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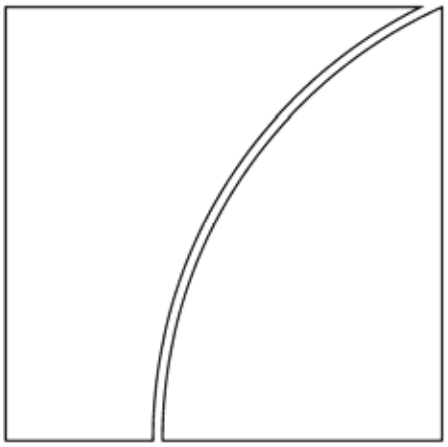

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Understanding Asian equity flows, market returns and exchange rates

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Abstract

This paper examines from various angles foreign investors' daily transactions in six emerging Asian equity markets and their relationship with local market returns and exchange rate changes over the period 1999-2006. Confirming much of the literature, we find that equity market returns matter for net equity purchases, and vice versa. In addition, we find that while currency returns tend to show little influence over foreign investors' demand for Asian equities, net equity purchases do have some explanatory power over near-term exchange rate changes. Moreover, we find that foreign investors do quite often move in or out of multiple Asian markets simultaneously – but more so on the way in than on the way out. Nonetheless, during specific events of heightened market volatility, we observe some interesting deviations from the full-sample average relationships.

JEL classification: F31, F32, F36, G12, G15.

Keywords: Asian equity markets, foreign investor, market returns, currency returns, exchange rate.

Contents

Understanding Asian equity flows, market returns and exchange rates

Chayawadee Chai-Anant and Corrinne Ho[§]

1. Introduction[1]

Capital flows have always been a topic of interest and concern among emerging markets, no less because of their implications for exchange rate movements and possibly financial vulnerability. There was a time when policymakers in these markets were worried about "sudden stops" and outflows. In recent years, however, the worry has been more about inflows and the associated upward pressure on the exchange rate. Increased investor optimism in emerging Asia since around 2003, for example, has not only coincided with general bullishness in financial markets, but also with the rise of Asian currencies to multi-year highs against the US dollar. Currency appreciation, in turn, is often seen as an additional factor drawing investors to Asia. Concerned authorities in the region have responded to varying extents with foreign exchange intervention and even direct measures to fend off these "hot" capital flows.

When it comes to assessing the relationship between capital flows and the *short-term* dynamics of financial and foreign exchange markets, portfolio flows hold the key. In emerging Asia, despite the rapid development of local bond markets since the late 1990s, the longer history of equity markets, their greater activity and better accessibility have kept non-resident equity flows more important than non-resident bond flows in most economies. It is therefore interesting to ask whether there is any systematic relationship between foreign investor activity in equities and short-term market dynamics. Are exchange rate gains/losses more of a driver or a consequence of foreign investor activity? How does foreign investor activity relate to Asian equity market returns? Furthermore, do foreign investors tend to see the various equity markets in the region as similar entities? Do they tend to flock to Asian markets when times are good and rush for the exit together at the first sign of trouble?

In this paper, we try to address these questions with data from six emerging Asian markets – India, Indonesia, Korea, the Philippines, Taiwan (China)[2] and Thailand – in the post-crisis years (1999–2006). These markets are chosen mainly because of the ready availability of daily data on foreign investor equity purchases and sales. Their flexible, albeit somewhat managed, domestic currency exchange rates are also crucial for the choice, given our specific interest in the role of exchange rate movements.

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§ The authors are from the Bank of Thailand and the Bank for International Settlements, respectively

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2 Hereafter, Taiwan.

Our analysis examines the three main relationships mentioned above. First, following a well-established area of research, we look at how foreign investors' net equity purchases relate to market returns. In particular, we check whether foreign investors tend to "chase" returns, buying more after observing increases in market returns and cutting back otherwise, and whether their activity has any systematic impact on near-term market returns. Second, we explore the relationship between net purchases and exchange rate movements. Compared to the first, this second relationship is less thoroughly investigated in earlier research works since day-to-day spot exchange rate movements in the markets sampled here became significant only after the Asian crisis. In this paper, we are not only interested in considering exchange rate changes (currency returns) as a component of total returns influencing foreign investors' demand for equities, but also in assessing whether such demand has any systematic influence on short-term exchange rate movements. Third, in addition to studying the behaviour of individual markets, we investigate the co-movement of net equity purchases *across* markets. In particular, we assess how often foreign investors net-buy or net-sell equities in most or all markets at the same time and whether foreign investors are prone to rushing out of Asian market simultaneously. Explicitly analysing foreign investor activity across multiple markets is to our knowledge a relatively novel dimension in the related literature.

