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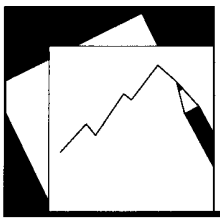

IMF Working Paper

Private Information, Capital Flows, and Exchange Rates

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Private Information, Capital Flows, and Exchange Rates [1]

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Abstract

We demonstrate empirically that not all capital flows influence exchange rates equally: Capital flows induced by foreign investors' stock market transactions have both an economically significant and a permanent impact on exchange rates, whereas capital flows induced by foreign investors' transactions in government bond markets do not. We relate these differences in the price impact of capital flows to differences in the amounts of private information conveyed by these flows. Our empirical findings are based on novel, daily-frequency datasets on prices and quantities of all transactions of foreign investors in the stock, bond, and onshore FX markets of Thailand.

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I. Introduction

The determination of exchange rates has long been an important but vexing topic in international finance. Beginning with the work of Glosten and Milgrom (1985), Kyle (1985), and Admati and Pfleiderer (1988), it has been argued that in order to understand the price formation in a financial market, one generally needs to distinguish between participants' private and public information sets. For foreign exchange (FX) markets, this notion is strongly supported by the empirical evidence which finds that exchange rates are explained statistically by capital flows because these flows convey investors' *private* information. Economists have, in addition, become increasingly aware that not all types of capital flows are equally important for exchange rate determination; some flows appear to matter far more than others do. It has, however, proven difficult so far to identify *which* capital flow components convey the most private information, partly because private information by its very nature cannot be observed directly.

In this paper we provide robust empirical evidence that not all capital flows influence exchange rates equally: capital flows induced by foreign investors' stock market transactions have both an economically significant and permanent impact on exchange rates, whereas capital flows induced by foreign investors' transactions in the government bond market do not. We further find that, foreign investors' stock market transactions reveal private information, whereas their government bond market transactions do not. The reason for the difference in the effects of these types of order flow on the exchange rate therefore appears to be the difference in their private information content.

In order to analyze the economic linkages between transactions in the FX markets and domestic capital markets, we rely on several novel datasets. By combining these we are able to distinguish between FX transactions which are driven by investors' equity market transactions, those that are driven primarily by investors' bond market transactions, and a residual component. The datasets consist of nearly two years' worth of *daily-frequency* transactions undertaken by foreign investors in the onshore foreign exchange, stock, and bond markets of Thailand. Crucially, the data consist of daily totals of *all* buy and sell transactions rather than merely a (possibly non-representative) subset of these transactions. We also make use of institutional features of financial markets in Thailand, notably settlement practices and regulations that strictly limit the size of foreign investors Thai baht-denominated bank balances, as these features ensure that foreign investors' aggregate transactions in the stock and bond markets are closely linked with their aggregate transactions in the FX market. Knowledge of these features enables us to construct simple measures of the portions of FX order flow that

are driven, respectively, by investors' stock and bond market transactions. These constructed series, in turn, enable us to estimate the influence that various components of overall FX order flow exert on the exchange rate, both contemporaneously and in the long run.

How are domestic equity and bond markets linked with the FX market? For a foreign investor, cash balances in the country's currency need not be acquired or sold for their own sake. Rather, they are often bought or sold as a byproduct of the investor's decisions to buy or sell stocks and bonds that are denominated in the domestic currency. This observation should be uncontroversial for many emerging market economies, in which regulations and market incompleteness prevent investors from holding sizable quantities of cash or short-term money market instruments and in which no suitable off-shore markets exist to acquire or sell the financial assets the investor is interested in. The question is whether the private information contained in FX order flow is based primarily on information generated *initially* in stock or bond markets and is then subsequently transmitted to the foreign exchange market where it may generate follow-up adjustments in the currency's exchange value.

By showing conclusively that the stock market provides much of the private information of relevance for the determination of exchange rates, our study provides a new piece to the exchange rate determination puzzle. We are, of course, not the first ones to notice the existence of statistical linkages between foreign investors' order flow in a stock market and exchange rate returns; see, e.g., Goodhart (1988), Brooks and others (2001), and Gehrig and Menkhoff (2004) for earlier studies. FX dealers state routinely that they study their own customers' order flow in capital markets carefully in order to extract any information that may be relevant for the FX market. Francis, Hasan, and Hunter (2006, p. 219) note that "there are important, yet not well understood, dynamic relationships between international equity and currency markets and these are driven by information spillover via the mechanism of currency order flow." Also using intraday data, Albuquerque, de Francisco, and Marques (2008) note that market-wide private information on equity returns helps forecast returns for several currency pairs. Dunne, Hau, and Moore (2010) find that intraday data on returns on the French stock market index and the US dollar–euro exchange rate have significant explanatory power for daily S&P100 returns. Our results strongly support the view expressed in these studies that the private information relevant for FX fluctuations is revealed or conveyed mainly by the portion of order flow that is induced by stock-market transactions. Relative to earlier studies, one of our contributions is to demonstrate that this result holds both in the short and long run.

To the best of our knowledge, our study is also the first of its kind to analyze the exchange rate determination puzzle empirically by combining *comprehensive* datasets on order flow

and returns from *three* separate financial markets—FX, stock, and bond markets—for an entire country. By utilizing data from Thailand, a major emerging market economy, our contribution also serves to broaden the geographical range of data employed in exchange rate determination studies; the majority of previous studies in this field have used datasets from developed economies.[1] Our paper is also closely related to the large body of empirical work, starting with Evans and Lyons (2002), that finds that models of exchange rate determination which include order flow as an explanatory variable dramatically outperform models which rely exclusively on public information (e.g., macroeconomic data releases).[2]

Our empirical findings are thus in line with the by-now broad agreement among researchers that order flow affects exchange rates because it carries private information (Osler, 2009). In contrast, there has been much less empirical work on the *nature* of the private information that is conveyed by FX order flow. This gap partly persists because private information by its nature cannot be observed directly. It may also reflect, however, the fact that many studies of FX order flow do not sufficiently exploit known institutional linkages between FX markets and domestic financial markets that help identify causal or feedback relationships. For instance, little attention appears to have been paid so far to the fact that in many economies investors who wish to buy (sell) domestic financial assets must simultaneously buy (sell) the relevant currency in the FX market. Such a direct link between capital market and FX market transactions can arise either because of regulatory restrictions on investors' holdings of cash (and near-cash) holdings or because of a lack of access to the domestic money market to finance their capital market transactions.

