trades:	6.3%	4.2%		28.5%		
average	11.4	64.2		4,800	770	61
std.				52,000	6,200	940
t-statistic					0.6	0.3

Table 9

Coefficient Estimates for the Spread Component Model

The model to be estimated is:

$$\Delta p_t = a(Q_t - Q_{t-1}) + b_1 Q_{t-1} + \cdots b_8 Q_{t-8} + c(D_t - D_{t-1}) + u_t$$

where ΔP_{it} is the price change measured in pips (i.e. 0.0001DM/$) from t-1 to t. Q_{t-j}, j = 0,1,...,8 and measured in US$ million, is the transacted quantity at lag j effected at dealer quote, positive for buyer-initiated trade (at dealer i's offer) and negative for seller-initiated trade (at dealer i's bid). D_t is an indicator variable with value 1 for buyer-initiated trade, and value -1 for seller-initiated trade. All coefficients are multiplied by a factor of 10. Sample: Nov. 1 -- Dec. 8, 1995, 2227 observations.

	a	b_1	b_2	b_3	b_4	b_5
coeff. est.	0.302	0.458	-0.007	0.171	0.189	0.052
t-statistic	3.06*	3.69	-0.08	2.01*	2.14*	0.59

(Cont'd)

	b_6	b_7	b_8	*sum of* b_j*'s*	c	R^2
coeff. est.	-0.134	0.119	0.030	0.879	13.58	0.096
t-statistic	-1.51	1.35	0.34	3.37*	10.9*	

* Significant at the 5% confidence level.

	Direct (Reuters 2000-1)	**Voice Broker (Telephone)**	**Electronic Broker (Matching system)**
Anonymity (ex ante)	No	Yes	Yes
Reciprocity	Yes	No	No
Quote availability in fast markets	Yes	Low	Low
Speed	Very fast	Relatively slow	Very fast
Liquidity	Very good (“line up the banks”)	Good, especially during non-overlapping hours	Good, limited at times
Trade size	varies, only medium available for large trade	small to median (median $5 million)	small, but growing (median $3-5 million)
Commissions	None	Yes (starts at $8/million)	< voice broker fees
% volume: my dealer	23.5%	25.9%	17.4%
*Market-wide statistics**	25%	21%	18%

* Sources for market-wide statistics: Bank for International Settlements survey, 1993 and 1996.

Fig. 1 Comparison of trade channels for interbank dealings.

Date 11/7		Currency: DM/$		Dealer Name	Value Date 11/9	
CUSTOMER		BUY	SOLD	RATE	NET POSITION	AVERAGE
		($ mil.)	($ mil.)	(DM/US$)	($ mil.)	(DM/US$)
Previous balance					-22.6	
BANK 1	B	5		1.4151	-17.6	
BANK 2	B	8		51	-9.6	
BANK 3	Q		2	50	-11.6	
COLLEAGUE 1		5		48	-6.6	
IMM	50	(6.25)	4.4	48	-11.0	
BANK 4	Q		3	47	-14.0	1.4151
CUSTOMER 1	S	17.22	(24.375)	53		
BANK 5	Q		10	53		
BANK 6	B		5	54	-12.0	
BANK 7 **	R	10		50	-2.0	
...	...	...	...	...	...	...

Fig. 3. Example: one of my dealer's actual trading blotters on November 7, 1995.

This figure provides an example of one of many trade blotters recorded by my DM/US$ dealer every day. Each page starts with a balance from the previous page, or previous day if it is the first blotter of a trading day. The first column is the counterparty identity of each trade, such as the name of a corporation in a customer trade, the name of a bank in an inter-dealer trade, or the name of the dealer's colleague in an internal deal. The second column indicates the trade channels, where B stands for voice broker (by name of the broker), Q for electronic broker, S for the name of the salesperson involved in a customer trade, and R for Reuters direct trade. A number in the second column associated with an entry of "IMM" in the first column indicates the number of contracts traded on the IMM futures market. Entries in the "BUY" and "SELL" columns are in millions of U.S. dollars. When the original trade amount is in DMs, such as an IMM trade with contract size denominated in DMs or a trade involving a customer with a DM invoice, my dealer enters the DM amount as well in parentheses, and then convert the DM amount to U.S. dollars at the corresponding DM/US$ trade price for position keeping.

** For this Reuters direct trade, I match up with Reuters 2000-1 records and identify the time as 14:41 GMT, and the quoted spread 50-55. Since the dealer is buying at the bid, this trade is identified as an incoming trade.