We employ a variety of techniques in our analysis. We start off with standard time series techniques to assess the full-sample relationships in individual markets. We then turn to other statistical techniques to characterise the cross-market relationship of net equity purchases. Finally, we use event study analysis to see whether the full-sample average relationships hold in specific episodes of stress.

Our main findings are as follows:

- Consistent with the literature, we find evidence that foreign investors do on average "chase returns", net-buying (net-selling) equities following an increase (decrease) in market returns. Moreover, there is evidence that movements in net purchases are on average followed by changes in market returns in the same direction, suggestive of "positive feedback trading" behaviour.
- Currency returns are found to matter relatively little for net equity purchases. This result does not necessarily mean that currency returns do not affect investors' decisions – it simply points to the fact that stock market returns measured in foreign currencies tend to be dominated by the local currency return component rather than the exchange rate return component, especially at the daily frequency.
- More notably, net purchases (sales) are significantly associated with near-term currency appreciations (depreciations). This result may seem obvious for those who view foreign investors as "big fish" in the "small ponds" of Asian currency markets. Nonetheless, it may still be surprising to some, given that there is no unique view on whether and how foreign investor equity transactions might systematically translate into foreign exchange flows. In any case, the detected impact is relatively small, possibly reflecting the effect of official intervention in the foreign exchange market.
- The typical average relationships mentioned above are the most clearly detected in Korea, Taiwan, Thailand and, to a lesser extent, India. These relationships tend to be weak in the two smallest and least active markets, Indonesia and the Philippines, which also happen to have relatively lower foreign investor participation during the sample period, thus implying the relative dominance of domestic factors.
- With respect to cross-market co-movement, there is evidence that the direction of net equity flows in each market is not independent of that in other markets, and that it is quite common to see foreign investors net-buy or net-sell equities in five or all six markets simultaneously on a given day. This result is not surprising, given that Asian equities are known to be influenced by common external factors such as US equity market returns or

volatility. However, a more curious finding is that foreign investors tend to net-buy in multiple markets more often than net-sell. Thus, it seems that during our sample period, equity inflows are more a regional phenomenon, while outflows are more idiosyncratic.

- Finally, the average relationships obtained from the full sample period still hold in some events of heightened market volatility (eg the May-June 2006 multiple market sell-off), but break down in some others (eg 11 September 2001 attacks). In the latter cases, foreign investors express more optimism than do domestic investors, providing a stabilising effect on stock prices.

The rest of the paper is organised as follows. Section 2 reviews the related literature and places the contribution of this paper. Section 3 introduces the data and some preliminary diagnoses. Using time-series techniques, section 4 explores the relationship among net equity purchases, market returns and exchange rate changes in individual markets. Section 5 examines the cross-market co-movement of net purchases and the probability of simultaneous inflows or outflows in multiple markets. Section 6 presents a number of event studies to assess whether the average statistical relationships found over the full sample still hold in specific episodes of heightened market volatility. Section 7 concludes with a discussion of some caveats and policy implications.

2. Related literature

The three relationships studied in the paper intersect with three broad families of existing works: one is concerned with assessing the link between foreign investor behaviour in equity markets (as proxied by net portfolio flows) and market returns, another with analysing the connection between financial flows and exchange rates, and the third with understanding whether foreign investors tend to behaviour similarly in certain markets.

The relationship between foreign investors' net equity purchases and the performance of equity markets is a well-researched one. A key question here is whether any such relationship detected has a positive or a negative sign, and whether foreign investor activity tends to be a cause or an effect of market returns. For example, using monthly data, Bohn and Tesar (1996) and Bekaert et al (2002) find a positive relationship between equity flows and market returns, with equity flows tending to move into markets with a rise in returns and retreat from those with a decline. This positive relationship is often hypothesised as "return-chasing", "trend-chasing" or "momentum trading". Many subsequent works using weekly or daily data also find evidence in support of this hypothesis (eg multiple-country works include Froot et al (2001), Griffin et al (2002), Richards (2005); single-country studies include Karolyi (2002) on Japan, Chai-anant (2003) on Thailand, Bonser-Neal et al (2002) on Indonesia).

One explanation for return-chasing is the search for profit under extrapolative expectations. Investors form a view about future performance based on recent past performance, thus allocating more funds to where returns have risen and cutting back otherwise. Another explanation is the informational asymmetry between different groups of investors. Brennan and Cao (1997) suggest that if foreign investors are less informed than their domestic counterparts about domestic market conditions, they would revise their expectations – and adjust their portfolio investments – relatively more in response to news about market returns, resulting in a positive correlation between flows and (past) returns.[3] Stop loss orders and

[3] Testing this implication with quarterly data, the authors conclude that US investors appear less informed in non-US equity markets, but non-US investors are not disadvantaged when investing in the US market. Frankel and Schmukler (1996), studying the Mexican crisis, also conclude that foreign investors are less informed about the situation than domestic investors. Cohen and Remolona (2007) also find that, before the Asian

forced liquidation of stocks to meet margin calls can similarly result in a positive correlation, at least on the down side.

