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Private information, capital flows, and exchange rates ☆

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ABSTRACT

Not all international capital flows influence exchange rates equally. Capital flows induced by foreign investors' transactions in local stock markets have an impact on exchange rates that is economically significant and permanent, whereas capital flows induced by investors' transactions in local government bond markets do not. The differences in price impacts are related to differences in the amounts of private information conveyed by these flows. Our findings are based on daily-frequency data on all transactions undertaken by foreign investors in the stock, bond, and onshore FX markets of Thailand over a period of nearly two years.

1. Introduction

The determination of foreign exchange rates has long been an important but empirically challenging topic in international economics. Models that aim to relate foreign exchange (FX) rates directly to macroeconomic fundamentals tend to have disappointing out-of-sample and forecasting properties (Meese and Rogoff, 1983; Cheung et al., 2005, 2017). Instead of contin-

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uing to try to model exchange rates primarily as variables that equilibrate exports and imports of goods and services across countries, economists turned to modeling exchange rates as the relative prices of assets denominated in various currencies, with trade flows and financial flows *both* responding to asset demands and supplies. Moreover, 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 more fully, one needs to distinguish between the private and public information sets of market participants. Because published data about macroeconomic fundamentals constitute public information, models that rely exclusively on macroeconomic fundamentals are bound to disappoint as the miss the influence investors' private information.

There is by now broad agreement among researchers that FX order flow, defined as the difference between buyer-initiated and seller-initiated transaction volumes in the FX market, helps explain exchange rates because it conveys investors' private information. Market-relevant private information can pertain to future changes in aggregate economic activity and inflation as well as to firm-level cash flows and discount rates. FX order flow that is driven by market participants' private information ("informed trades") should have, in principle, a permanent effect on exchange rates. In contrast, FX order flow that is not driven by private information ("noise trades") should have at most a temporary impact on exchange rates. Models of exchange rate determination which include order flow as an explanatory variable—such as those in Evans and Lyons (2002, 2012) and, more recently, Krohn and Moore (2017)—tend to dramatically outperform models which rely exclusively on macroeconomic variables and other forms of public information, in terms of both in-sample goodness of fit and out-of-sample forecasting accuracy.[1]

These empirical studies show convincingly that FX order flow matters because it conveys private information. However, they do not examine *where* in the economy the private information originates. Rime et al. (2010, p. 73) note that "economists are still [waiting] for conclusive evidence explaining where the information in order flow stems from." Specifically, does the private information originate in the FX market itself, or is it generated in other financial markets, and is it transmitted to the FX market via linkages between financial markets?

Several empirical studies have found significant statistical linkages between foreign investors' order flow in local stock markets and returns in the FX market (see, e.g., Goodhart, 1988; Brooks et al., 2004; Gehrig and Menkhoff, 2004; Siourounis, 2008; Albuquerque et al., 2008; Dunne et al., 2010). Francis et al. (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."[2]

The empirical findings we present in this paper are fully consistent with these earlier studies. One main contribution of our paper is to expand the scope of the earlier work, by estimating the effects of FX order flow associated with investors' transactions in *both* stock and government bond markets. Using an order flow regression setup, we find that the portion of foreign investors' FX order flow that is associated with their transactions in the local stock market has a statistically significant contemporaneous influence on the exchange rate, whereas the portion of FX order flow that is related to their government market transactions does not. In addition, we find that the effect of stock-market-related FX order flow on the exchange rate is permanent, whereas all other portions of FX order flow have at most a transitory influence.

To establish these empirical results, we employ datasets from three different financial markets—FX, stock, and bond markets—for an entire country. The data consist of nearly two years' worth of all *daily-frequency* transactions undertaken by foreign investors in the onshore foreign exchange, stock, and bond markets of Thailand. Importantly, the data comprise all buy and sell transactions of foreign investors in all three markets. We also exploit knowledge of certain institutional features of financial markets in Thailand, such as regulations which strictly limit the size of Thai baht-denominated bank balances that may be held by foreign investors in Thailand, to demonstrate that the statistical linkages across these financial markets are not mere coincidences but are, at least in part, induced by these institutional features.

To the best of our knowledge, our study is the first of its kind that analyzes 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. Having datasets for three financial markets is what makes it possible to estimate the portions of FX order that are associated with, or triggered by, order flow in the stock and bond markets. This, in turn, makes it possible to answer the question as to whether the private information that appears to influence exchange rates is diffuse, i.e., whether it is generated roughly equally by transactions in both domestic capital markets, or if it is concentrated in just one of the domestic markets—the stock market. By utilizing data from Thailand, a major emerging market economy, our study also serves to broaden the geographical range of data employed in exchange rate determination studies; previous studies in this field have generally used datasets from developed economies.[3]

[1] For surveys of the market microstructure literature on the subject of exchange rate determination, see Lyons (2001), Sarno and Taylor (2002), Osler (2009), and King et al. (2013). Linkages between private information and capital flows—as opposed to those between private information and exchange rates—are examined by Forbes and Warnock (2012), Broner et al. (2013), and Tille and van Wincoop (2014). Ter Ellen et al. (2013) examine various decision rules institutional investors report using for their FX market transactions.

[2] It is also well known that FX dealers routinely scrutinize their own customers' order flow carefully in order to extract any information that may be relevant for exchange rates; importantly, this scrutiny extends to linkages in their customers' order flow across two or more financial markets.

[3] Exceptions to this claim are Richards (2005) and Chai-Anant and Ho (2008), who provide descriptions of investors' trading behavior and of financial market dynamics in several Asia–Pacific economies. Rime and Tranvåg (2012) and Duffuor et al. (2012) also examine order flow and exchange rate dynamics in selected emerging-market economies. Gyntelberg et al. (2014) examine empirically whether portfolio balance effects may explain returns in both the stock market and the FX market of Thailand.

Private information is not observable. How might one establish, then, that our empirically estimated differences in the price impacts of stock-market- and bond-market-induced FX order flow are due to differences in the amounts of private information conveyed by these two types of order flow? Recall that the main "end-user" or final counterparty of the group of foreign investors in a given economy is the group of domestic investors: In the aggregate, if foreign investors wish to be net buyers (sellers) of shares and bonds, domestic investors must be net sellers (buyers) of these assets. If private information is an important driver of the buy and sell decisions of foreign investors, the information conveyed by their net transactions must primarily be the *difference* in the amounts of private information held by the two groups of investors. For the differences in price impacts of stock-market and bond-market induced FX order flows to reflect differences in private information, it should be the case that (a) foreign investors as a group have either significantly less or more private information than domestic investors have in the stock market, whereas (b) there is no significant difference in private information between the two investor groups in the government bond market.

How might one substantiate the claim that private information and, in particular, private information differentials relative to domestic investors affect foreign investors' transactions in the domestic stock market but not in the domestic government bond market? Two groups of findings in the existing literature on international capital flows may be adduced to answer this question. The *first* group concerns empirical relationships between foreign investors' stock and bond market transactions and various components of asset returns. The *second* group relates to observable differences in investor behavior—specifically, the absence or presence of return chasing and flow momentum—and how these differences reflect the absence or presence of private information.

