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WHAT DETERMINES TRANSACTION COSTS IN FOREIGN EXCHANGE MARKETS?

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ABSTRACT

Using detailed data on the currency transactions of institutional fund managers, this paper shows that funds that experience high returns on their currency holdings also incur lower transaction costs on their currency trades. This finding holds both in the cross section, i.e. funds that perform better on average incur lower average transaction costs, as well as in time series, i.e. funds that do better over the past two months incur lower transaction costs on subsequent transactions. The results are consistent with foreign exchange dealers bidding for information from successful traders. They are also consistent with foreign exchange dealers exploiting price inelastic demand for foreign currency trades, or funds acting as secondary liquidity providers in foreign exchange markets. The paper also investigates the role of fund size, transaction frequency and return volatility on transactions costs. Copyright © 2007 John Wiley & Sons, Ltd.

KEY WORDS: Exchange rates; foreign exchange; currencies; transaction costs

1. INTRODUCTION

Two important determinants of transactions costs incurred by traders in financial markets are the perceived information content of the trade and the trade disclosure regime. If trading is anonymous, as in equity markets, then the market intermediary offers a price based on his/her unconditional expectation of the information content of aggregate order flow (see Kyle, 1985). In contrast, if trading is not anonymous, as in foreign exchange markets, then the execution price for any trade can be conditioned on the identity of the counterparty trading with the intermediary. Furthermore, it is not always necessary that an informed trade will obtain a worse price than an uninformed trade. An important determinant of whether this is the case is the trade price disclosure regime—in markets with little post-trade transparency, dealers can more easily rebate transaction costs for informed traders to subsequently benefit from such purchased information in follow-on trading or price-setting.

This logic is made explicit in the model of Naik *et al*. (1999), who use a stylized model of a competitive dealership market in which trades are negotiated and trade details are published with a delay. In such a market, an informed trade can obtain a better price because the intermediary profits in subsequent trading from the information contained in the trade. According to the model, the intermediary rebates a part of the profit to the counterparty bringing in the information. The assumptions about market structure in Naik *et al*. (1999) capture the key features of the foreign exchange market, in which trades are negotiated (i.e. trading is not anonymous) and post-trade disclosure is virtually non-existent.

This paper uses very detailed proprietary data on trading in the foreign exchange market and tests key implications of the model of Naik *et al*. (1999). In so doing, it makes two important contributions to the

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literature. First, it sheds light on trading behaviour in foreign exchange markets, demonstrating that trading in these markets is very different from equity markets. Note here that trading volume in foreign exchange markets dwarfs trading volume in highly analysed equity markets like the NYSE. [1] Second, it shows, contrary to the conventional wisdom based on studies of equity markets, that better informed traders in foreign exchange markets obtain better, not worse, transactions prices. Both in the cross section and time series, better performing funds tend to have lower transaction prices on their currency trades. This is in accordance with the theoretical model and is consistent with foreign exchange dealers bidding for information from successful traders. The finding is robust to controlling for other well-known determinants of transaction costs, such as fund size, transaction frequency and return volatility.

Related empirical analyses of the foreign exchange market have tended to focus on the effects of volatility and inter-dealer competition on spreads. [2] This paper is the first to employ transactions data of foreign exchange trading by large institutional investors to explore the interaction between intermediaries and customers. The funds considered here trade a range of securities, including international equities, debt, derivatives and currencies. The level of detail about the cross section of funds is quite high, enabling the measurement of the effects of fund-specific attributes on the prices funds receive from dealers, which in turn influences their trading behaviour in several ways.

The proprietary data utilized in this paper are not time-stamped, hence only the day on which a transaction occurred is known. Hence, the effective spread on a transaction is measured as the distance between the transaction price and the close spot foreign exchange price on the day on which a fund conducted the transaction. This measure is the one that has been widely employed in the microstructure literature using dealing with daily data (see Biais and Declerk, 2006, for one recent example). The measure would be an exact measure of a fund's bid-ask spread if traders transacted precisely at the day's close.[3] The lack of time stamps introduces two alternative interpretations of the results.

First, these results are consistent with the presence of traders who help dealers achieve desired inventory levels by being secondary liquidity providers. Such traders might be given better transactions prices for taking on positions that dealers find unpalatable. They would also accrue returns from liquidity provision or from their trading behaviour. This is possible if traders are contacted by dealers directly, or if traders are simply good at identifying intraday currency movements, buying on dips and selling on spikes in currencies.

Second, these results could arise if dealers perceive differing price elasticities of demand for foreign exchange, and exploit this when pricing. Say there are two distinct trader types in the data. The first type comprises traders who specialize in currency trading. The second consists of traders who purchase currencies primarily to transact in underlying international securities, and have little price elasticity of demand for foreign currencies. If dealers price discriminate, they might rebate transactions prices for the high return earners, and provide worse execution for those funds not specializing in currency trading. This explanation is undermined somewhat by the time-series evidence in this paper that recent good performance is rewarded with better transactions prices. This suggests that even within categories, there may be rebates conditional on accruing high returns.