There are several types of private information that stock market investors may have about the fundamental determinants of a firm's value. These include knowledge of the quality of the firm's products, the prospects for successful product innovation, management quality, and the strength and likely strategies of the firm's competitors. As was noted by Lyons (2001) and Evans and Lyons (2002, 2008), private information may further include passively collected information about macro variables and other exchange rate fundamentals which may be dispersed among customers. This type of private information is relevant for both equity and bond market participants. Private but dispersed information characterizes many macro variables at the center of exchange rate modeling, such as output, money demand, and consumer preferences. These variables are first realized at the micro or household/firm level and only later aggregated by markets and/or governments. For some macro variables, government-

[1] Richards (2005) and Chai-Anant and Ho (2008) provide descriptions of investors' trading behavior and of financial market dynamics in several Asia–Pacific economies.

[2] For surveys of this large literature see Lyons (2001), Sarno and Taylor (2002), and Osler (2009).

provided aggregations exist, but their publication lags the underlying realizations by weeks and months, leaving room for market-based aggregation well in advance of their eventual publication. For other measures, such as risk preferences and money demand functions, the task of aggregation is left fully to markets.

Although we do not focus explicitly on this issue, our paper is also related to studies which analyze the types of private information that are conveyed by FX order flow. Consistent with our own findings, these studies find that FX order flow carries private information about macroeconomic data. This information is aggregated by dealers based on customer order flow and ultimately incorporated in the exchange rate. Evans and Lyons (2007) show that Citibank customer order flow has substantial predictive power for future revisions in the real-time estimates of U.S. and German GDP, inflation, and money stocks. The authors also point out that order flow aggregates and conveys investors' private information that is only revealed later in aggregate economic statistics. Of relevance to market makers and FX dealers are therefore not only the publicly-available news releases but also what they can learn from the order flow initiated by their end-user customers acting on (what the dealers believe to be) private information. Froot and Ramadorai (2005) show that State Street Corporation institutional investor flow data have predictive power for changes in real interest rates at horizons up to thirty days. Rime, Sarno, and Sojli (2010) report that order flow carries information about upcoming macro news releases for the euro vis-à-vis the US dollar, the pound, and the yen.

Our findings are also related to the studies that provide evidence as to which types of investors bring private information to the FX market. Osler and Vandrovych (2009) report that order flow generated by leveraged investors, such as hedge funds and banks, have a strong and lasting impact on the exchange rate whereas order flow from unleveraged institutional investors, large corporations, government agencies, and central banks appears to convey little private information. The papers of Fan and Lyons (2003) and Carpenter and Wang (2007) provide evidence that in FX markets, transactions initiated by financial customers convey more information, at least in the short run, than do transactions initiated by commercial customers. If leveraged investors' FX order flow indeed conveys more private information than does that of other institutional investors, the findings we report in this paper suggest stock market induced FX flows may be generated, to a large extent, by leveraged investors. This view is consistent with investor surveys which report that hedge funds are more active in equity than in bond markets in Asia. Our findings also suggest that non-equity market related FX market transactions may be driven primarily by non-leveraged institutional investors and commercial customers.

The fact that foreign investors engage in the generation of private information does not imply that they are either better or worse informed on average than domestic investors are. It also does not imply that foreign investors earn either higher or lower profits on average from their equity market strategies. For our analysis to apply, we only require that there be heterogeneity between foreign and domestic investors with respect to their private information sets in order to give rise to transactions between these investor groups in the stock market and indirectly the FX market. That said, we find that the serial correlation patterns present in foreign investors' order flow in the Stock Exchange of Thailand (SET) indicate that they have, on average, *less* private information about SET-listed firms than domestic investors have. This finding is consistent with the studies by Choe, Kho, and Stulz (2005), Dvořák (2005), Chan, Menkveld, and Yang (2007), and Taechapiroontong and Suecharoenkit (2011), who report that foreign investors tend to have less private information than resident investors have in the equity markets of Korea, Indonesia, China, and Thailand, respectively.

The remainder of the paper is structured as follows. Section II provides an overview of the three financial markets of interest and introduces the datasets. Section III provides a stylized model that helps structure and interpret the empirical evidence presented in Section IV. Section V concludes.

II. The Markets and the Data

In this section, we provide a brief overview of the onshore FX, stock, and government bond markets in Thailand, focusing mainly on aspects of the markets and data that are important for the empirical analysis conducted in Section IV. We also note certain regulatory features of the financial markets in Thailand that induce a relationship between foreign investors' capital market transactions and their FX market transactions that is closer in Thailand than in many other economies.

A. Sample Period and Foreign Investor Definition

All observations are daily. The data cover the period from the beginning of January 2005 through Friday, 15 December 2006. The data we received initially ran through mid-2008. However, after conducting a preliminary analysis we decided not to use data after mid-December 2006. On Tuesday, 19 December 2006, the Thai authorities imposed additional and

very stringent capital control measures, highlighted by a 30% unremunerated reserve requirement (URR) on nonresident or foreign investors' financial holdings apart from stock market holdings. The introduction of these measures caused a severe structural break in the behavior of financial markets in Thailand. For instance, following the introduction of the URR measures, foreign investors' participation in the onshore financial markets of Thailand dropped off sharply, the volume of offshore baht trading increased, and a large differential opened up between onshore and offshore baht–dollar quotes.[3]

Throughout the paper, we focus on the transactions of what we refer to as foreign investors that are not resident in Thailand. Formally, these comprise (i) corporations, institutions, funds, financial institutions or juristic persons located outside Thailand; (ii) entities of foreign governments located outside Thailand; (iii) branches and agents of domestic juristic persons located outside Thailand; and (iv) natural persons who reside in Thailand but are not of Thai nationalities and do not have alien identity or residence permits. According to information we received from the Bank of Thailand (BoT) Data Management Group, financial institutions domiciled outside of Thailand are by far the dominant group in this set, with a share well in excess of 90% of total transactions.

Foreign investors who hold bank balances in Thailand are required to do so by holding so-called nonresident baht accounts, or NRBAs. During the sample period, NRBA regulations were broadly stable.[4] For our study, the most important of the NRBA rules is that balances held in NRBAs may not exceed THB 300 million per nonresident customer at the end of each day. (For the range of exchange rates that prevailed during the sample period, this limit fluctuated between US$7.1 and US$8.6 million.) This limit covers all accounts of a given customer with all domestic financial institutions.