Regarding the first group, we may turn to empirical studies of the determinants of international financial flows. For instance, Cenedese and Mallucci (2016) analyze the relationships between the cross-border capital flows undertaken by international mutual funds—a highly influential group of institutional investors—and four components of the returns in the equity and bond markets of 31 countries, including 13 emerging market economies, using monthly data from January 2004 to December 2013. The four return components are (changes in) expectations of future cash flows, interest rates, exchange rates, and discount rates. Cenedese and Mallucci report that news about future cash flows rather than news about changes in discount rates are the main source of variation in equity market returns, especially in emerging market economies. The authors also find that real interest rate shocks and exchange rate shocks are not associated, empirically, with international equity flows. In contrast, the authors report that bond flows toward emerging markets are influenced importantly by U.S. dollar real interest rate shocks, i.e., by shocks that do not originate in the host countries. Similarly, Ahmed and Zlate (2014) report that debt-instrument flows to emerging markets are correlated significantly with policy interventions and business cycle conditions in developed economies.

That future cash flow shocks are a main driver of the stock market flows of international mutual funds is highly relevant for our study, since expectations about local firms' future cash flows and earnings are private information long before they become public information in the form of firms' published earnings reports. In emerging markets, foreign investors tend to be at a private-information disadvantage relative to domestic investors, in part because firm-specific news and rumours first surface in the local-language(s) press and thereby become accessible to domestic investors before they are picked up by the international press and become accessible to foreign investors. In contrast, as most governments release all press statements and statistical reports simultaneously in the country's local language(s) as well as in one or more internationally used languages (frequently English), it is not plausible to argue that foreign investors nowadays are at a systematic disadvantage relative to domestic investors when it comes to information about inflation, economic growth, government finances, and other variables that affect future discount rates—the most important drivers of local bond market returns.

With respect to the second group of findings, *viz.*, observable differences in investor behavior, Cenedese and Mallucci (2016) report that when equity market return shocks are driven by cash-flow news, international mutual funds tend to engage in short-term trend-chasing behavior. In contrast, the authors do not find that the bond market flows of international mutual funds exhibit trend-chasing behavior. Brennan and Cao (1997) show that if one group of investors (here: foreign investors) is at a systematic private information disadvantage and if this information disadvantage never dissipates fully, it is optimal for this group of investors to engage in trend-chasing behavior. Correspondingly, if there are no private information differentials, optimizing investors should not engage in trend-chasing behavior. As we report in more detail in Section 3 below, there is evidence of flow momentum in foreign investors' equity and FX market transactions in Thailand—but not in their transactions in the government bond market. We interpret this absence of flow momentum in foreign investors' transactions in the government bond market as an indication that a private information disadvantage is not an important driver of their bond market transactions.

Our empirical work is also related to 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, provide significant amounts of private information, in the sense that their order flow appears to have a strong and lasting impact on the exchange rate, whereas order flow generated by unleveraged institutional investors, large corporations, government agencies, and central banks appears to convey little private information. Fan and Lyons (2003) and Carpenter and Wang (2007) state that in FX markets, transactions initiated by financial customers convey more private information, at least in the short run, than do transactions initiated by commercial customers. If the FX order flow initiated by leveraged investors indeed conveys more private information than does the order flow of other institutional investors, our findings suggest that the reason for this difference lies in the fact that stock-market-induced FX flows may be generated to a signif-

icant extent by leveraged investors. This view is consistent with anecdotal evidence supplied in investor surveys, which report that in Asia hedge funds are more active in equity markets than they are in bond markets.[4]

The remainder of the paper is structured as follows. Section 2 provides an overview of the financial markets of interest and introduces the datasets. Section 3 discusses the relationship between private information differentials and serial correlation in order flow. Section 4 presents the econometric evidence on the differences in price impacts of various types of FX order flow. Section 5 concludes.

2. The markets and the data

In this section, we provide an overview of the onshore FX, stock, and government bond markets in Thailand, focusing on aspects of the markets and data that are important for the development of our empirical analysis. We also discuss certain regulatory features of the financial markets in Thailand that induce a close relationship between foreign investors' capital and FX market transactions.[5]

2.1. Sample period and foreign investor definition

Throughout the paper, we focus on the transactions of foreign investors. Formally, foreign investors in Thailand 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) Statistics and Information Systems Department, financial institutions domiciled outside of Thailand are by far the most active group of foreign investors, with a share well in excess of 90% of total transactions conducted by foreign investors.

Foreign investors who hold bank balances in Thailand are required to do so by holding so-called nonresident baht accounts, or NRBAs. NRBA-related regulations were broadly stable during the sample period.[6] For our purposes, the most important regulation is that balances held in NRBAs were not allowed to 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, and it is strictly enforced by the authorities.

If foreign investors in Thailand, as a group, wish to build up (unwind) their positions in baht-denominated financial assets such as bonds or shares, they can do so in the short run in 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 and matching the proceeds of these transactions with their capital market transactions. Because of the fairly low 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-denominated shares and bonds by transacting in the onshore FX market. This institutional feature is one of the keys to our ability to link foreign investors' order flow across markets.

All observations are daily. The sample period runs from January 4, 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, headlined by a 30% unremunerated reserve requirement (URR) on nonresident or foreign investors' financial holdings apart from stock market holdings. 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-dollar trading increased, and a large differential opened up between onshore and offshore baht-dollar quotes.[7]

2.2. 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

[4] If foreign investors generate private information in the domestic stock market, this does not imply, *per se*, that they are (on average) better or worse informed than domestic investors are. It also does not imply that foreign investors earn higher or lower profits on average. That said, we empirical autocorrelation patterns present in foreign investors' order flow in the Stock Exchange of Thailand (SET) indicate that foreign investors had, on average, *less* private information about SET-listed firms than domestic investors had during the sample period. This finding is consistent with the studies by Choe et al. (2005), Dvořák (2005), Chan et al. (2007), and Taechapiroontong and Suecharoenkit (2011), who report that foreign investors tend to have *less* private information than domestic investors have in the equity markets of Korea, Indonesia, China, and Thailand, respectively.

[5] Additional characterizations of the datasets and further descriptive statistics are provided in Gyntelberg et al. (2009, 2014).

[6] The NRBA regulations relevant for our study went into effect in October 2004, i.e., just before the start of the sample period. The full range of applicable regulations is stated in Bank of Thailand (2017).

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

can be domestic or foreign-owned banks and brokers, provide wholesale FX trading services. In addition to conducting inter-dealer transactions, the FX banks also conduct FX purchases and sales with both domestic and foreign end-users. 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).

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 their regulatory capital ("individual currency limit") and also to maintain a net overall FX position across *all* foreign currencies of no more than 20% of regulatory 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. Banks 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 these 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. There are five types of FX transactions: spot trades (separated further into same-day, "tomorrow" or $T+1$, and "next" or $T+2$ transactions), outright forwards ($T \geqslant 3$), 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.[8]

Daily-frequency gross and net capital flow series for all five types of FX contracts were constructed for us by BoT staff. This was done by first 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 the gross and net flows between dealers and their *foreign* customers.

From conversations we held with several 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. Transactions between the BoT and FX dealers 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 had not occurred. 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.