Three recent papers are closely connected to the ideas in this paper. First, Osler *et al.* (2006) provide independent evidence for the importance of strategic dealing, using detailed transaction records from a foreign exchange dealer at a German bank. The data distinguish between financial and commercial transactions, and the authors demonstrate that the narrowest spreads are incurred by the financial transactions, which are most likely to contain information. They investigate several hypotheses for their findings, and conclude that they are likely driven by strategic dealing, a conclusion identical to the one in this paper. Second, Bernhardt *et al.* (2005) analyse the London Stock Exchange and find evidence that larger trades benefit from lower transactions prices, and attribute this to intertemporal competition between dealers for customer transactions. While their analysis provides evidence consistent with price discrimination (considered as one alternative explanation of the results in this paper), the authors do not consider asymmetric information in their model. Finally, asymmetric information is considered by Green *et al.* (2006), who find evidence of different prices incurred by differentially informed traders in municipal bond issues. However, these authors measure 'informedness' using a mixture of distributions model, not having access to trader identity directly.

More generally, this paper is related to the large literature on the effects of anonymity on the microstructure of asset markets. Theoretical analyses include those of Lyons (1996), Admati and Pfleiderer (1991), Röell (1990), Forster and George (1992), Pagano and Röell (1996) and Seppi (1990). Empirical papers include Madhavan and Cheng (1997), who use data from the NYSE to show, consistent with the predictions of Seppi (1990), that liquidity traders trade large blocks[4] in the non-anonymous 'upstairs' market, incurring lower transactions costs, while informed traders trade anonymously. Theissen (2003) finds that liquidity traders receive better execution in the non-anonymous Frankfurt Stock Exchange. Fishman and Longstaff (1992) show that in commodity futures markets with dual trading brokers, informed traders have lower profitability than they would in the absence of dual trading. The findings in this paper appear opposite to those presented in these empirical papers. If the logic of the Naik *et al.* (1999) model is correct, this may not be surprising in light of the differences between the structure of the foreign exchange market and the markets under investigation in these papers.

The evidence in this paper also speaks to the growing literature on international portfolio investment flows. Authors such as Froot *et al.* (2001), Seasholes (2004) and Froot and Ramadorai (2005, 2007) present evidence that the aggregated investment flows of institutional investors positively anticipate equity and currency returns in local markets. This observed anticipation could be generated by superior information on the part of these institutions, or simply by price pressure. If information lies behind the observed anticipation, standard microstructure models would suggest that the response of intermediaries in local markets would be to raise prices to avoid adverse selection risk from the trades of large foreign institutions. The results in this paper suggest that in non-anonymous currency markets, intermediaries might welcome such informed trading rather than penalize it, making informed trading in currencies even more profitable. The paper also demonstrates that studying the cross-section of foreign institutional traders yields rich insights about trading behavior that are not apparent from aggregated flows.

The second section introduces the data and measures used in the study. The third section describes the empirical methodology, and the fourth section provides results from the specifications. Section five concludes.

2. DATA

2.1. Foreign exchange transactions data

The foreign exchange transactions data used in this paper are provided by State Street Corporation (SSC). State Street is the largest US master trust bank and one of the world's largest global custodians. It has approximately $7 trillion of assets under custody. State Street records all transactions in these assets, including cash, underlying securities, and derivatives. SSC sees approximately 3–6% of total global flow in currencies in the course of its custodial business.

Only currencies classified by the IMF as having some variant of a free float are used in this study. The 19 countries in the sample are: Australia, Canada, Euroland, Japan, New Zealand, Norway, Sweden, Switzerland, UK, Mexico, Indonesia, Korea, Philippines, Singapore, Taiwan, Thailand, Poland, India and South Africa. Pre-euro, Euroland is an aggregate, that represents trades in all of the 11 Euroland countries—these trades are paired with the deutsche mark prior to the introduction of the euro. Our sample period begins on 1 January 1994, and continues through 9 February 2001, covering 1855 days for the 19 countries.