If foreign investors in Thailand, as a group, wish to either build up (unwind) their positions in baht-denominated financial assets such as bonds or shares, they can do so in the short run in the following three ways: (i) by drawing down (building up) their existing baht-denominated bank balances held in NRBAs, (ii) by selling (buying) shorter-term fixed income assets, including money market claims, to (from) domestic market participants, and (iii) by engaging in baht-denominated FX transactions. Because of the stringent limits on allowable balances in NRBAs and a general lack of liquidity in the private money markets in Thailand, foreign investors typically acquire (liquidate) the funds required for the purchase (sale) of baht-

[3] See Abhakorn and Tantisantiwong (2012) for a detailed examination of the impact of the URR measures on the performance of various financial markets in Thailand.

[4] The relevant NRBA regulations went into effect in October 2004, i.e., shortly before the start of the sample period.

denominated shares and bonds by transacting in the onshore FX market.[5] This institutional feature is one of the keys to our ability to link foreign investors' order flow across markets.

B. The Onshore FX Market

The structure of the onshore FX market in Thailand is similar to that in many other countries. There is no single organized exchange that handles FX transactions. Rather, the wholesale market is over-the-counter. Licensed currency dealers, which can be domestic or foreign-owned banks and brokers, provide wholesale FX trading services.[6] In addition to conducting interdealer transactions, the FX banks also conduct FX purchases and sales with both domestic and foreign "end-users."

The onshore FX market in Thailand is regulated and closely monitored by the BoT. Licensed FX dealers (mostly commercial banks) are required by the BoT to limit their net FX positions in any one currency to no more than 15% of regulatory capital (individual currency limit) and also to maintain a net overall FX position across all foreign currencies of no more than 20% of capital (aggregate currency limit) at the end of each day. The position limits tend to be particularly important for the branches of foreign banks that operate in Thailand. Dealers frequently rely on FX swaps to adhere to these limits.

All licensed FX dealing banks must submit detailed reports of all FX transactions to the BoT on a daily basis. In the banks' daily reports, each transaction record states the name of the counterparty, its type ("other dealer," "domestic customer," "nonresident customer," and BoT), the transaction amount in dollar equivalent, the currencies involved (the vast majority of all transactions is in Thai baht vs. U.S. dollars), the applicable exchange rate, and the type of FX transaction. The five types of FX transactions are spot trades (separated further into same-day, "tomorrow" or $T + 1$, and "next" or $T + 2$ transactions), outright forwards ($T \geq 3$), and FX swaps. Each transaction is classified as either a "buy" or a "sell;" because transactions are recorded from the point of view of the reporting bank, a "buy" consists of a purchase of *foreign currency* (by far most commonly the U.S. dollar) by the reporter and hence a sale of baht to the counterparty.[7]

[5]Foreign currencies converted into baht by foreign customers are normally, though not necessarily, credited to their NRBAs before being spent on equities and bond securities. Similarly, the proceeds of sales of equities and bonds by foreigners are frequently credited first to NRBAs before being converted into foreign currencies.

[6]At the beginning of 2005, there were 39 licensed FX dealers in Thailand; 21 were domestic financial institutions and 18 were subsidiaries of foreign financial institutions. After a couple of mergers in late 2005, the number of licensed FX dealers in Thailand was 37 during all of 2006 (20 domestic and 17 foreign).

[7]The banks' daily transaction records do not contain information about the exact time the transaction occurred, which counterparty—the reporter or the customer—was the initiator of the transaction, the bid-ask spread, or whether the transaction took place at the dealing bank's bid or ask quote.

The daily-frequency gross and net capital flow series for all five types of FX contracts have been constructed by the BoT. This was done by aggregating all reported transactions across reporters to obtain the gross flow series, and then taking the difference between aggregate buys and sells to obtain the net flow series. For this study, our access to the aggregate data was limited to gross and net flows between dealers and their *foreign* customers. From conversations we held with FX dealers in Thailand, we believe that the vast majority of all "spot-tomorrow," "spot-next," and outright forward transactions between dealers and their customers (both resident and non-resident) is initiated by the customers. Hence, for these contracts our net flow series should match the theoretical concept of order flow, which focuses on which counterparty *initiates* the transaction, very well. In contrast, FX dealers told us that FX swaps tend to be initiated by either the FX dealing banks or their non-bank customers; in consequence, in the case of FX swaps our net capital flow measure may not be a good proxy for customer order flow.[8] Transactions between the BoT and FX dealer banks generally consist of intervention operations. To the extent that the BoT's intervention operations conform to the "leaning against the wind" metaphor, the findings we report in this paper would be even more pronounced if BoT intervention did not occur.[9]

The average daily transaction volume between dealers and their foreign customers was US$ 780 million in 2005 and US$ 1,155 million in 2006. In both 2005 and 2006, two-day spot transactions made up roughly 45% of the foreign customer total, FX swaps accounted for an additional 33 to 35%, spot-tomorrow transactions contributed 11 to 13% to the total, and spot-today and outright forwards ($T \geq 3$) each accounted for about 4% of the total transaction volume between dealers and their foreign customers. In both 2005 and 2006, all three daily spot FX net capital flow series were positive on average, i.e., foreign customers were net buyers of spot baht in both years. Conversely, in both years foreign customers were net sellers of baht through outright forwards and FX swaps.

As is the case with most other emerging market economies, FX trading in Thailand occurs almost exclusively during Thai business hours. The bilateral THB/USD spot exchange rate used in this study is as of 7:15 pm Bangkok time. This collection time coincides roughly with the end of the business day in Bangkok, ensuring that the daily FX returns series reflect all relevant intraday economic information without being affected by global market developments that occur *after* the close of business in the onshore market.[10]

[8]This may help explain some of our ancillary findings, such as the fact that net FX swaps purchases by foreign investors do not appear to explain exchange rate fluctuations.

[9]See Bank of Thailand, Financial Markets Operations Group (2005) for an overview of the approach the BoT took to conducting FX interventions during the sample period.

[10]Other data sources generally report daily-frequency FX rates as of 5 pm New York time, i.e., at the conventional end of a 24-hour trading day in major FX markets.