Table 1 shows that foreign investors were, across all FX categories, net sellers of baht on average at the daily frequency in both 2005 and 2006, with net transaction totals somewhat higher in 2006 than in 2005. Looking at the individual FX categories, foreign investors were net buyers of baht on average in the spot-today, spot-tomorrow, and spot-next FX categories, but net sellers of baht through outright forwards and FX swaps. The table also reveals considerable dispersion of the daily figures around these averages. To wit, whereas foreign investors bought about $19.6 million per day *on average* in the spot-next segment in 2006, the maximal daily net sales and purchases during that year were $766.2 and $659.2 million, respectively.

As is the case with most other emerging market economies, trading in the onshore FX market in Thailand occurs almost exclusively during Thai business hours; virtually no transactions occur overnight. 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 developments that occur after the close of business in the onshore market.

2.3. 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. Investors can trade securities on the SET through any of 39 brokerage houses, many of which are foreign-owned. Settlement for equities is generally performed on a $T+3$ basis. Average daily net purchases of stocks (buys minus sells) on the SET by foreign investors in

[8] The transaction records do not provide information about which counterparty—the reporter or the customer—initiated the transaction, the bid-ask spread, or whether the transaction took place at the bank's bid or ask quote. In addition, the transaction records do not contain intraday time-stamp information.

Table 1
Daily net transaction volumes of nonresident investors in the FX, stock, and bond markets. Net transactions are the buy-total minus the sell-total, in millions of US$.

	Mean	St.Dev.	Minimum	Maximum
2005, 4 Jan–30 Dec				
FX market, total	−56.2	200.1	−888.6	576.3
Spot, today	18.9	19.3	−8.1	289.2
Spot, tomorrow	20.0	50.9	−193.7	219.6
Spot, next ($T+2$)	24.4	116.7	−486.7	349.6
Outright forwards	−21.1	48.6	−250.5	114.6
FX Swaps	−98.3	113.3	−483.5	271.8
Stocks, total	12.1	39.4	−110.1	169.4
Bonds, total	−6.4	47.4	−182.5	162.3
Bonds, outright	−4.6	31.4	−174.7	96.7
Bonds, other	−2.5	39.3	−134.9	113.7
2006, 3 Jan–15 Dec				
FX market, total	−78.8	264.6	−1712.9	671.1
Spot, today	20.4	20.3	−192.3	56.4
Spot, tomorrow	22.9	98.0	−257.8	342.0
Spot, next ($T+2$)	19.6	181.4	−766.2	659.5
Outright forwards	−17.5	78.6	−591.8	447.6
FX Swaps	−124.3	138.7	−564.5	363.8
Stocks, total	12.7	60.1	−147.5	388.8
Bonds, total	−7.4	68.0	−234.2	225.7
Bonds, outright	−7.6	54.0	−225.6	179.4
Bonds, other	0.7	40.0	−134.8	120.8

2005 and 2006 were US$ 12.1 million and US$ 12.7 million; cf. Table 1. As was the case with their FX market transaction, there was considerable dispersion in their daily net transactions of shares; in 2006, the largest net daily sale of shares was $147.5 million, while the largest net daily purchase of shares was $388.8 million.

In 2005, roughly 28% of total trading volume on the Stock Exchange of Thailand was conducted by foreign investors. Domestic retail or "individual" investors accounted for about 10% of trading volume, and the remainder—62%—was conducted by domestic institutional investors. These include proprietary trading and local institutions such as asset management companies and pension and provident funds. In 2006, the shares of foreign, domestic-retail, and domestic-institutional investors in total trading volume on the stock exchange were 34%, 12%, and 54%, respectively.

2.4. The bond market

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

On a daily average basis, foreign investors were net sellers of bonds in both 2005 and 2006; cf. Table 1. As was the case with FX and stocks, there was considerable dispersion in the daily flows around the average values. In 2006, net daily sales of ordinary bonds were as high as $225.6 million, while net daily purchases of ordinary bonds were as high as $179.4 million. During the sample period, trading in the secondary bond markets was overwhelmingly (about 98%) concentrated in BoT and government paper. 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.

In 2005 and 2006 combined, foreign investors generated about 17% of all trading volume in the bond market. Based solely on their relative market shares, then, foreign investors were considerably less important in the bond market than they were in the stock market. Among the domestic institutional investors, which accounted for 81% of total trading volume, the most important groups were asset management companies (36%), non-dealer license (13%), domestic non-financial companies (12%), and "other" entities (17%). Individual domestic investors generated only 2% of total bond market trading volume.

During the sample period, foreign investors' net daily transactions in the government bond market were, on average, only about half the size of their net daily transactions in the stock market. However, the standard deviation of flows was of roughly the same magnitude across the two markets. The smaller average size of foreign investors' net bond market transactions should not be interpreted as indicating that liquidity is worse in the bond market than in the stock market. As is the case with the government bond markets of many other countries, trading volume in Thailand government securities is very

heavily concentrated in a handful of "benchmark" securities. Anecdotal evidence indicates that foreign investors' transactions in the government bond market are concentrated in the securities that enjoy benchmark status.[9]

2.5. Additional market aspects

During the sample period, foreign investors' net daily stock market transactions were nearly uncorrelated *contemporaneously* with their net bond transactions. The full-sample correlation between these two series was less than 0.05 in absolute value, and the null hypothesis that the population correlation coefficient is 0 cannot be rejected at the 90% significance level. As we discuss in more detail in Section 4.3 below, the near-zero contemporaneous correlation among the stock and bond transactions has important simplifying implications for the way impulse response functions may be constructed from a vector autoregressive (VAR) model.

3. Private information and serial dependence in order flow

A fundamental tenet of market efficiency is that if all market participants possess common and homogeneous—and therefore in essence "public"—knowledge about asset returns and discount rates, there should be no flow momentum or return chasing behavior (Samuelson, 1965). Information heterogeneity among investors has important consequences for their optimal decision making procedures. Brennan and Cao (1997, p. 1854) demonstrate that if a group of investors—say, foreign investors in a local stock market—are at an information disadvantage relative to other investors (say, local investors), it is optimal for the former group to engage in return-chasing behavior even if the financial market in question is otherwise efficient.[10] Conversely, the presence of flow momentum, or non-zero serial correlation, in the net purchases or sales of assets undertaken by foreign investors may indicate that these investors' decisions are driven in part by private information disparities. Likewise, the absence of flow momentum in another financial market (say, a local government bond market) may indicate that there is no meaningful differences in the private information sets of foreign and domestic investors.

Should foreign investors' net daily transactions in the Stock Exchange of Thailand exhibit flow momentum, i.e., nonzero serial correlation, this finding would be a strong indicator that their decisions are driven in part by private information—specifically, private information differentials vis-á-vis local investors. Conversely, if there is no meaningful difference in private information across foreign and domestic investors in the local bond market, foreign investors' net daily transactions in that market should be serially uncorrelated.

Line (1) in Table 2 shows that foreign investors' daily net equity trades were indeed characterized by positive serial autocorrelation, or positive flow momentum, during the sample period. The null hypothesis that the first five autocorrelation coefficients of the series of daily net equity purchases are jointly zero is rejected strongly. Positive serial correlation is consistent with foreign investors having, on average, *less* private information than domestic investors have.