The fund is the primary unit of analysis in the data.[5] The funds in the data are a mix of funds trading currencies for a variety of purposes. Some funds use currencies to simply fund purchases of other assets, while others actively hedge currency risk, and make speculative trades on international currency movements. Note that aggregated transactions from these funds statistically forecast excess currency returns over 40-day periods in both major and emerging market currencies (see Froot and Ramadorai, 2005). There are a total of 13 230 funds represented in the data, from which 1275 funds are selected. Each fund trades in at least seven of the 19 currencies in the set, of which at least one is an emerging market. Each fund has an active period of at least 120 days, and trades at least 50% of those days. There are a total of 3 642 690 transactions made by these funds over the sample period, and a total of 1 921 530 fund-

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currency-days on which trades are actually conducted. Each transaction is a cross-currency transaction, meaning that each buy is matched with a countervailing sell. Since the preponderances of transactions (above 95%) in the data are conducted against the US dollar, there is very little double-counting in the data. For the current study, any transaction which has a present value of less than US $1000 for any currency is excluded to clean out transactions that were effected for the purposes of corporate actions. This filter eliminates less than 0.01% of the total volume for any currency, and does preserve transactions (such as income repatriation) that are in the $1000–$100 000 range.

2.2. Measuring performance and transactions costs

Performance. The dollar return for each fund-day is computed as:

$$r_{i,k,t+1} = B_{i,k,t}(s_{t+1} - s_t - (i_t^{\$} - i_t^k)) \tag{1}$$

where $B_{i,k,t}$ is the balance accumulated by fund i in currency k on day t, computed as the cumulative sum to date t of the fund's (present valued) transactions in currency k[6]; s is the value of the log nominal exchange rate defined in terms of USD per unit of foreign exchange; $i^{\$}$ and i^k are, respectively, the continuously compounded one-period USD and foreign currency riskless interest rates. Note that this return is the same if computed using real exchange rates and real interest differentials rather than nominal variables.

This measure of returns is obtained by comparing the returns on holding currency balances unhedged relative to what the returns would have been if hedged using a forward contract. To see this:

$$r_{i,k,t+1} = B_{i,k,t}((s_{t+1} - s_t) - (\phi_{t,t+1} - s_t)) \tag{2a}$$

$$= B_{i,k,t}(\text{Unhedged}_{t+1} - \text{Hedged}_{t+1}) \tag{2b}$$

where $(i_t^{\$} - i_t^k) = \phi_{t,t+1} - s_t$ is the forward premium by covered interest parity (ϕ is the log price of a forward contract in USD per unit of foreign exchange, and s is the nominal exchange rate in USD per unit of foreign exchange). Hence, a trader who sold the entire foreign currency balances forward would earn a return equal to the interest differential. In contrast, if the trader did not sell the balances forward, the realized return would be $s_{t+1} - s_t$. Consequently, the return for a trader who does not hedge his/her balances, relative to one that does sell his/her balances forward is given in equation (1).

In the specifications below, this return is normalized by the balance, to yield a percentage return per day per fund, $r_{i,k,t+1} = (s_{t+1} - s_t - (i_t^{\$} - i_t^k))$. This is used in the time-series regressions. Furthermore, in all specifications, days on which transactions are conducted are not included when computing fund returns, to avoid the possibility of any mechanical contamination.

For the cross-sectional regression specifications, a Sharpe ratio is computed which divides the mean daily return, $\mu(r_{i,k,t})$, by the standard deviation of the daily return, $\text{Vol}(r_{i,k,t})$, over the entire life of the fund:

$$\text{SR}_{i,k} = \frac{\mu(r_{i,k,t})}{\text{Vol}(r_{i,k,t})} \tag{3}$$

Transactions costs. A widely accepted method for measuring the transaction cost of trades in equity markets is the effective spread of a trade (see Roll, 1984; Stoll, 1989; Huang and Stoll, 1997). It is a measure of the distance between the price at which the trade is conducted, and the pre-existing quote midpoint in the market prevailing at the time of the trade.

The percentage signed effective spread on a transaction conducted on date t, transactions indexed by τ, is computed as:

$$\text{spr}_{t,\tau} = \iota \log\left(\frac{C_{t,\tau}}{S_t}\right) \tag{4}$$

Here, $C_{t,\tau}$ is the contracted price of the (spot or forward) foreign exchange trade. In the case of forward transactions, the effective $C_{t,\tau}$ is calculated as the ratio of the present values (computed using standard

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foreign exchange conventions, see Appendix A.1) of the notional amounts transacted forward in each currency. Here ι is a sign indicator, -1 for a purchase, and $+1$ for a sale—this ensures that the spread is positive when there is a cost incurred by the trader, and negative when the trader performs better than the daily spot close. S_t is the spot cross-rate between the two transacted currencies on day t.

The absence of time stamps in the data forces reliance on the close spot foreign exchange rate between the currencies on the day the transaction was conducted. This introduces noise into the spread measure. Spreads are winsorized at the 1 and 99 percentile points of the distribution across all fund days within each currency to attenuate the effect of outliers on the results.[7] Note that experimenting with different benchmarks such as prior day's close price; the average of prior day's close and current day's close, and the midpoint of daily high and low prices obtained by funds in the data set does not affect the results.[8]

The mean spread across all transactions conducted by a fund in each of the currency groups (denoted by spr_i, and measured in basis points) is used to measure the average transaction cost for the fund.