From *CODE* *BANK NAME* * 1441GMT 071195 */4260
Our terminal: *CODE* Our user: *DEALER NAME*

```
        DM 10
#  5055
        I  SELL
#  VAL  09NOV95
#  TO  CONFIRM  AT  1.4150  I  BUY  10  MIO  USD
#  MY  USD  TO  USD  DIRECT
#  THANKS  AND  BYE
        VAL  09NOV95
        MY  DEM  TO  BANK  NAME  FRANKFURT
        TO  CONFIRM  AT  1.4150  I  SELL  10  MIO USD
#
        # INTERRUPT #

        # END REMOTE #

( 239 CHARS)
```

Fig 4. Example of an actual Reuters Dealing 2000-1 communication at 14:41 Greenwich Mean Time (GMT) on November 7, 1995.

The example in this figure describes an incoming trade in which another dealer requests a quote for $10 million worth of DMs from my dealer, and hit my dealer's bid price of 1.4150 DM/US$ (The offer side of the two-way quote is 1.4155 DM/US$). Such a $10 million trade is considered normal among major DM/US$ dealers who maintain "$10 million relationship" with each other. Note that the bid-ask spread of 0.0005 DM/US$ (or 5 pips) is only 3.5 basis points of the trade size. Coded information in the first two lines (in italics) indicates the identities of the two parties (actual names disguised) involved in this inter-dealer direct trade. The conversation is very concise, often in pre-programmed Reuters language, so that a trade can be completed in just a few seconds. The Reuters 2000-1 dealing system allows a FX dealer to conduct such conversations with four dealers simultaneously.

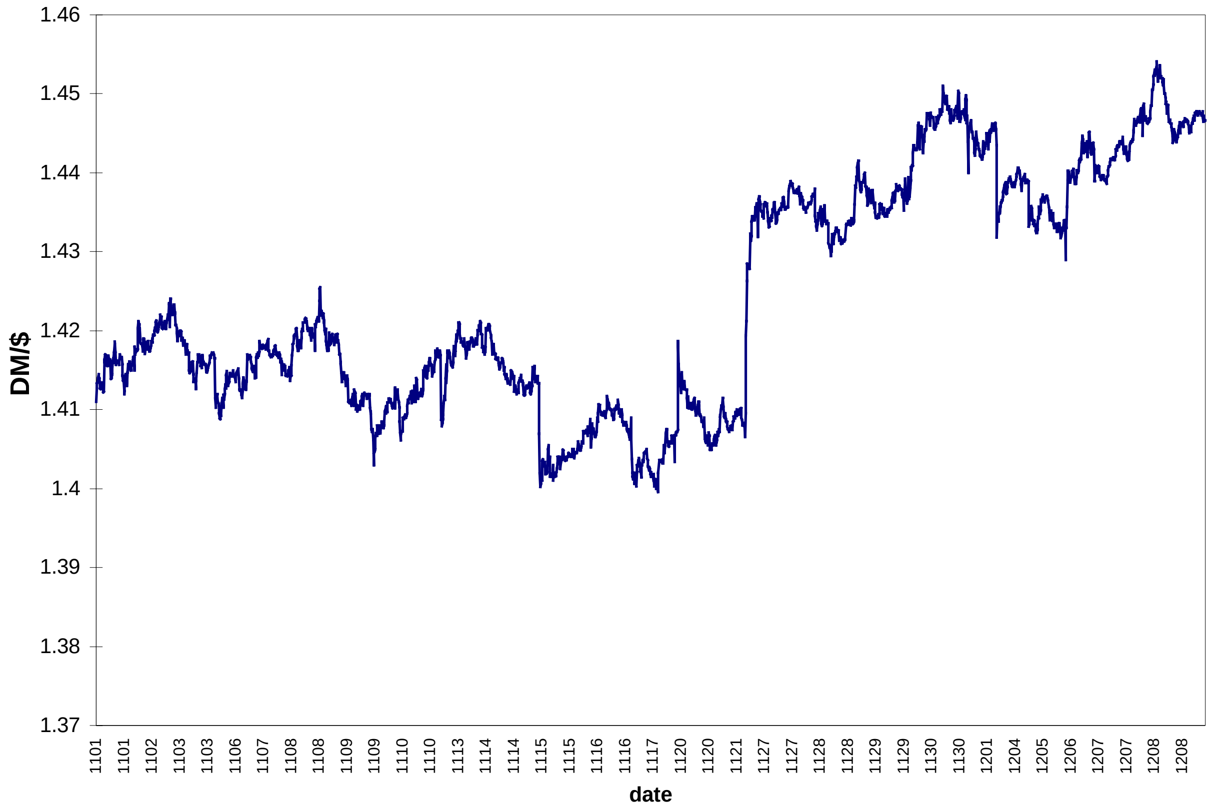

Fig. 4 Transaction price: DM/$, *Nov. 1 - Dec. 8, 1995*.