In contrast, there is very little serial correlation in foreign investors' net daily bond market transactions; cf. lines (2)–(4) in the table. The null hypothesis that the first five autocorrelation coefficients of the series of combined daily bond purchases—cf. line (4)—are jointly equal to 0 can *not* be rejected. The absence of autocorrelation is indicative of a lack of private information disparities. Given that bond market transactions in Thailand are heavily concentrated in government and central bank paper, and given that it is not plausible to assume that foreign investors are at a significant information disadvantage relative to domestic investors—at least at daily horizons—with regard to government paper, the lack of serial correlation is not surprising from a market microstructure perspective.[11]

Moreover, lines (6) and (7) in Table 2 show that foreign investors' transactions in the one-day and two-day spot segments of the FX market also exhibit positive serial correlation during the sample period. The sum of the daily FX spot and outright forwards series also exhibits non-negligible serial correlation; cf. line (9) in Table 2.

Taken together, we interpret these serial correlation patterns as a strong indication that while foreign investors' order flow in the stock market and at least two segments of the FX market are determined in part by private information disparities, this is not the case for their transactions in the bond market.

4. Empirical results

The propositions we wish to test are (a) that the portion of FX order flow that is induced by investors' stock market transactions has statistically significant contemporaneous and permanent effects on the exchange rate and (b) that the portion of

[9] To compare the linkages between trading volume and liquidity across the stock and government bond markets in greater depth, one would need to have access to disaggregated, intra-day data on all transactions in individual bond and stock securities. Unfortunately, we do not have such data. Moreover, we are not aware of any empirical studies that have examined the trading liquidity at the level of individual bonds and stocks in Thailand or have compared liquidity conditions across the two markets.

[10] The main assumption that is required to establish this result is that "the information advantage of [local investors] is the result of a gradual process of superior acquisition rather than of periodic large information leakages to locals." This assumption appears to be realistic for Thailand and many other emerging market economies.

[11] Observe that we do not claim that private information plays no role at all in the government bond market. We rely on a weaker condition: that there is no significant private information *differential* between domestic and foreign investors in this market.

Table 2
Autocorrelations in foreign investors' net daily order flow. *Source:* Bank of Thailand, CEIC, BIS, authors' calculations.

		Lags (in days)				
		1	2	3	4	5
(1)	*Equities*	0.55	0.42	0.34	0.23	0.17
	Bonds					
(2)	Bonds outright	−0.06	0.01	0.02	−0.03	0.02
(3)	Bonds other	−0.06	−0.01	−0.05	−0.07	0.06
(4)	Bonds, total	0.04	0.02	−0.01	−0.06	0.02
	Foreign exchange					
(5)	Spot, today	0.11	−0.03	0.01	0.07	0.10
(6)	Spot, tomorrow ($T+1$)	0.50	0.34	0.25	0.20	0.19
(7)	Spot, next ($T+2$)	0.29	0.23	0.14	0.14	0.12
(8)	Forwards	0.07	0.00	0.08	0.08	0.00
(9)	Sum of spot and forwards	0.21	0.14	0.05	0.02	0.14
(10)	FX Swaps	0.34	0.28	0.26	0.28	0.26

FX order flow that is induced by investors' bond market transactions does not. Table 3 provides the acronyms and brief descriptions of all variables used in this section.

To simplify and streamline the exposition and discussion of our empirical work, we aggregated the three FX spot series and the outright-forward series into a single new series, called `FX_SPOT`, and we combined the two bond market order flow series into a series called `BONDS`. All empirical findings reported in this section are based on these simplifications. To demonstrate that the main results reported in this section—that the portion of FX order flow that is associated with stock market variables has a statistically significant and permanent impact on the exchange rate, and that the other portions of FX order flow have at most a transitory impact on the exchange rate—are unaffected by these simplifications, we report the results obtained using a much less restrictive set of specification assumptions in Appendix A.1.

If each transaction record submitted by the FX dealing banks to the BoT contained information about whether the FX market transaction was associated with a transaction in (i) the domestic stock market, (ii) the bond market, or (iii) neither of the above, it would be straightforward to test our hypothesis directly: First, one would use the information contained in the transaction records to split the overall FX order flow into three separate time series. Second, one would set up and estimate an order flow regression, with the FX return as the dependent variable and the three FX order flow series as the regressors. Unfortunately, such detailed information regarding each transaction's potential linkages to other financial markets is not collected.

We do, however, have nearly two years' worth of complete daily data on the order flow undertaken by all foreign customers in the FX, stock, and bond markets. We employ a two-stage procedure. In the first stage, we construct proxies for the portions of investors' daily FX order flow that are associated with investors' order flow in the stock and bond markets, respectively. In the second stage, we perform an order flow regression with daily baht-dollar returns as the dependent variable and these proxy variables (as well as additional control variables) as the regressors, and we test whether the coefficients of the constructed regressors are statistically significant. 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 in lieu of the original series dates back, at least, to the work of Barro (1977).

The standard errors of all coefficient estimates were computed using the method proposed by Newey and West (1987) in order to be able to conduct statistical inference that is robust to the presence of heteroskedasticity and serial correlation in the disturbance terms. Lag length choices were made on the basis of the Schwarz criterion (SC). The regression models passed Chow-type specification tests for structural breaks in the regression relationships. As we explain in more detail below, the second-stage regression is estimated by 2SLS because it employs constructed rather than directly observed regressors.

4.1. FX order flow induced by stock and bond market transactions

In order to determine if FX order flow is affected by foreign investors' transactions in the stock and bond markets, we first regressed the `FX_SPOT` order flow series on foreign investors' contemporaneous bond and stock market order flow variables. The results of this regression are shown in Table 4.

The regression estimates show that a US$ 1 million increase in foreign investors' net purchases of shares on the stock market was associated, on average, with a contemporaneous increase of about US$ 1.071 million in net purchases of baht. The point estimate of the coefficient, 1.071, is statistically significantly different from 0 but not different from 1. One can thus not reject the hypothesis that investors stock market purchases are associated one-for-one with transactions in the (com-

Table 3
Variable mnemonics and descriptions. Order flow is measured as the net daily transactions between banks and foreign customers. Net daily transactions are defined as the difference between banks' daily "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
BONDS_OUTRIGHT	Order flow, "outright" bonds
BONDS_OTHER	Order flow, "other" bonds
BONDS	Order flow, 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_STOCK	Portion of FX_SPOT series that is explained by stock market order flow
FX_SPOT_BOND	Portion of FX_SPOT series that is explained by bond market order flow
FX_SPOT_RESID	Residual: FX_SPOT − FX_SPOT_STOCK − FX_SPOT_BOND

Table 4
Influence of stock and bond market transactions on FX flows. Dependent variable: FX_SPOT, i.e., all customer FX market order flow except 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.