C. The Equity Market

Our stock market price data consist of the daily closing values of the SET index, which is the main share price indicator of the Stock Exchange of Thailand. The SET index is market capitalization-weighted and is based on the stock prices of companies listed on the main board of the exchange. The mean daily return of the SET index was very close to zero in both 2005 and 2006. Except for a brief period of heightened global market volatility during May and June 2006, stock price volatility was fairly low and constant during the sample period. As with the FX datasets, we terminate the sample period on 15 December 2006.

We also have daily-frequency gross buy and sell transaction volumes on the SET by foreign investors.[11] Investors can trade securities on the SET through any of 39 brokerage houses, many of which are foreign-owned. Settlement for equities is performed on a $T + 3$ basis. Average daily gross transaction volume (buys+sells) on the SET by foreign investors in 2005 and 2006 was the equivalent of US$ 229 million and US$ 286 million, respectively, or less than a third of average daily gross transactions volumes between dealers and their foreign customers.

D. The Bond Market

Foreign investors' participation in the Thai bond markets in 2005 and 2006 was quite limited. Daily transaction volumes by foreign investors averaged US$ 55 million and US$ 88 million in these two years, amounting to only 15% and 19%, respectively, of all bond market trades. In 2005 and 2006, trading volume in the secondary bond markets was overwhelmingly (about 98%) concentrated in BoT paper and in government bonds and bills. Even though the stock of outstanding corporate bonds in Thailand has grown rapidly in recent years, trading in corporate bonds was very limited during the sample period.

Our bond market dataset consists of daily-frequency buy and sell transaction totals by foreign investors in the secondary bond market. Bond market transactions are classified according to whether they are "outright" (or "ordinary") or "other" transactions. In our sample, "outright" transactions make up about 70% of all transactions. According to information we received from private-sector dealers and BoT staff, these transactions are mainly associated the one-day ($T + 1$) settlement segment of the spot FX market, although some transactions settle on

[11] Albuquerque, de Francisco, and Marques (2008) used firm-by-firm equity transactions data to construct proxies for firm-specific and market-wide private information. Because of the aggregate nature of our data, we could not perform such calculations and hence cannot distinguish separately between these motives for trading activity.

a $T + 2$ or even $T + 3$ basis as well. "Other" bond trades tend to occur mainly in connection with banks' financing transactions and settle mostly on a same-day or a $T + 1$ basis. They make up about 30% of the total bond market transaction volume of the banks' foreign customers.

Consistent with market settlement practices, we found that two-day spot FX order flow was related systematically to stock market variables but not to bond market variables. We also found that one-day FX-spot order flow was related systematically to investors' transactions in both the "outright bonds" and "other bonds" categories, but only barely to stock market variables.[12]

During the sample period, foreign investors' net daily stock market transactions were nearly uncorrelated with their "outright" bond flows as well as with their "other" bond flows (with correlations below 0.05). In addition, foreign investors' net flows in "outright" and "other" bonds were also only slightly positively correlated with each other, with a correlation coefficient of about 0.15. Overall, these findings suggest that the three types of domestic capital market transactions are undertaken for different reasons.

III. Private Information and FX Markets

We are interested in analyzing the following, highly stylized setting of the signal extraction problem that FX dealers face in a dealer-based wholesale FX market. The dealers and their non-dealer foreign customers are assumed to have access to the same amounts of public information. We also assume that the arrival process for public information is sufficiently stationary to let the FX market equilibrate in response to public information releases without the dealers having to obtain information about their customers' order flow. In all transactions, foreign investors are assumed to be the "aggressors," or initiators, of financial transactions. By regulation, foreign investors are not allowed to hold substantial amounts of cash, bank balances, or short-term money market instruments. Therefore, foreign investors' net position changes in the domestic stock and government bond markets are closely linked to their net order flow in the FX market. We further assume that investors' order flow in the stock market is based mainly on private information, whereas their order flow in the bond market is based exclusively on public information. As we will show below, these assumptions are consistent

[12]The R^2 statistic of the regression of the two-day spot FX series on the stock market variables alone was 0.19, and the R^2 of the regression of the one-day spot FX series on the bond market variables was 0.11. For comparison, the R^2 value for the regression of one-day spot FX order flow on just the stock market variables was only 0.05.

with observed serial correlation patterns present in net transactions by foreign customers in the stock, bond, and FX markets.

Consider the situation where a dealer receives a customer order to purchase the domestic currency for dollars and the dealer has to decide whether to adjust her bid and ask quotes in response to this incoming order (Bacchetta and van Wincoop, 2006; Dunne, Hau, and Moore, 2010). There are three main possibilities that the dealer must consider. First, if she believes that the incoming order is a pure liquidity or "noise" order, her optimal reaction is *not* to adjust the quotes other than for liquidity and inventory rebalancing reasons. Second, suppose the customer order is based on a *public* information event; an efficient FX market can determine the new equilibrium exchange rate without dealers having to resort to observing the order flow of their foreign customers to help decide how they should adjust their quotes.[13] Third, if the customer order flow is based on, or is believed to be based on, *private* information, the dealer's optimal reaction is to adjust her bid and ask quotes in the direction of the trade. Such a customer order to buy baht will lead to an appreciation of the baht.

How might a dealer discern whether a customer's incoming buy order for baht is based on private information? The FX dealer may rely on an important clue: Is the customer more likely to use the proceeds of the baht purchase to acquire bonds or equities in the local capital markets?[14] If it is the former, the FX transaction that is generated by the bond market transaction—by assumption—represents either a liquidity or a public information-based trade and therefore does not add to the market-relevant information the FX dealer already has. On the other hand, if the trade is induced by an equity market transaction, it is more likely than not based on the investor's private information. It therefore conveys the investor's private information not only to the stock market but also to the FX market. In the aggregate, these transactions will therefore generate a permanent exchange rate reaction.

Our stylized story of how investors' private information is discerned by FX dealers and how it affects prices depends critically on the assumption that private information affects inves-

[13]To be sure, Love and Payne (2008, p. 468) show empirically that "even macroeconomic information that is publicly and simultaneously released to all market participants is partially impounded into [the exchange rate] via the key micro level price determinant—order flow." However, as Berger and others (2008, p. 106) point out, the observed order flow following a public news event could "be, at least in part, simply a byproduct of the price movement arising from the direct reaction of the exchange rate to the surprise component of the news announcement." Moreover, the empirical result of Love and Payne applies to *total* customer order flow and does not suggest that domestic and foreign customers would behave differently in reaction to public news releases. Thus, any order flow generated by a subset of customers following a news event may not be informative for FX dealers' purposes.