The figure plots the transaction price of DM/$ of each incoming passive trade over the entire 25-day sample period. The sample period, Nov. 1 - Dec. 8, 1995, covers 25 continuous trading days except for (1) weekends and (2) Thanksgiving Day (11/23) when the U.S. operation is closed, and the day before (11/22) and after (11/24) when the dealer, like most other North American dealers, did not quote or trade in the Reuters 2000-1 direct interbank market. Passive trades include customer trade, internal deal, limit order, Reuters incoming trade, and brokered trade which is signed by quote-based methodology and determined as incoming passive trades. Note that the date (x-axis) tick mark is not evenly distributed, indicating different trade volume (in terms of numbers of passive trades) across trading days.

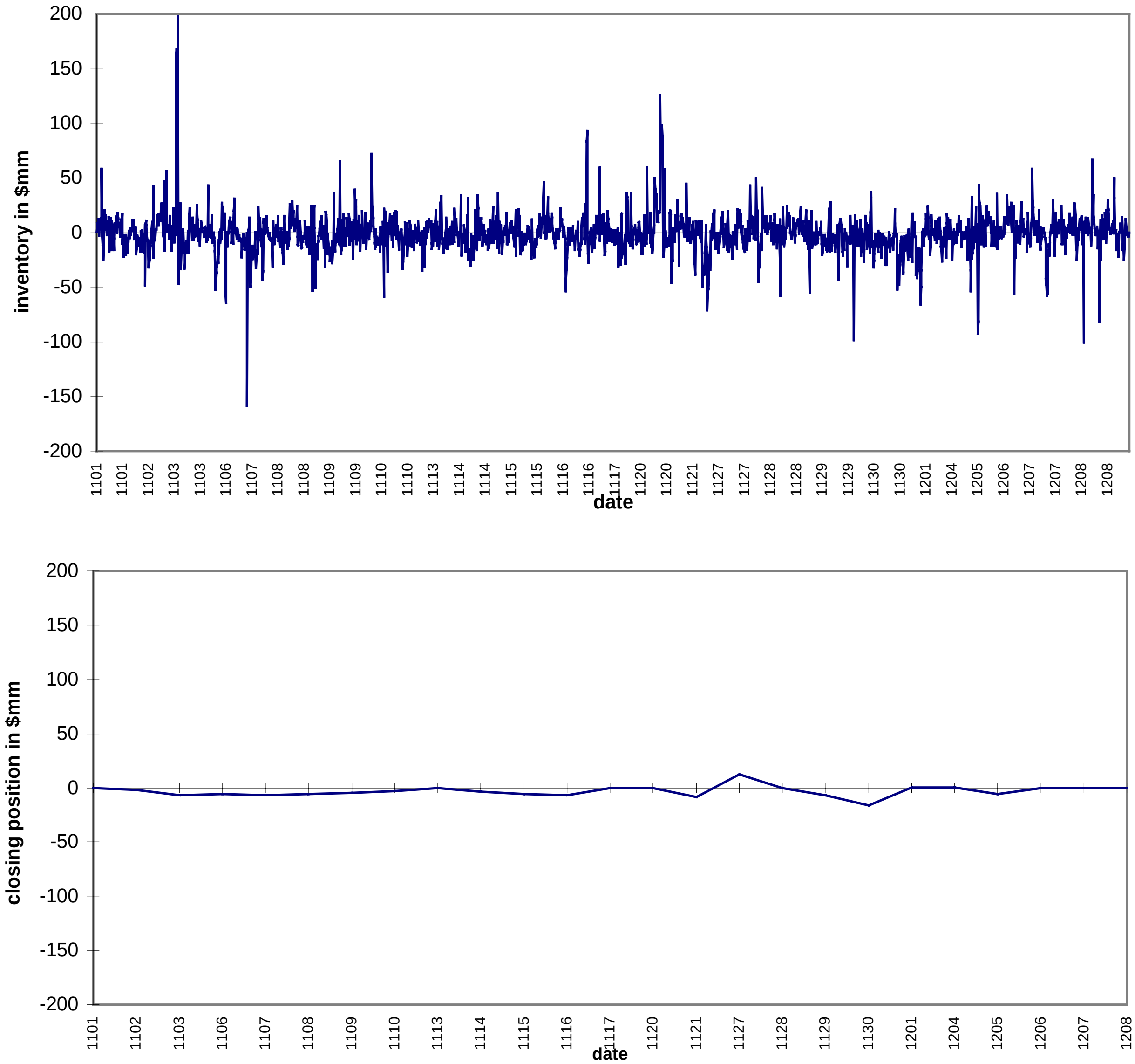

Fig. 5 Net inventory and daily closing position in millions of US$, *Nov. 1 - Dec. 8, 1995*.