Regressor	Coefficient	Std. error	*t*-statistic
C	28.022	7.856	3.57
STOCKS	1.071	0.274	3.91
BONDS	0.439	0.177	2.49

$R^2 = 0.128$, F-stat $= 34.6$, Prob. F-stat. $= 0.00$.
Number of observations: 472.

bined) spot and forward segments of the FX market. A US$ 1 million increase in purchases of bonds was associated with US$ 0.439 million in additional baht purchases.[12]

To be sure, we do not claim that investors' transactions in the stock, bond, and FX markets are driven *exclusively* by private information. Their transactions could, and should, also be driven by public information releases. Indeed, Rime et al. (2010, p. 77) estimate that up to 15% of the daily fluctuations in order flow in the FX markets of the euro, the UK pound, and the Japanese yen vs. the US dollar can be explained by macroeconomic news—as well as by hedging and liquidity motives unrelated to macroeconomic conditions. For the purposes of our analysis, however, it is not necessary to include proxies for public information in order to estimate pricing effects driven by private information. Because contemporaneous public and private information are orthogonal by assumption, we may appeal to a well-known result in econometrics—that the omission of relevant regressors which are orthogonal to the included regressors does not cause omitted-variable bias—to conclude that the non-inclusion of variables that proxy for public information does not create an omitted-variable bias in the regression reported in Table 4.

Using the coefficient estimates reported in Table 4, we constructed proxies for the portions of daily FX spot order flow that are driven by (a) stock market order flow, called FX_SPOT_STOCK, and (b) bond market order flow, called FX_SPOT_BOND. Observe that the two fitted series, FX_SPOT_STOCK and FX_SPOT_BOND, are single-variable linear functions of STOCK and BOND, respectively. They therefore have the same serial correlation properties as the variables they are based on. Hence, FX_SPOT_STOCK features significant autocorrelation in the sample, whereas FX_SPOT_BOND does not. Moreover, FX_SPOT_STOCK and FX_SPOT_BOND are also only weakly contemporaneously correlated with each other.

The residual from the regression reported in Table 4, called FX_SPOT_RESID, serves as the third regressor in the second-stage order flow regression model and the vector autoregression (VAR) that are examined in the next two subsections. By construction, FX_SPOT_RESID is uncorrelated with both FX_SPOT_STOCK and FX_SPOT_BOND. The first five autocorrelation coefficients of FX_SPOT_RESID are 0.12, 0.02, −0.03, −0.03, and 0.10, respectively. The null hypothesis that the first five serial correlation coefficients are jointly 0 can be rejected at the 5% level but not at the 1% level. Note that the three constructed order flow series are measured in the same units, *viz.*, millions of dollars.

[12] In addition to this regression, we also ran regressions which included contemporaneous SET index returns (SET) and the first three lags of the STOCKS and BONDS series as additional regressors. While the coefficient on SET was statistically significant, its inclusion (or omission) did not affect the coefficients or standard errors of the order flow variables in the regression reported in Table 4. Moreover, none of the lagged regressors were statistically significant. Thus, the relationships between the order flow series are mainly contemporaneous.

4.2. Order flow regression

We next regressed daily baht-dollar returns (THB), computed as log first differences, on the two fitted FX order flow series, FX_SPOT_STOCK and FX_SPOT_BOND, and on the residual order flow series, FX_SPOT_RESID; cf. Table 5. The model was estimated using two-stage least squares (2SLS). Use of 2SLS is necessary because the regressors are constructed rather than directly observed; the resulting statistical dependence between the regressors and the error term of the second-stage regression would render OLS-based inference invalid.[13]

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, on average, with an appreciation of the baht. The first main empirical result of the order flow regression is that the coefficient of FX_SPOT_STOCK, the stock-market induced portion of order flow, is statistically significant. The point estimate indicates that, during the sample period, a net increase of US$ 100 million in purchases of baht that was related to investors' stock market transactions was associated with a same-day appreciation of the baht against the U.S. dollar of ca. 0.13%. Second, the coefficient of FX_SPOT_STOCK is the *only* slope coefficient that is statistically significant; the coefficients of the bond-market portion and the residual part of the FX order flow are both statistically insignificant.

4.3. Long-run impact of FX order flow on the exchange rate

To analyze the longer-run impact that FX order flow driven by investors' transactions in the equity and bond markets may have on exchange rate returns, we also estimated a four-variable vector autoregression (VAR) consisting of FX_SPOT_STOCK, FX_SPOT_BOND, and FX_SPOT_RESID—i.e., the components of FX spot order flow that are driven by stock and bond market variables and the residual component—and THB, the baht-dollar returns. Three lags of all variables were included. The results of an alternative specification, in which the VAR was estimated with 6 instead of 3 lags, are reported in Appendix A.2. The results are virtually the same as those for the 3-lag VAR.

Of primary interest are the impulse response functions (IRFs) and cumulative response functions (CRFs), which show how shocks to the three order flow series are propagated over time to baht-dollar returns. As noted earlier, the three order flow series are either only barely or completely uncorrelated contemporaneously with each other in the sample. The choice of ordering of the three variables is therefore (numerically) immaterial when employing the so-called orthogonal (or Cholesky) method for computing the IRFs and CRFs. Moreover, the generalized impulse response functions (GIRFs) proposed by Pesaran and Shin (1998) coincide with the orthogonalized IRFs if the variables are uncorrelated.[14]

Fig. 1 shows the IRFs and CRFs that trace the dynamic effects of innovations in the three components of FX_SPOT on the exchange rate, out to ten business days.[15] The IRF shown in the top-left panel of the figure indicates that a shock to the FX order flow component that may be attributed to equity market variables has a negative and statistically significant *initial impact* on baht returns;[16] the FX rate response on subsequent days is close to zero and, with the exception of day 4, not statistically significant. The *cumulative* impact of such a shock, shown in the top-right panel of the figure, is a permanent and statistically significant appreciation of the baht. Put differently, the initial impact of an innovation in FX order flow is *not* reversed if it is driven by stock-market flows.

In contrast, both the initial and cumulative impacts of FX order flow innovations driven by bond market transactions are close to zero as well as not statistically significant; cf. the middle row of Fig. 1. Thus, the finding that bond-induced FX order flow does not influence FX rates holds in the long run as well. Finally, even though the *initial* response to a shock to the residual portion of FX order flow—cf. the bottom row of the figure—is a statistically significant appreciation of the baht, this effect is largely reversed over the next 4–5 business days. In consequence, the *cumulative* response of THB/USD to this type of shock is not statistically different from zero after 4 or 5 days. Taken together, these results demonstrate that the portion of FX order flow that reflects investors' transactions in the stock market has statistically significant short- and long-run effects on the exchange rate, whereas the two other portions generate at most transitory effects.

We may now relate these results to the finding reported in Section 3, *viz.*, that foreign investors' order flow in the stock market and foreign exchange market is serially correlated whereas their order flow in the bond market is not. We had argued that flow momentum in net transactions of a subset of investors in an otherwise efficient market may indicate that private information differentials are affecting their transactions. Combining the two sets of findings, we infer that private information conveyed via FX_SPOT_STOCK to the FX market may explain the large and permanent effect of this order flow series on the exchange rate. Conversely, the indirect evidence for a lack of private information conveyed via FX_SPOT_BOND may

[13] Mishkin (1982) and Pagan (1984) examined the econometric issues that arise when using constructed regressors. Pagan showed that whereas all three coefficient point estimates as well as the standard errors of the *residual* regressor are actually estimated consistently by OLS, the OLS-based estimates of the standard errors of the two *fitted* regressors would be inconsistent. We specified the second-stage regression equation as recommended by Pagan and used instruments for the two fitted regressors.

[14] See, in particular, Proposition 3.1 in Pesaran and Shin (1998).