2.3. *Summary statistics*

Table 1 describes the cross section of funds in each currency. First, the cross-sectional distributions of total absolute trades by fund and number of trades per fund are both right-skewed. Furthermore, the standard deviation of total absolute trades per fund is very high. This indicates that the few funds that are larger than the cross-sectional mean trade size have transacted very large amounts. Second, the number of funds that transact in each currency is highest in the major currencies, and there is a large attenuation of both the mean and the standard deviation of the number of transactions per fund in the other currencies. In addition, the mean total absolute transact per fund in the smaller currencies is significantly lower than that in the larger, more liquid currencies.

Table 1. Summary statistics: cross-section of funds

	$N(F)$	$\mu_i(\Sigma_t(\tau_t^i))$ US\$ MM	$m(\Sigma_t(\tau_t^i))$ US\$ MM	$\sigma_i(\Sigma_t(\tau_t^i))$ US\$ MM	$\mu_i(N_t(\tau_t^i))$	$m(N_t(\tau_t^i))$	$\sigma_i(N_t(\tau_t^i))$
Major							
Euroland	1275	1285.67	199.42	4097.78	1002.57	680	1073.92
Japan	1150	655.30	119.83	2083.00	452.59	306	467.49
UK	1249	409.03	78.06	1270.66	398.60	254	473.39
Switzerland	1121	201.22	23.46	1060.10	128.04	81	182.69
Canada	1021	273.45	18.61	1142.78	301.13	83	777.27
Australia	1162	270.18	18.10	1297.67	251.17	102	534.37
Other							
Sweden	1124	116.14	18.65	415.44	121.94	80.5	144.42
New Zealand	817	64.50	3.09	348.97	69.44	28	233.08
Korea	582	41.93	8.46	136.37	100.87	43.5	155.27
Singapore	1040	26.78	4.87	104.32	75.68	44	100.67
Norway	783	28.37	3.66	122.69	46.58	29	55.89
Mexico	638	14.76	2.72	37.34	70.55	27	114.68
South Africa	487	22.15	3.81	74.66	79.32	28	147.13
Taiwan	244	29.64	5.15	78.63	23.14	10	33.80
Thailand	666	12.99	2.43	39.74	68.21	25.5	126.33
India	142	41.35	8.28	103.09	106.73	41.5	158.36
Indonesia	550	12.84	2.43	36.75	69.99	33	104.34
Poland	197	11.44	2.31	25.59	51.43	18	87.37
Philippines	530	9.59	1.61	25.96	69.91	26	96.71

Note: The currency trading funds in the sample are custodial clients of State Street Corporation. The sample period is from 1 January 1994 to 9 February 2001. Column 1 reports the number of funds that transact in each currency. Columns 2–4 report the fund cross-sectional mean, median and standard deviation, respectively, of time-aggregated absolute value of trades for each fund, in millions of US\$. Columns 5–7 report the mean, median and standard deviation for the total number of trades per fund in each currency. The rows indicate the currency for which the statistics are being computed. Currencies are grouped into 'Major' and 'Others'.

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Table 2. Summary statistics: performance and transactions costs

	Currency groups		
	All	Major	Other
Spread			
μ	−3.096	−3.731	−2.381
median	−1.807	−2.689	−0.446
σ	10.418	6.075	18.638
Sharpe ratio			
μ	−0.015	−0.015	−0.008
median	−0.016	−0.019	−0.009
σ	0.050	0.049	0.040
Volatility			
μ	30.539	37.579	27.290
median	26.005	39.586	20.600
σ	14.124	8.217	20.592

Note: The table presents descriptive statistics on the Sharpe ratio of funds measured using daily returns on their transactions in the currencies of the specified group of countries (all, major and other), the volatility of fund returns in basis points, measured by averaging the standard deviation of daily fund returns from trades in the currencies of each group of countries (all, major and other); and the mean effective spread in basis points over all fund transactions (spreads are winsorized at the 1 and 99 percentile points of the distribution of all fund-days within each currency). Statistics are reported for each of the currency groups, major, other, and all currencies. The first row in each panel reports the cross-sectional mean across funds, the second the cross-sectional median and the third the cross-sectional standard deviation across funds of these three measures.