[14]In Thailand the overwhelming majority of all trades undertaken by foreign investors are effected by institutional investors. FX traders are well aware of the investment styles and any market specialization of their end-user customers.

Table 1. Autocorrelations in foreign investors' net daily order flow

	Lags (in days)				
	1	2	3	4	5
Equities	0.55	0.42	0.34	0.23	0.17
Bonds					
Bonds outright	−0.06	0.01	0.02	−0.03	0.02
Bonds other	−0.06	−0.01	−0.05	−0.07	0.06
Foreign exchange					
Spot, today	0.11	−0.03	0.01	0.07	0.10
Spot, tomorrow ($T+1$)	0.50	0.34	0.25	0.20	0.19
Spot, next ($T+2$)	0.29	0.23	0.14	0.14	0.12
Forwards	0.07	0.00	0.08	0.08	0.00
Sum of spot and forwards (FX_SPOT)	0.21	0.14	0.05	0.02	0.14
FX Swaps	0.34	0.28	0.26	0.28	0.26

Source: Bank of Thailand, CEIC, BIS, authors' calculations.

tors' transactions significantly in some capital markets—such as the stock market—but less so in others—such as the government bond market. Given that private information by its nature is not directly observed, how might one verify that this assumption is valid? Following the reasoning of Brennan and Cao (1997), "flow momentum" or non-zero serial correlation in purchases or sales of assets by a subset of investors, can be an indication that these investors' decisions are affected by disparities in private information. Conversely, an absence of flow momentum may indicate that the private information set of foreign investors is not meaningfully different from that of domestic investors. Applied to our datasets, then, if our identifying assumptions are empirically relevant, foreign investors' transactions in the stock market of Thailand (and, indirectly, in at least some segments of the onshore FX market) should exhibit nonzero serial correlation whereas their transactions in the bond market should not.

The first line in Table 1 shows that foreign investors' daily net equity trades were indeed characterized by positive serial autocorrelation, or positive flow momentum, during the sample period. This pattern is consistent with these investors having, on average, *less* private information than domestic investors in the stock market have. In contrast, there is very little serial correlation in foreign investors' net daily bond market transactions, indicative of a lack of private information disparities. Given that bond market transactions are heavily concentrated in government and central bank paper, this is not surprising. The contemporaneous correlation between foreign investors' daily net stock and bond market transactions is 0.05;

Table 2. Variable mnemonics and descriptions

All order flow series refer to net daily transactions between banks and foreign customers. Order flow is defined as the difference between banks' "buy" and "sell" transactions with their customers. The order flow series are measured in USD millions.

Variable name	Description
THB	First difference of log of baht–dollar exchange rate
SET	First difference of log SET index, in dollar terms
STOCKS	Order flow, stocks
OUTRIGHT_BOND	Order flow, "outright" bonds
OTHER_BOND	Order flow, "other" bonds
BOND	Sum of "outright" and "other" bond order flow series
FX_SPOT	Order flow, all FX transactions except swaps
FX_SWAP	Order flow, all FX swap transactions
FX_SPOT_STOCKS	Portion of FX_SPOT series that is explained by stock market variables
FX_SPOT_BOND	Portion of FX_SPOT series that is explained by bond market variables
FX_SPOT_RESID	Residual of FX_SPOT series

although slightly positive, this number is not statistically different from zero at the 90% confidence level. Taken together, we interpret these empirical regularities as a strong indication that while foreign investors' transactions in the stock market are determined in part by private information, this is not the case for their transactions in the bond market.

Table 1 further shows that foreign investors' transactions in the one-day spot, two-day spot, and swaps segments of the FX market also exhibit positive serial correlation during the sample period. We make use of this empirical regularity in the following section, when we trace the effects of bond and stock market flows in the FX market.

IV. Empirical Results

The hypothesis we wish to test if FX order flow which is induced by investors' stock market transactions has a statistically significant and permanent effect on the exchange rate, whereas FX order flow induced by bond market transactions does not. Table 2 provides the acronyms and brief descriptions of all variables used in this section. To simplify the exposition and discussion of our empirical work, we combine all FX order flow series *except* for FX_SWAP into a

single series, which we call FX_SPOT. None of the findings regarding the differences in influence of stock and bond market induced order flow are changed by this simplification.

We do not observe directly whether a customer's FX transaction is associated with a transaction in the domestic stock or bond markets.[15] We are also not able to reconstruct the FX dealers' real-time information about their customers' transactions. Relative to the FX dealing banks, however, we possess the important informational advantage of having complete rather than only partial data on each day's aggregate order flow effected by foreign investors in the FX, stock, and bond markets. Having these detailed data from three separate financial markets lets us construct proxies for the subsets of foreign investors' FX order flows that are driven by their stock and bond market transactions.[16]

We employ a two-stage procedure to estimate the contemporaneous impact of FX order flow driven by investors' transactions in the equity and bond markets. In the first stage, we construct proxies for the portions of daily FX order flow that are driven by stock and bond market variables. In the second stage, detailed below, we regress daily baht–dollar returns on these proxy variables as well as on additional control variables and test the null hypothesis that the coefficients on constructed regressors are equal. The reported standard errors use the method proposed by Newey and West (1987) to adjust for possible heteroskedasticity and serial correlation in the regression errors. The models passed several tests for structural breaks and other forms of mis-specification.

A. FX Order Flow Induced by Stock and Bond Market Transactions

To determine if FX order flow is affected by the stock or bond market, we first regressed the FX_SPOT order flow series on our bond and stock market variables. The results of this regression are shown in Table 3. The regressors in this model are the contemporaneous stock and bond market variables (returns and order flow).[17] The regression estimates show that

[15] If each transaction record submitted by the FX dealing banks to the BoT contained information to denote whether the customer's FX transaction was associated with a transaction in (i) the domestic stock market, (ii) the bond market, or (iii) neither of the above, it would of course be straightforward to test our hypothesis directly: One would run an order flow regression with FX returns as the dependent variable and the three FX order flow series as regressors.

[16] The practice of splitting a time series into two components—one constructed as the fitted part from a preliminary or first-stage regression and the other defined as the residual from that regression—and using *both* the fitted and residual components as explanatory variables dates back at least to the work of Barro (1977).