[15] At time horizons longer than ten days, the functions are essentially flat and therefore do not provide additional information about the system's longer-horizon dynamic properties.

[16] Recall that a baht appreciation versus the dollar means that fewer baht are needed to buy one dollar. Hence, a baht appreciation is expressed as a *negative return* on THB/USD.

Table 5
FX order flow regression. Dependent variable: THB, log first difference of the baht/dollar exchange rate. Negative values of the regression coefficients imply an appreciation of the baht versus the dollar. The coefficients and standard errors of the regressors (but not of the constant term) are scaled to denote a percentage change in the dependent variable in response to a US$100 million change in the regressor. Estimation method: Two-stage least squares. As instruments for the fitted regressors, we used lagged stock market and bond market order flow variables as well as lagged stock market returns. The standard errors are calculated using the Newey-West method, with a Bartlett kernel and a lag length of 6.

Regressor	Coefficient	Std. error	*t*-statistic
C	0.001	0.001	1.35
FX_SPOT_STOCK	−0.131	0.060	−2.19
FX_SPOT_BOND	−0.055	0.061	−0.89
FX_SPOT_RESID	−0.011	0.039	−0.28

$R^2 = 0.11$, F-stat = 2.63, Prob. F-stat. = 0.05.
Number of observations: 436.

explain why FX order flow associated with bond market transactions does not appear to influence the exchange value of the baht in either the short or the long run.

4.4. Possible alternative explanations of the empirical findings

We now discuss two possible alternative, i.e., not information-based explanations of our finding that only equity-driven FX order flow has a large and permanent effect on the exchange rate: differences in the hedging of FX risk across stock and bond holdings, and the influence of carry trade investments.

4.4.1. Hedging activity

One possible alternative explanation of our finding is that FX risk incurred by equities is left (more or less) unhedged by investors, whereas it is more fully hedged if it is incurred by bonds. In the Thai baht FX market, FX risk is typically hedged mainly through FX swaps. Thus, if there was hedging of bond-related FX risk but not of equity-related FX risk, FX swap order flow should be driven more by bond flows than it is by equity flows.

In Table 6, we report the results of a regression of the FX_SWAP series on the contemporaneous order flows in the equity, "outright" bond, and "other" bond markets. The main result is that foreign investors appear to use FX swaps to hedge both their equity and their "outright" bond transactions. In fact, the point estimate of the coefficient on the stock market order flow series (−1.346) is considerably larger, in absolute value, than that on the "outright" bond order flow series (−0.168); the difference between the two coefficient estimates is statistically significant. This indicates that differences in hedging behavior cannot explain our finding.

As is also shown in Table 6, the coefficient on the BONDS_OTHER order flow series is −0.464; i.e., about half of the FX risk associated with "other" bond transactions is 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.

4.4.2. Carry trade activity

Another conceivable 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 fixed income securities 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. However, we found that neither contemporaneous nor lagged fluctuations in baht-dollar interest rate differentials were 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.

We also examined the possibility that fluctuations in the dollar-yen cross rate could have been an important driver of carry trade activity. Over the sample period as a whole, we did find that fluctuations in dollar-yen helped explain, in a statistical sense, contemporaneous baht-dollar movements. Specifically, a 1% daily appreciation of the yen against the dollar was associated, on average, with a same-day 0.3% appreciation of the baht against the dollar. However, the inclusion of yen-dollar returns as an additional regressor in the order flow regressions did not perceptibly change either the coefficients or the standard errors of the order flow variables. Hence, even if carry trades were significant during the sample period, they did not affect our findings regarding either the empirical importance of FX order flow induced by stock market transactions

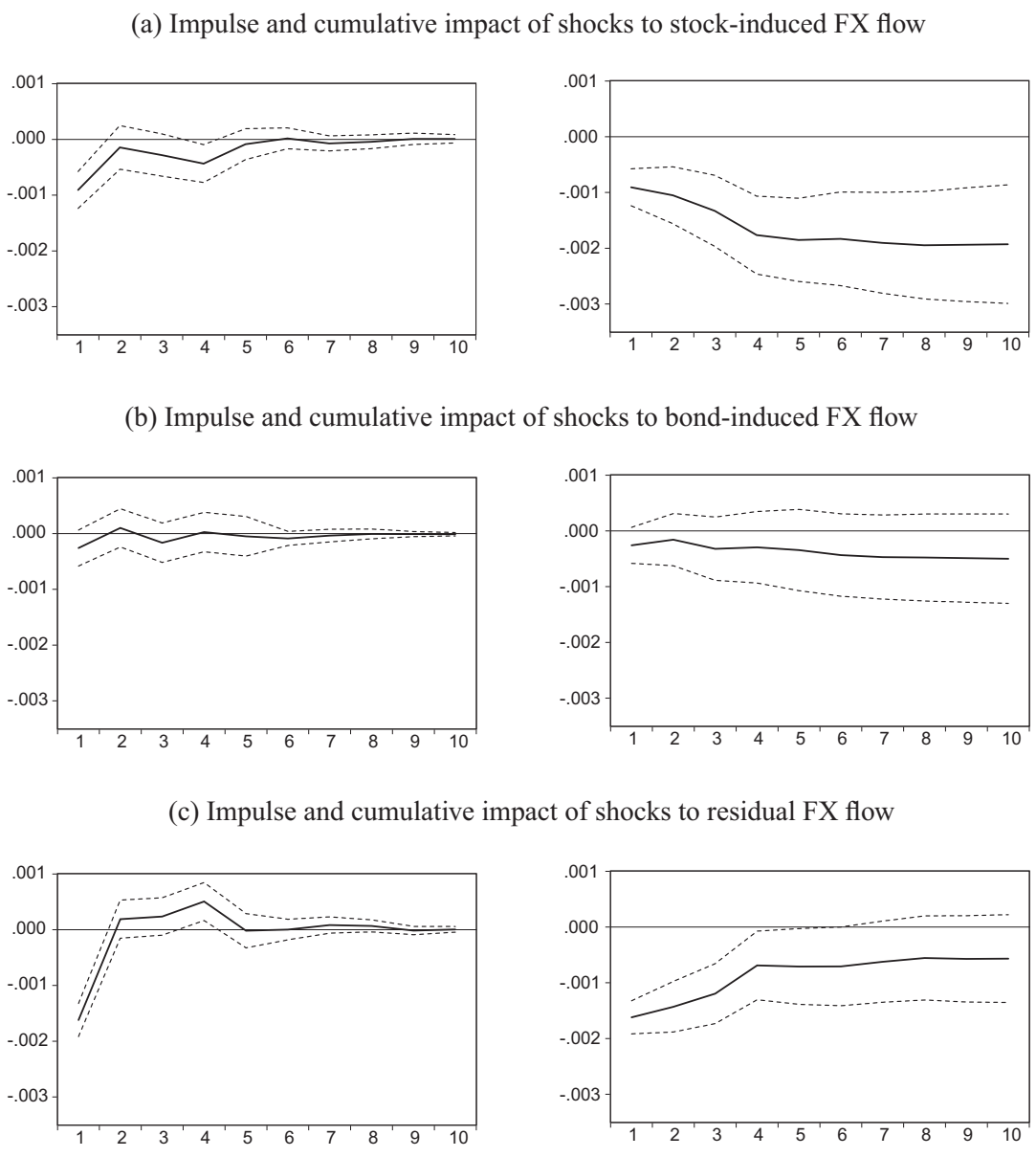

Fig. 1. THB/USD exchange rate responses to FX order flow shocks. The left-hand panels show impulse response functions (IRFs), and the right-hand panels show cumulative response functions (CRFs) of the THB/USD exchange rate to one-standard-deviation shocks in three types of FX order flow: those induced by stock-related trading (top row), bond-related trading (middle row), and the residual series (bottom row). A baht appreciation vis-á-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.

or the lack of empirical importance of FX order flow induced by bond market transactions for the exchange value of the baht against the dollar.