Table 2 presents descriptive statistics for the performance and transactions costs measures. First, measured Sharpe ratios, on average, are negative across all currencies. From a separate calculation, median total dollar profits are approximately \$600 000 across all fund currencies, over an average trading period for all funds of 948 trading days. Clearly the funds are making a loss, on average, relative to fully hedging their currency balances.[9] Nevertheless, the dispersion in performance is quite high. The standard deviation of dollar profits for all currencies is very high, on the order of US \$60 million. These profits seem to be about evenly distributed between the major countries and other countries, though from inspecting the median dollar Sharpe ratios, it seems as though the funds are doing better in the other/emerging market countries. Second, measured spreads are on average negative in the cross section, across all measures and currency groups, indicating that the funds appear to be transacting at rates better than the close price on days on which transactions were conducted. It is clear that the reported spreads are quite small compared to similar numbers in equity markets, considering the large size of the notional amounts reported in Table 1. This confirms the commonly accepted notion that foreign exchange markets are extremely liquid compared to almost any other type of asset market. The mean winsorized spread paid by funds in each of the three currency groups is of the order of 2–3 basis points which is in accordance with the magnitudes of reported spreads in the foreign exchange market (Cheung *et al.*, 2004, report that DM/\$, £/\$, ¥/\$ and CHF/\$ all have mean spreads of between 3 and 4.5 basis points). The standard deviation of fund mean spreads in the cross section is between 10 and 19 basis points, signifying that there is a good deal of variation across funds in this measure. The high standard deviation in the measure also reflects the noise contributed from the lack of time stamps in the data. Finally, the table also presents the volatility of fund daily returns (measured as the standard deviation of daily returns on currency transactions in each group of countries). Perhaps surprisingly, the volatility of fund returns is higher on average on account of their transactions in the major currencies—the average annualized volatility of returns in the major currencies (under the assumption that successive daily currency returns are i.i.d.) is 5.94% per annum. This can be compared to the 4.31% per annum volatility of fund returns from trading in the other currencies. However, the cross-sectional standard deviation of fund return volatility is more than twice as high in the other than in the major

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countries, suggesting that there are many funds with high return volatility, generated by their trades in emerging market currencies.

3. REGRESSION SPECIFICATIONS

3.1. Cross-sectional specifications

As a first step, cross-sectional regressions are estimated to identify the determinants of fund transactions costs. Writing spr_i^{gr} for the average spread (expressed in basis points) experienced across all currencies in a specific group by fund i; Vol_i^{gr} for fund return volatility measured over its lifetime in the currencies in a specific group; and SR_i^{gr} for the Sharpe ratio over the fund's lifetime in the currencies in a specific group, the specification is:

$$\text{spr}_i^{gr} = \alpha + \beta_{Vol}\text{Vol}_i^{gr} + \beta_{SR}\text{SR}_i^{gr} + \beta_{size}\text{size}_i^{gr} + \beta_{tr}\text{tr}_i^{gr} + \varepsilon_i \quad (5)$$

There are two additional regressors in equation (5). The first is $\text{size}_i^{gr} = \sum_{j=1}^{J_i} \sum_{gr} |f_{i,gr,j}|$ (where j indexes the days that fund i is alive), a measure of the size of a fund, constructed as the summed absolute value of the net transact per day in currencies in the specified group across the fund's lifetime. The second is $\text{tr}_i^{gr} = (1/J_i) \times \sum_{j=1}^{J_i} n(\tau_{i,j}^{gr})$, the daily mean number of transactions entered into by fund i in currencies belonging to the specific group. This is a measure of fund transaction frequency.

Next, greater flexibility is allowed by estimating the equations in a panel setting, stacking the dependent variables, the spreads, for each fund i and currency k. Estimating in a panel lends greater power to the specifications, and also allows for separate country fixed effects, to capture variation in the mean across currencies. In these panel specifications, Vol_i and SR_i are estimated over the transactions in all currencies within each group. This is because dealers are more likely to condition spreads on the performance and volatility of returns of the fund in the currency group as a whole. Additionally, this helps us to avoid the problem of sparse trades in specific currencies. The panel specification is:

$$\text{spr}_{ik}^{gr} = \alpha + \beta_{Vol}\text{Vol}_i^{gr} + \beta_{SR}\text{SR}_i^{gr} + \beta_{size}\text{size}_{ik}^{gr} + \beta_{tr}\text{tr}_{ik}^{gr} + \varepsilon_{ik} \quad (6)$$

3.2. Time-series specification

The following time-series specification is estimated for each currency group:

$$\text{spr}_{i,k,t} = \alpha + \Gamma^{spr}(L)\text{spr}_{i,k,t-1} + \Gamma^{r}(L)r_{i,k,t-1} + \varepsilon_{i,k,t} \quad (7)$$

$r_{i,k,t}$ denotes the returns for a fund i in a currency k on day t. $\text{spr}_{i,k,t}$ is the average spread over all transactions done by fund i in currency k on day t. Clearly, the most natural test would be to use cumulative returns up until time $t-1$ as the conditioning variable, rather than daily returns. However, since cumulated returns will be $I(1)$ over medium length sample periods, putting them into the regression would be statistically unsound. In order to capture lower frequency dynamics, therefore, lags of up to three months (60 trading days) are incorporated into the regression. Continuity restrictions are then imposed on the coefficients by aggregating all daily lags 1–60, thus forcing the coefficients within the aggregation to be identical. This is equivalent to conditioning the mean spread on the cumulative return (and the cumulative spread) accrued over the past 60 days.