[17] We also considered including the first three lags of the SET, STOCKS, BONDS_OUTRIGHT, and BONDS_OTHER series. However, none of the lagged regressors had statistically significant coefficients, and their inclusion does not significantly affect the coefficients or standard errors of the contemporaneous regressors. We also considered omitting the SET regressor; doing so raised the point estimate of the STOCKS regressor somewhat but did not change the overall conclusions.

Table 3. Influence of stock and bond market variables on FX flows

The dependent variable is FX_SPOT, customer FX market order flow excluding FX swaps.

Estimation method: Ordinary least squares.

The standard errors are calculated using the Newey-West method with a Bartlett kernel and the lag length parameter set to 6. The *p*-values denote the significance of the associated *t*-statistics for the two-sided null hypothesis that the coefficient in question is zero.

Regressor	Coefficient	Std. Error	*t*-statistic	*p*-value
C	31.6	7.08	4.40	0.000
SET	4124.1	732.3	5.63	0.000
STOCKS	0.862	0.167	5.17	0.000
OUTRIGHT_BONDS	0.171	0.181	0.94	0.350
OTHER_BONDS	0.510	0.168	3.04	0.003
	R^2	0.243	F-stat.	35.3
	Adj. R^2	0.236	Prob. F-stat.	0.000

Number of observations: 444 after adjustments.

a US$ 100 million increase in foreign investors' net purchases of shares on the stock market was associated, on average, with an increase of about US$ 86 million in net purchases of baht. This point estimate is statistically significant. In contrast, similar-sized increases in either "outright bond" or "other bond" were associated with only US$ 17 million and US$ 51 million increases, respectively, in purchases of baht. The regression results also show that a 1% (0.01) daily return on the SET Index was associated, on average, with a US$ 41 million increase in net purchases of baht by foreign investors during the sample period.

To be sure, transactions in the stock market and FX market need not be driven solely by investors' private information. The transactions could also be driven by public information releases as well as by hedging and liquidity needs that are unrelated to economic conditions in Thailand. For the purposes of our analysis, it is not necessary to include measures of contemporaneous public information in our regressions. Given that the public and private information sets are orthogonal by construction, the omission of variables that proxy for public information—while causing the R^2 numbers to be a bit smaller—does *not* create bias or inconsistency in the estimates of the coefficients and standard errors of the included regressors.

Based on these coefficient estimates, we constructed proxies for the portions of daily FX order flow that driven by stock market variables and the *combined* effects of the two bond market variables, respectively. The residual from the first-stage regression, called FX_SPOT_RESID,

Table 4. FX order flow regression

The dependent variable is THB, the log-first-difference of the baht/dollar exchange rate. Negative values of the regression coefficients imply an appreciation of the baht versus the dollar.

Estimation method: Two-stage least squares.

The standard errors are calculated using the Newey-West method, with a Bartlett kernel and a lag length of 6, to adjust for possible heteroskedasticity and serial correlation in the regression errors. The *p*-values denote the significance of the associated *t*-statistics of the two-sided null hypothesis that the coefficient in question is zero.

Regressor	Coefficient	Std. Error	*t*-statistic	*p*-value
C	0.0011	0.0003	3.78	0.000
THB(-1)	−0.180	0.0657	−2.72	0.007
THB(-2)	−0.181	0.0488	−3.70	0.000
FX_SPOT_STOCKS	-2.64×10^{-5}	0.31×10^{-5}	−8.61	0.000
FX_SPOT_BOND	-0.76×10^{-5}	0.57×10^{-5}	−1.34	0.182
FX_SPOT_RESID	-0.90×10^{-5}	0.46×10^{-5}	−1.98	0.049
	R^2	0.443	F-stat.	35.13
	Adj. R^2	0.434	Prob. F-stat.	0.00

Instruments: Lagged stock and bond market variables.
Number of observations: 332 after adjustments.

serves as a third regressor in the order flow regression model we present in the following subsection.

B. Order Flow Regression

We next ran a regression with baht–dollar returns as the dependent variable and the two fitted (stock and bond) order flow series and the residual order flow series from the first stage regression as the explanatory variables. The results of this regression are shown in Table 4. [18]

We estimated the order flow regression with a two-stage least squares method, using instruments for the fitted regressors to obtain consistent estimates of the reported standard errors.[19]

[18]The inclusion of additional regressors that serve as proxies for public information led to a small increase in the overall goodness of fit of the model, but the results for the order flow regressors were unchanged.

[19]Mishkin (1982) and Pagan (1984) examine the econometric issues that arise when using constructed or fitted regressors. Pagan shows that whereas the coefficients as well as the standard errors of the *residual* regressors are estimated consistently by OLS, the OLS-based estimates of the standard errors of the *fitted* regressors would be inconsistent. We therefore used instruments for the fitted regressors.

The use of two-stage least squares is necessary because we use constructed rather than directly observed regressors; the resulting statistical dependence between the regressors and the error term of the second-stage regression renders inference using OLS-based standard errors invalid.

The coefficients of all three order flow regressors are negative, i.e., a net purchase of baht by investors through any of the three types of order-flow is associated with an appreciation of the baht. However, the coefficient on the bond-market induced portion of FX order flow is *not* statistically different from 0. Furthermore, the coefficient of the stock-market induced portion of order flow is not only almost three times as large (in absolute terms) as is the coefficient on residual order flow, it is also much more precisely estimated and the difference between the two coefficient estimates is statistically different from zero. The point estimates indicate that a net increase of US$ 100 million in purchases of baht related to investors' stock-market transactions would have been associated, on average, with an appreciation of the baht against the U.S. dollar of ca. 0.26% during the sample period. In contrast, an equal-sized increase in the residual portion of FX order flow would have generated a contemporaneous appreciation of the baht of less than 0.1%.