5. Concluding remarks

We have argued that investors' private information related to the stock market helps explain the observed exchange rate fluctuations. We tested this proposition using daily-frequency data from three financial markets in Thailand, and we found strong evidence in favor of the proposition. To paraphrase a famous dictum of *Animal Farm* (Orwell, 1945), some capital flows are more equal than others: Only the relatively small portion of FX order flow that is driven by investors' transactions in the stock market has a lasting statistical impact on the exchange rate. Given that the serial correlation patterns present in the observed flows in the stock and FX markets are consistent with private information asymmetries between domestic and for-

Table 6
Determinants of FX swap order flow. Dependent variable: FX_SWAP, the net FX swap transactions conducted between banks and foreign investors. Estimation method: Ordinary least squares. Robust standard errors are based on the Newey-West method, with a Bartlett kernel and 6 lags.

Regressor	Coefficient	Std. error	*t*-statistic
C	−31.520	6.983	−4.51
STOCKS	−1.346	0.186	−7.24
BONDS_OUTRIGHT	−0.168	0.182	−0.92
BONDS_OTHER	−0.464	0.198	−2.34

$R^2 = 0.185$, F-stat = 9.99, Prob. F-stat. = 0.00.
Number of observations: 406.

eign investors, we inferred that the reason why stock market-induced capital flows have a lasting effect on the exchange rate is that they convey investors' *private information*. We also found that the much larger portion of FX order flow that is not explained by stock market variables played at most a transitory role in determining the exchange rate. Taken together, these findings strongly suggest that FX order flow is relevant for the exchange rate if it is based on and conveys investors' private information about the prospects of individual firms and the corporate sector as a whole.

To assess the generality of our findings, it would be useful to conduct similar studies for additional economies, time periods, and financial markets. For instance, if an economy has a significant stock of *corporate debt* that is actively traded in secondary markets, and if trading in corporate debt conveys investors' private information about the prospects of the firms whose marketable debt they trade, our basic hypothesis would suggest that international capital flows induced by foreign investors' transactions in the corporate bond market should also have a significant impact on the exchange rate. Separately, in view of the growing role of foreign direct investment (FDI) in driving global capital flows, it should be interesting to explore whether international capital flows that are driven by FDI decisions are of relevance for exchange rates in a manner that is comparable to the influence of stock market-induced order flow.

Our work also suggests that data collection efforts for international capital flows could be made more informative if these flows were categorized according to their private information content. If such a classification were available, analysts would

Table A.1
Alternative specification of first-stage regressions. The estimation method is OLS. HAC-robust standard errors are computed using the Newey-West method with a Bartlett kernel and 6 lags. The number of observations is 444 in all four models. The lagged dependent variable (LDV) was included as an additional regressor in all four models.

Regressor	Coefficient	Std. error	*t*-statistic
(a) Dependent variable: Spot-Today			
C	16.979	1.553	10.93
STOCKS	0.025	0.011	2.19
BONDS_OUTRIGHT	−0.020	0.021	−0.94
BONDS_OTHER	0.033	0.066	0.51
LDV	0.110	0.041	2.71
$R^2 = 0.02$, F-stat. = 2.51, Prob. F-stat = 0.04			
(b) Dependent variable: Spot-Tomorrow			
C	8.411	3.050	2.76
STOCKS	0.072	0.063	1.15
BONDS_OUTRIGHT	−0.222	0.086	−2.56
BONDS_OTHER	−0.146	0.076	−1.91
LDV	0.531	0.055	9.68
$R^2 = 0.342$, F-stat. = 57.1, Prob. F-stat = 0.00			
(c) Dependent variable: Spot-Next (Two-day)			
C	7.095	7.489	0.95
STOCKS	0.896	0.124	7.24
BONDS_OUTRIGHT	0.053	0.158	0.33
BONDS_OTHER	0.590	0.184	3.21
LDV	0.233	0.059	3.96
$R^2 = 0.210$, F-stat. = 29.1, Prob. F-stat = 0.00			
(d) Dependent variable: Outright forwards			
C	−18.175	2.980	−6.10
STOCKS	0.032	0.049	0.64
BONDS_OUTRIGHT	0.182	0.071	2.58
BONDS_OTHER	0.007	0.087	0.85
LDV	0.054	0.047	1.16
$R^2 = 0.023$, F-stat. = 2.69, Prob. F-stat = 0.03			

likely focus their attention on those flows that convey private information in order to better explain why exchange rates of various countries experienced appreciations or depreciations.

Appendix A. Additional specification tests

The empirical results reported in Section 4 naturally reflect the specification choices we made in the design of the first- and second-stage regressions. In this appendix, we demonstrate whether our results continue to hold under less restrictive specification assumptions.

A.1. Less-restrictive specification of the first-stage regressions

For the first-stage regression reported in Table 4, we had combined the three spot-FX order flow series and the outright forward FX order flow series to create an aggregate FX order flow series which we called FX_SPOT. In the *single* first-stage regression, FX_SPOT was regressed on foreign investors' stock market order flow series (STOCKS) and the combination (BONDS) of "outright" and "other" bond market order flow. From this regression, we constructed the fitted order flow components FX_SPOT_STOCK and FX_SPOT_BOND as well as the residual order flow series FX_SPOT_RESID; these three series were used in the second-stage, order flow regression.

Clearly, many other regression specifications are conceivable. A non-restrictive alternative specification strategy, which we pursue here, is to regress each of the four underlying FX flow series *separately* on the series STOCKS, BONDS_OUTRIGHT and BONDS_OTHER. The portions of FX order flow that are explained by bond and stock market order flow, respectively, would be computed separately for each of the four regressions. Combining the separate fitted series would then generate alternative estimates of FX_SPOT_STOCK, FX_SPOT_BOND, and FX_SPOT_RESID to be fed into the order flow (second-stage) regression.

The output of the four first-stage regressions is reported in Table A.1. Of the four regressions, the one with the largest coefficients (in absolute value) is the one in which SPOT_NEXT (two-day spot) is the dependent variable, cf. panel (c). In this regression, the coefficient on STOCKS equals 0.896; the hypothesis that this coefficient is equal to 1 cannot be rejected at conventional significance levels. The coefficient on BONDS_OTHER is positive and is statistically significantly different from both 0 and 1. The coefficient on BONDS_OUTRIGHT is also positive but is quite small and not statistically significant.