The chart at the top plots the $DM dealer's net position in millions of US$ at the time of each incoming passive trade over the entire 25-day sample period. Note that the date (x-axis) tick mark is not evenly distributed, indicating different trade volume (in terms of numbers of passive trades) across trading days.

The chart at the bottom plots the dealer's daily closing inventory in millions of US$ over the 25-day sample period. The chart has the same scale as the one at the top.

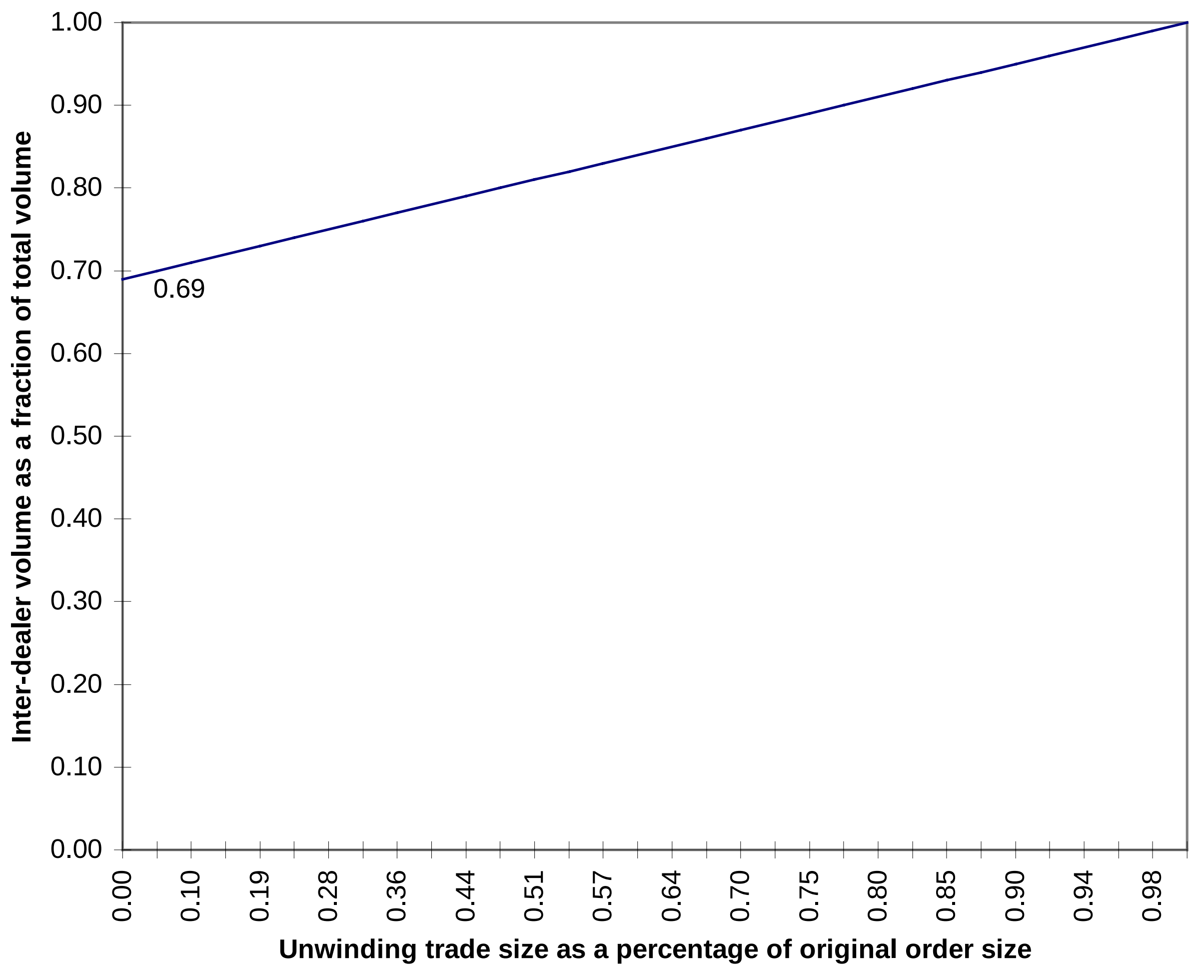

Fig. 6 Inter-dealer volume and size of unwinding trade in an illustrative example.

The plotted relationship between inter-dealer trade volume and unwinding trade size is a generalized result of the relationship between the dealer's unwinding trade size and the amount of inventory shocks (both as percentages of original order size) that have to be laid off to maintain zero expected profits. The example assumes that all the dealer's unwinding trades are outgoing active trades at other dealers' quotes. Under a simple quote schedule linear in trade size, the dealer use small unwinding trades of identical sizes to reduced the price impact.