There are several estimation issues that arise in this context. First, in the cross-sectional context, returns that accrued on days on which a fund traded were removed, to avoid generating any mechanical association between spreads and performance. This is no longer necessary in the context of the time-series regression, since lagged spreads are also in the specification, creating a natural control.[10] Second, the specification is restricted to days on which a fund trades (note that the right-hand side variables are constructed using the prior 60 days for each trading day on which a spread is observed), so t denotes the days on which a fund trades. Finally, standard errors are corrected using the Newey–West procedure, to account for heteroskedasticity or autocorrelation of the residuals.

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3.3. Performance and persistence

One corollary of the Naik *et al.* (1999) logic is that since more successful currency funds are rewarded by dealers for the information content of their trades, they should not gain by attempting to stealth trade as in Kyle (1985). In other words, informed traders have no incentive to split orders over multiple time periods to hide from dealers, i.e. successful traders should have less persistent order flow. I explore this conjecture in the paper, estimating:

$$p_i^{gr} = \alpha + \beta_{p,SR}\mathrm{SR}_i^{gr} + \varepsilon_i \tag{8}$$

In equation (8), the right-hand side variable is the Sharpe ratio of fund i, estimated as described in the Data section of the paper, and the left-hand side variable is a measure of the persistence of a fund's foreign exchange order flow, obtained by conditioning current order flow on lagged order flow:

$$f_{i,k,t} = c + a(L)f_{i,k,t-1} + \varepsilon_{i,k,t} \tag{9}$$

$f_{i,k,t}$ is the US dollar order flow of fund i into currency k at time t,[11] and $p_{i,k} = (1/n(L))\sum_L a(L)$ is the simple average of the lag coefficients.

Throughout the paper, all cross-sectional and panel estimation standard errors are corrected for heteroskedasticity using the robust covariance matrix of White (1980).

4. RESULTS

4.1. Results from cross-sectional analysis

Table 3 reports results from estimating the basic cross-sectional specification (5). The first important observation from the table is that the coefficient on the Sharpe ratio is estimated to be negative for all currency groups, and is highly statistically significant for the major currencies, as well as for all currencies. Using the moments estimated in Table 2, the magnitude of the coefficient indicates that a fund that performs two standard deviations better than the mean Sharpe ratio across all funds will experience an approximately 1.65 basis point spread reduction on its average transaction. From Table 1, the average total transact for funds across all currencies is approximately US \$3.5 billion. Thus, the coefficient magnitude represents a saving of approximately US \$580 000 across the lifetime of a high-performing fund.[12] The equivalent number for the major countries is a saving of approximately US \$370 000. Note that these numbers are likely to understate the true magnitude of the savings for highly successful currency funds since the sample under study in this paper contains a mix of funds trading currencies for a variety of purposes. The second observation is that the size proxy employed in the paper does not appear to be statistically significant for the all and other groups. However, there is evidence that larger funds transact at worse prices in the major currencies in our data. Third, there is evidence in the other group of currencies that funds with a high average number of daily transactions are penalized with high transactions costs. Finally, the volatility of a fund's returns comes in with a positive coefficient, as the theory would predict, but is not statistically significantly estimated.

Table 4 reports the results from panel estimation, and reveals that high Sharpe ratios are consistently associated with lower spreads, for all and major currency groups, much the same as in the cross-sectional analyses. Second, the coefficient on the daily average number of transactions per fund currency is now strongly statistically positive across all three currency groups. Clearly, funds that engage in greater numbers of transactions per day (controlling for the overall size of each fund) are penalized with higher spreads. The other variables, as in the cross-sectional results, are not statistically significant.