The coefficient on STOCKS is not statistically significant in panel (b), in which SPOT_TOMORROW is the dependent variable; the two bond variables have significant though numerically small coefficients; the signs of both coefficients are actually "wrong", i.e., negative. In the regressions with SPOT_TODAY as the dependent variable, the coefficients of all three regressors are very small; cf. panel (a). In the regression with FX_FORWARD as the dependent variable (cf. panel (d)), only BONDS_OUTRIGHT has a significant coefficient, 0.182. However, the R^2 statistic is minuscule (0.02).

We next constructed 12 separate "fitted" time series (4 regression models, 3 regressors per model) and combined them to compute new, alternative estimates of the portions of FX order associated with order flow in the stock and bond markets. The new estimates are called FX_SPOT_STOCK_ALT and FX_SPOT_BOND_ALT, respectively; the alternative estimate of FX_SPOT_RESID_ALT was computed by subtracting FX_SPOT_STOCK_ALT and FX_SPOT_BOND_ALT from FX_SPOT.

The results of the second-stage order-flow regression using this alternative set of regressors are reported in Table A.2. Notably, the point estimate of FX_SPOT_STOCK_ALT, −0.159, is quite close to the coefficient of FX_SPOT_STOCK in Table 5, *viz.*, −0.131, and the two associated *t*-statistics are almost identical. And, as was the case for the results shown in Table 5, the coefficients of FX_SPOT_BOND_ALT and FX_SPOT_RESID_ALT are both statistically insignificant in this alternative, less-restrictive specification.

A.2. More lags in the vector autoregression

Three lags of all variables were used to estimate the VAR in Section 4.3. As an additional specification test, we examine whether the conclusions we offered earlier, regarding the dynamic influences of the three order flow series on FX returns, continue to hold if we increase the number of lags of all variables from 3 to 6. The impulse response functions (IRFs) and

Table A.2
FX order flow regression using a different set of regressors. The coefficients and standard errors of the regressors (but not of the constant term) are scaled to denote a percentage change in the dependent variable in response to a US$100 million change in the regressor. Estimation method: 2SLS. See Table 5 for the list of instruments.

Regressor	Coefficient	Std. error	*t*-statistic
C	-4.87×10^{-4}	5.12×10^{-4}	−0.95
FX_SPOT_STOCK_ALT	−0.159	0.072	−2.21
FX_SPOT_BOND_ALT	0.400	0.377	1.06
FX_SPOT_RESID_ALT	−0.011	0.041	−0.26

$R^2 = 0.048$, *F*-stat. = 2.93, Prob. *F*-stat = 0.03.
Number of observations: 353.

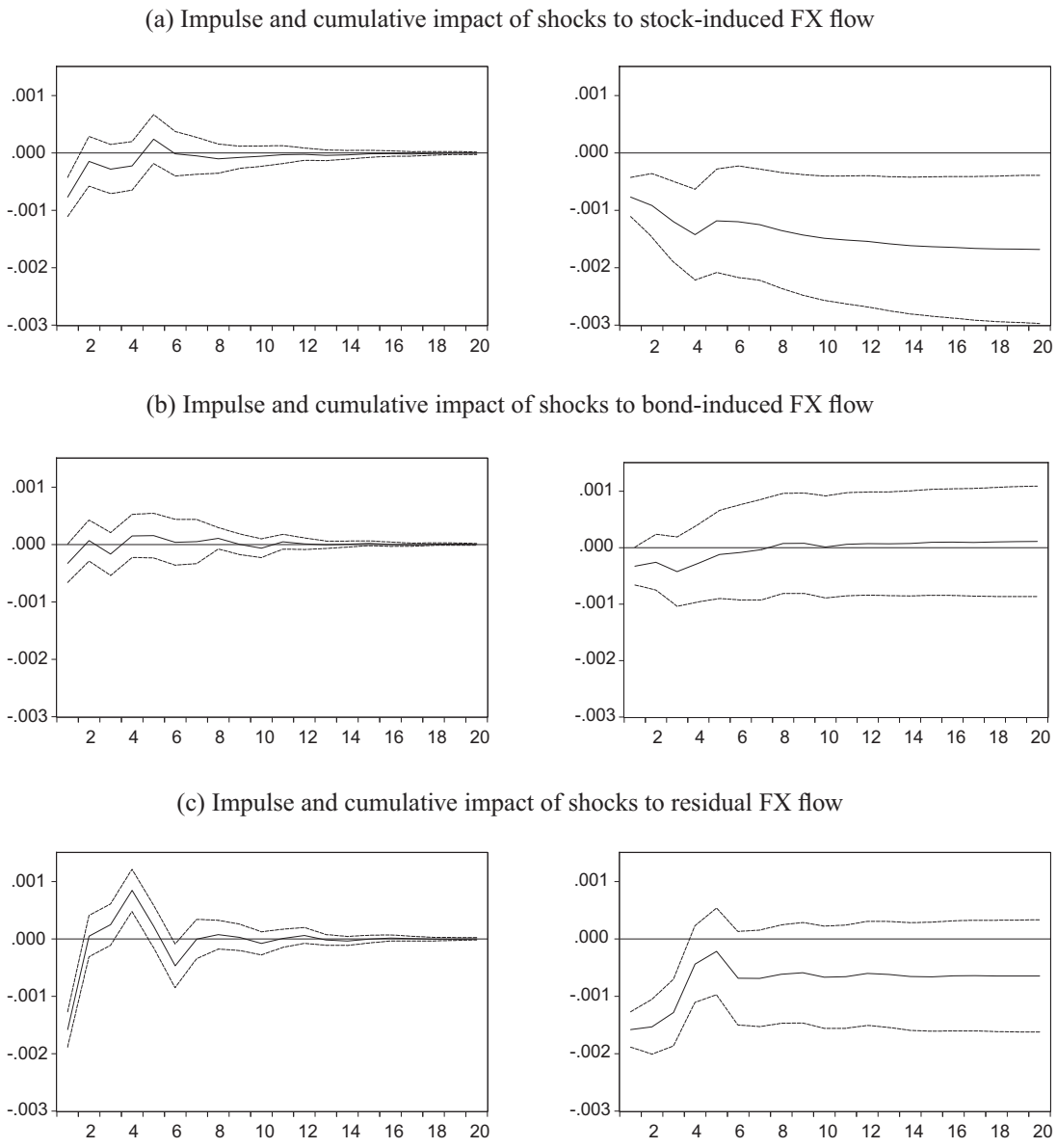

Fig. A.1. THB/USD exchange rate responses to FX order flow shocks—Alternative VAR specification, with 6 lags. The left-hand panels show impulse response functions (IRFs), and the right-hand panels show cumulative response functions (CRFs) of the THB/USD exchange rate to one-standard-deviation shocks in three types of FX order flow: those induced by stock-related trading (top row), bond-related trading (middle row), and the residual series. A baht appreciation vis-á-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.

cumulative response functions (CRFs) from the re-estimated VAR are shown in Fig. A.1. To further assess the robustness of the inferences, 20 days rather than just 10 days are shown in the new CRFs and IRFs.

The conclusions are the same as those offered in Section 4.3. First, stock-related FX order flow has a significant and permanent effect, and the sign is "correct". Second, bond-related FX order flow does not have statistically significant impact in either the short or the long run. Third, the residual component of FX order flow has an influence that is significant on impact (and with the correct sign), but is no longer statistically significant 4 or more days after the shock.

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