C. Longer-Run Impact of Portions of FX Order Flow on the Exchange Rate

To analyze the immediate as well as the longer-run impact of FX order flow driven by investors' transactions in the equity and bond markets, we estimated a four-variable vector autoregressive (VAR) model consisting of the constructed FX order flow series on (i) stock market variables, (ii) bond market variables, (iii) the residual portion of order flow, and (iv) baht–dollar returns. Three lags of all variables were included. We orthogonalized the impulse response functions using the Cholesky decomposition method to let innovations in the order flow series drive FX returns, but not vice versa. The three order flow series were found to be weakly exogenous to the baht–dollar returns series. Our choice of ordering the variables in the Cholesky decomposition is thus supported by the data.[20]

The associated impulse response functions (IRFs) and cumulative response functions (CRFs), which trace the effects of innovations in the three components of `FX_SPOT` on the exchange

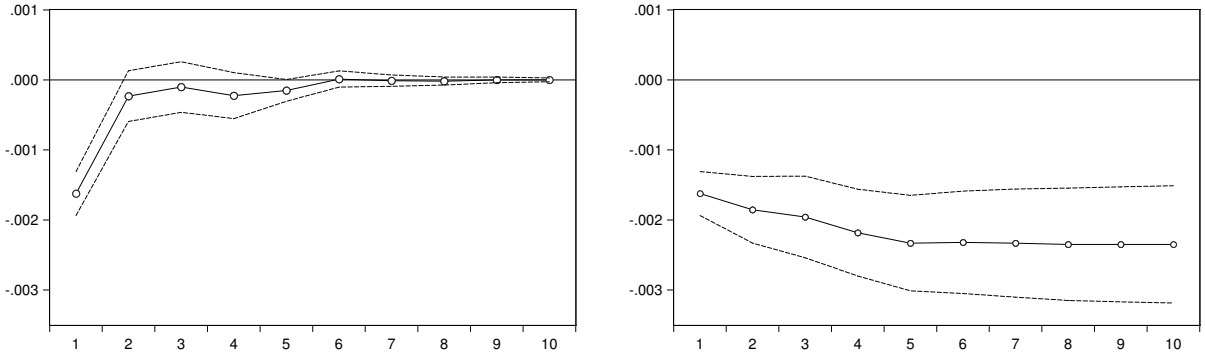
[20] Killeen, Lyons, and Moore (2006) also found weak exogeneity of order flow with respect to exchange rates for the case of the French franc/Deutsche mark exchange rate pair. To check the robustness of our conclusions, we re-estimated the VAR with 6 lags instead of 3 lags, and we also constructed the IRFs and CRFs using a "structural" decomposition in addition to the Cholesky decomposition. Our conclusions were not affected by these alternative specifications.

Figure 1. Short and longer-term THB/USD exchange rate responses to FX order flow shocks

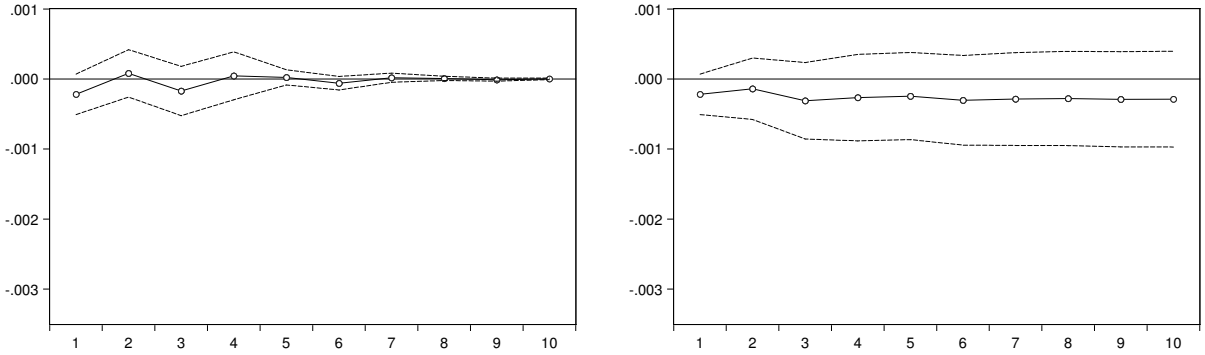
The left-hand panels show impulse response functions, and the right-hand panels show cumulative response functions of the THB/USD exchange rate to 1-standard-deviation shocks in three types of FX order flow: those induced by stock-related trading (upper row), bond-related trading (middle row), and the residual series (bottom row).

A baht appreciation vis-à-vis the dollar is shown as a *negative* response. The units of measurement are business days on the horizontal axes and percent changes on the vertical axes. Dashed lines denote two-sided 95% confidence bands.

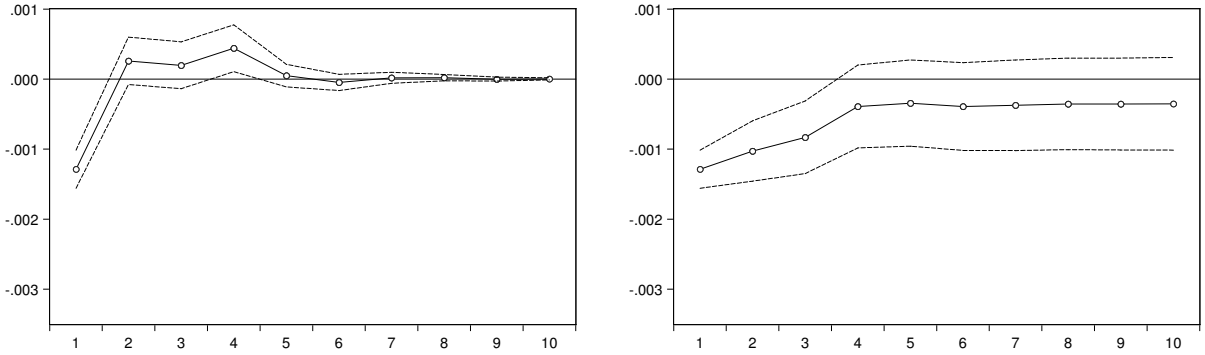
(a) Impulse and cumulative impact of shocks to stock-induced FX flow



(b) Impulse and cumulative impact of shocks to bond-induced FX flow



(c) Impulse and cumulative impact of shocks to residual FX flow



rate out to ten days, are shown in Figure 1. At longer time horizons, the functions are essentially flat and therefore do not provide additional information about the system's medium- to long-term dynamic properties. The impulse response functions shown in the top-left and bottom-left panels of Figure 1 indicate that a 1 standard deviation innovation FX order flow that can be attributed to equity market variables has an *initial* impact on baht returns that is about 25% larger (−0.16% vs. −0.13%) than that of a 1 standard deviation innovation in residual order flow. Taking into account, further, that during the sample period the standard deviations of the equity driven and residual portions of net FX spot market order flow were US$ 73.2 million and US$ 134.6 million, respectively, it follows that—dollar for dollar—innovations in the equity market driven portion of the FX order flow have an initial impact on the baht that is *more than twice as large* as that of innovations in the residual portion.