4.2. Results from time-series analysis

The time-series results lend support to the cross-sectional and panel regression results presented above. Table 5 shows that spreads respond negatively to past increases in performance. In other words, funds that are

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Table 3. Explaining transactions costs in the cross section

	Currency groups		
	All	Major	Other
Sharp ratio	**−16.584**	**−11.152**	**−29.683**
	6.229	*4.264*	*18.697*
Volatility	0.013	0.001	0.002
	0.021	*0.035*	*0.023*
Size	−0.017	**0.059**	−0.297
	0.059	*0.030*	*0.838*
Transactions	0.995	0.164	**14.342**
	1.005	*0.549*	*4.593*
R^2	0.004	0.006	0.006
N	1275	1275	1275

Note: This table presents estimates of a cross-sectional regression of mean effective spreads of funds on a number of fund characteristics. Results are presented for the all, major and other currency groups. The equation estimated is:

$$\text{spr}_i = \alpha + \beta_{SR}\text{SR}_i + \beta_v\text{Vol}_i + \beta_S\text{size}_i + \beta_{tr}\text{tr}_i + \varepsilon_i$$

The left-hand side variable in this regression is the mean effective spread in basis points over all fund transactions (spreads are winsorized at the 1 and 99 percentile points of the distribution of all fund-days within each currency). The right-hand side variables in order are: the Sharpe ratio of funds measured using daily returns on their transactions in the currencies of the specified group of countries (all, major and other) (SR); the volatility of fund returns in basis points, measured by averaging the standard deviation of daily fund returns from trades in the currencies of each group of countries (all, major and other) (Vol); the summed absolute value of the net transact per day across each fund's life, expressed in billions of US dollars (size); and the mean daily number of transactions conducted by each fund (tr). All variables are estimated only for those currencies that are members of the specified currency group (in columns). N is the number of observations in the regression, and the R^2 statistic is reported after all the coefficient estimates. White heteroskedasticity consistent standard errors are coefficients presented in italics.

successful in accruing high returns over the prior 60 days experience lower spreads on subsequent transactions. The magnitude of the coefficient indicates that for the average fund, a one percentage point increase above mean 60-day returns is associated with a statistically significant reduction in the subsequent daily average spread of 0.2 basis points across all currencies. For the other/emerging market currencies, the responsiveness of spreads is even greater. The third column of Table 5 reveals that a one percentage point increase in returns above the mean is associated with a 1.6 basis point decline in the average daily spread on the subsequent day. While the results for the major countries are consistent in sign, they are not statistically significant at conventional levels.

In addition to confirming the cross-sectional results, the time-series results suggest that a static exploitation of price inelastic currency demand by dealers cannot be the entire explanation for the findings in this paper. There appears to be the possibility of acquiring transaction costs rebates conditional on recent good performance.

4.3. Persistence and performance results

Table 6 shows that across all currency groups, persistent order flow is negatively explained by performance. In other words, less persistent order flow is associated with better performing funds. The coefficient is statistically significant for the other group of currencies, and for all countries, but not statistically significant at conventional levels for the group of major currencies. This result provides support for the conjecture that better performing traders in foreign exchange do not need to stealth trade a la Kyle (1985).

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Table 4. Explaining transaction costs in the panel

	Currency groups		
	All Spread	Major Spread	Other Spread
Sharpe ratio	**−17.959**	**−11.324**	−30.328
	5.818	*2.770*	*18.797*
Volatility	0.020	0.036	0.025
	0.018	*0.024*	*0.024*
Size	0.036	0.110	0.218
	0.085	*0.074*	*1.883*
Transactions	**1.093**	**1.254**	**9.351**
	0.269	*0.176*	*2.313*
N	0.001	0.010	0.001
R^2	14 776	6978	7798

Note: This table presents estimates of a panel regression of mean effective spreads of institutional funds on a number of fund characteristics. Results are presented for the all, major and other currency groups. The equation estimated is:

$$\mathrm{spr}_{ik} = \alpha + \beta_{SR}\mathrm{SR}_i + \beta_{vol}\mathrm{Vol}_i + \beta_{size}\mathrm{size}_{ik} + \beta_{tr}\mathrm{tr}_{ik} + \varepsilon_{ik}$$

The left-hand side variable in this regression is the mean effective spread in basis points over all fund transactions in each currency (spreads are winsorized at the 1 and 99 percentile points of the distribution of all fund-days within each currency). The right-hand side variables in order are: the Sharpe ratio of funds measured using daily returns on their transactions in the currencies of the specified group of countries (all, major and other) (SR); the volatility of fund returns in basis points, measured by averaging the standard deviation of daily fund returns from trades in the currencies of each group of countries (all, major and other) (Vol); the summed absolute value of the net transact per day across each fund's life, expressed in billions of US dollars (size); and the mean daily number of transactions conducted by each fund (tr). All variables are estimated only for those currencies that are members of the specified currency group (in columns). The regression is estimated as a panel, each observation is indexed both by its fund i, and the currency k for which the left- and right-hand side variables are measured. N is the number of observations in the regression, and the R^2 statistic is reported after all the coefficient estimates. White heteroskedasticity consistent standard errors are coefficients presented in italics.