The cumulative effects of these innovations on the *level* of the Thai baht's exchange value are depicted by the CRFs shown in the right-hand panels of Figure 1. The top-right panel demonstrates that the previously noted *initial* impact of an innovation in FX order flow is not reversed subsequently if this innovation is driven by stock-market flows. In contrast, the center and bottom right-hand panels of Figure 1 show that the cumulative impact of an innovation in both the bond-induced and the residual portion of FX order flow on the *level* of the baht's exchange value is either never statistically different from zero (in the case of bond-induced order flow) or becomes statistically insignificant within four or five days (in the case of residual order flow). Hence, even though the initial or instantaneous effect of the residual component FX order flow is statistically significant, this variable has no *lasting* influence on the level of the baht.

These results demonstrate that the portion of FX order flow that reflects investors' transactions in the stock market has both economically and statistically significant long-run effects on the exchange rate, whereas the two other portions generate at most transitory effects. Given the autocorrelation patterns present in the stock, bond, and residual portions of FX order flow, we interpret these results as showing that it is private information conveyed by `FX_SPOT_STOCK` that accounts for the large and permanent effect of this series on the exchange rate.

Table 5. Determinants of FX swap order flow

The dependent variable is FX_SWAP, the FX swap order flow conducted by foreign investors in Thailand.

Estimation method: Ordinary least squares.

The numbers in the *p*-value column denote the significance of the associated *t*-statistics against the two-sided alternative that the coefficients in question are different from zero.

Additional regressors (coefficients not shown): Constant term and first three lags of explanatory variables.

Regressor	Coeff.	Std. Error	*t*-statistic	*p*-value
SET	−525.613	687.958	−0.764	0.445
STOCKS	0.380	0.217	1.750	0.081
OUTRIGHT_BOND	0.313	0.138	2.262	0.024
OTHER_BOND	0.830	0.215	3.865	0.000
	R^2	0.180	F-stat.	4.63
	Adj. R^2	0.142	Prob. F-stat.	0.00

Number of observations: 353 after adjustments.

D. Possible Alternative Explanations

1. Hedging Activity

A possible alternative explanation for the finding that only equity-driven FX order flow has a large and permanent effect on the exchange rate is that only FX risk incurred by equities is left unhedged by investors. In the Thai baht FX market, hedging of FX risk is typically undertaken through FX swaps. Thus, if there is hedging of bond positions but not of equity positions, FX swap order flow should be driven more by bond flows than by equity flows. However, as we show in Table 5, when we regress FX_SPOT order flow on contemporaneous order flow in the equity, "outright" bond, and "other" bond markets, we find that foreign investors did *not* use FX swaps differently for hedging their equity and "outright" bond transactions; the point estimate of the coefficient on contemporaneous stock market order flow is actually slightly larger than that of "outright" bond order flow, but the difference between these point estimates is not statistically significant. Differences in hedging behavior therefore can not explain our findings.

The low extent to which FX risk incurred by holding either equities or "outright" bonds is hedged may also reflect the fact that foreign investors face binding restrictions—such as pro-

hibitions on short-selling of many classes of financial assets—that make the hedging of FX market risk either too expensive or entirely infeasible.

As shown in Table 5, the coefficient on the OTHER_BOND order flow variable is 0.83, i.e., the FX risk associated with "other" bond transactions *does* appear to be almost fully hedged through offsetting FX swap transactions. This is consistent with anecdotal evidence that "other" bond market transactions are used mainly in conjunction with banks' local money market operations. This is also consistent with our finding that our inferences are not sensitive to the inclusion or removal of "other" bond transactions from the order flow regressions.

2. Carry Trade Activity

Another possible alternative explanation for our finding that bond market order flow does not appear to affect the exchange rate is that foreign investors could be buying and selling Thai bonds as part of a carry trade strategy. During the sample period, Thailand experienced robust economic growth and offered attractive interest rate differentials to investors. If foreign investors' bond transactions were mainly carry trades, the induced FX order flow should not contain private information and hence should not affect the exchange rate systematically. We find however, that contemporaneous and lagged fluctuations in baht–dollar interest rate differentials were *not* statistically significant drivers of bond market transactions. Thus, carry trade activity—by itself—cannot explain the lack of a significant relationship between bond-market induced FX order flow and exchange rate fluctuations.[21]

We also examined the possibility that fluctuations in the dollar–yen exchange rate could be an important driver of carry trade activity. We found that, over the sample period as a whole, fluctuations in dollar–yen indeed help explain, in a statistical sense, contemporaneous baht–dollar movements; a 1 percent daily appreciation of the yen against the dollar was associated with a same-day 0.3 percent appreciation of the baht against the dollar. However, the inclusion of yen–dollar returns as an additional regressor in the order flow regressions had only a negligible impact on the coefficients of the order flow variables.

[21] See Sarno and Sojli (2009) and Sarno and Valente (2009) for a review of the "feeble" or "footloose" connections between exchange rates and economic fundamentals such as interest rate differentials.

V. Concluding Remarks

In this paper, we have proposed that when it comes to external capital flows, it is foreign investors' private information related to the stock market and not the bond market which drives the exchange rate. We tested this proposition using daily-frequency data from three financial markets in Thailand, and found strong evidence in favor of this proposition. To paraphrase the famous dictum of Orwell (1945), some capital flows are indeed more equal than others when it comes to affecting exchange rates. Specifically, we found that only the relatively small portion of FX flows that is driven by foreign investors' transactions in the stock market has a *lasting* effect on the exchange rate. Given that these flows in the stock and FX markets are consistent with information asymmetry between domestic and foreign investors, we infer that the reason these flows have a lasting effect on the exchange rate is that they convey investors' *private* information to the market. In contrast, the much larger portion of FX flows that is not explained by stock market variables plays *at most* a transitory role in determining the exchange rate. Taken together, these findings strongly suggest that—at least for the case of Thailand—FX order flow is relevant for the exchange rate if it reflects investors' private information about the prospects of individual firms.

Our findings also suggest that data collection efforts on external capital flows might be made more informative if they were categorized according to their private information content. Having such data would enable economists and policy makers to distinguish more readily between information-driven flows and those that are driven by liquidity or "noise" trades. Our results suggest that analysts should focus their attention on those flows that convey private information.

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