Table 5. Performance and transactions costs over time

	Currency groups		
	All Spread	Major Spread	Other Spread
Lagged spread	0.0020	0.0019	−0.0146
	0.0023	*0.0024*	*0.0092*
Lagged returns	**−0.0020**	−0.0017	**−0.0159**
	0.0011	*0.0012*	*0.0055*
R^2	0.0032	0.0023	0.0364
N	1 921 530	1 492 154	429 376

Note: This table presents regression results of a Granger causality test of effective spreads on fund returns. The equation estimated is: $\mathrm{spr}_{i,k,t} = \alpha_i + \Gamma^{spr}(L)\mathrm{spr}_{i,k,t-1} + \Gamma^{r}(L)r_{i,k,t-1} + \varepsilon_{i,k,t}$, for all, major and other currency groups. Here, spreads are measured in basis points of transaction amounts. Spreads are winsorized at the 1 and 99 percentile points of the distribution of all fund days within each currency. The first two rows report the coefficients and t-statistics for lagged spreads, and the remaining rows for lagged returns. The regressor in each case is an aggregation of lagged spreads and returns from days 1–60 prior. Newey–West heteroskedasticity and autocorrelation consistent standard errors are coefficients presented in italics.

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Table 6. Performance and persistence

	Currency groups		
	All Persistence	Major Persistence	Other Persistence
Sharpe ratio	**−0.0807**	−0.0497	**−0.0689**
	0.0312	0.0314	0.0314
R^2	0.0058	0.0020	0.0034
N	1275	1275	1275

Note: This table presents regression results of a cross-sectional regression of persistence, constructed as described in Appendix A.1. on the Sharpe ratios. Results are presented for the currency groups of all, major and Other currencies. The equation estimated is:

$$p_i = \alpha + \beta_{p,SR}\mathrm{SR}_i + \varepsilon_i$$

5. CONCLUSION

This paper finds, in a cross section of funds trading foreign exchange, that funds earning high returns in excess of transaction costs tend to trade at better prices than the day's spot foreign exchange close prices. Furthermore, in time series, funds that perform well over a 60-day period trade at rates better than the daily close price on subsequent currency trades. These results are robust to the inclusion of control variables such as fund size, daily transaction frequency and return volatility. The paper argues that the results provide support for the model of Naik *et al*. (1999), who demonstrate that intermediaries in a theoretical market resembling the foreign exchange market bid for information by rebating the price for more informed traders.

The results in this paper suggest that trading in the foreign exchange market is very different from that in well-studied equity markets. Furthermore, the results suggest that while the use of aggregate information reveals much about markets, investigating possible heterogeneity in trading behaviour can also yield rich insights.

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APPENDIX A

A.1. Note on present valuation

Present values of all trades are computed in the foreign exchange data set, using the same procedure employed in Froot and Ramadorai (2005). The present value of a trade on each side, is computed as:

$$\mathrm{PV}_t^c = \delta_t^c c_t^c \tag{A1}$$

where δ_t^c is the discount factor applied to currency c at time t, and c_t^c is the amount bought or sold of the currency. Here,

$$\delta_t^c = ((1 + y_{t,t+n}^c)^{\lfloor n/T^c \rfloor}(1 + y_{t,t+n}^c)(n - \lfloor n/T^c \rfloor))^{-1} \tag{A2}$$

where $y_{t,t+n}^c$ is the interest rate in currency c over n days, reported at time t, and T^c is the interest basis for currency c, all countries in the data set report interest rates on a 365-day basis, except for Singapore, South Africa, Thailand and the UK, which report on a 360-day basis.

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NOTES

1. Daily global turnover in the foreign exchange market for the year 2000 averaged $1.1 trillion US (Source: BIS survey; Lehman Brothers).
2. See Huang and Masulis (1999) and Bollerslev and Melvin (1994) for a good summary of this literature.
3. The results in this paper are qualitatively unchanged by using spreads computed relative to prior day's close, the average of the day's and the prior day's close prices, or the midpoint of the daily highest and lowest transaction prices recorded in the data.
4. Other empirical studies investigating relationships between trade size and price include Holthausen *et al*. (1987), Keim and Madhavan (1996), Chan and Lakonishok (1993, 1995).
5. Fund family classification is not available, hence the fund is the primary unit of analysis. There is significant cross-sectional variation in the variables of interest at the fund level.
6. See Appendix A for the method used to compute the present value of transactions in the data set.
7. When winsorization is not done, the results are qualitatively unchanged, but less precisely estimated.
8. Note also that regression tests show no relationship between the measured spread and subsequent daily currency returns.
9. Since both spot and forward transactions are recorded for each fund, the return incorporates the hedging decisions of the funds.
10. Removing spreads from returns makes no material difference to the estimated coefficients on lagged returns.
11. Order flow at date t is measured as in Froot and Ramadorai (2005) as the net present value transacted by the fund in currrency k on day t. See Appendix A.1. for details on present valuation.
12. For the average fund, this is approximately 950 trading days.

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