Some works that detect a positive relationship between past market returns and current flows to that market also report a positive relationship between flows and current or future returns, suggesting "positive feedback" in foreign investors' trading behaviour. The earlier theoretical predictions of DeLong et al (1990) and Sentana and Wadhwani (1992) suggest that such behaviour could potentially lead stock returns to deviate from the equilibrium path implied by fundamentals. A number of authors have tested for such destabilising effect in the context of the Asian crisis in 1997. For example, using order and trade data, Choe et al (1999) find strong evidence of positive feedback trading and herding among foreign investors in the Korean stock market before the crisis. But when the crisis hit Korea in the last three months of 1997, positive feedback trading weakened while herding almost disappeared. The authors also find that days with heavy foreigner trading are not associated with any lasting price impact that can be deemed destabilising. However, using a more disaggregated data set that extends into the first half of 1998, Kim and Wei (2002) find that positive feedback and herding among foreign investors did not diminish during the crisis (defined as November 1997 to June 1998). Karolyi (2002) also finds that positive feedback trading among foreign investors in Japan continued during and after the Asian crisis, but does not find evidence that such behaviour destabilises the market.[4]

Notwithstanding the many existing works that document a positive relationship between equity flows and past market returns, there are also works that report a negative relationship, which is often hypothesised as "portfolio rebalancing" behaviour, ie investors reallocate funds away from assets in their portfolio that have appreciated in value (due to price rises and/or currency gains) towards those that have depreciated, in order to restore the optimal portfolio balance. Hau and Rey (2004), using monthly data on bilateral equity portfolio flows between the United States and five industrial economies and a VAR identification scheme that does not impose any causal ordering, are able to find empirical evidence of portfolio rebalancing.

The second relationship studied in this paper – that between net equity flows and exchange rates – also has its basis in a number of existing works. Some of the abovementioned works that investigate the impact of stock returns on equity flows also look into the role of exchange rate changes (currency returns) as a component of total returns for cross-border investors (eg Brennan and Cao (1997), Karolyi (2002), Chai-anant (2003)). Perhaps of more market and policy interest is whether exchange rates are themselves affected by equity flows. Especially in emerging markets, as they open up to cross-border portfolio flows and shift towards more flexible currency regimes, exchange rate fluctuations can be expected to become more exposed to the influence of foreign investor activity. Souriounis (2003) uncovers dynamic links between capital flows and exchange rate movements, suggesting that equity flows are important in explaining exchange rates. Focusing on emerging Asia, Richards (2005) mentions in a footnote that three of the five currencies covered in his study respond positively to innovations in net equity inflows. He suggests that this result should not be surprising given the evidence from other studies that foreign exchange order flows have a significant impact on exchange rates, at least in the short-term (eg Evans and Lyons (2002),

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crisis, local returns led returns of foreign investment in US-based closed-end funds, suggesting that foreign investors somewhat relied on local investors' sentiment toward market developments. However, this front-running by local investors over foreign investors broke down during the crisis period.

[4] This result complements a study with pre-Asian crisis era data by Hamao and Mei (2001), who find that foreign investors in Japan tend to be long-term players instead of short-term speculators and their presence has helped to improve overall liquidity, with little impact on underlying market volatility.

Froot and Ramadorai (2002)).[5] Although academic-style research on portfolio flows and exchange rates is not as abundant as the research on portfolio flows and market returns, market analysts have in practice often considered foreign investors' equity purchases to be one of the candidate determinants of short-term currency market dynamics, especially in emerging Asia.

Finally, our investigation of the cross-market co-movement of net equity flows is at first glance reminiscent of the discussions of "herding" and "contagion" that have proliferated since the financial crises in the late 1990s. However, authors such as Bikhchandani and Sharma (2001) and Karolyi (2003) are careful to point out that one should distinguish between true herding (irrational contagion) and spurious herding (fundamentals-based contagion). Indeed, co-movement of equity flows in multiple markets can be plausibly explained by factors other than the fickle or irrational behaviour of foreign investors. One possibility is that fundamentals in the host markets are correlated (eg due to increased economic integration or interdependence), exerting a similar "pull" on foreign capital. Froot et al (2001) report that the positive cross-correlation of equity flows tends to be stronger within a region (especially in Asia and in industrialised Europe) and that the regional correlation of stock returns is even more evident. Another possibility is that common external shocks "push" international investors into different host markets at the same time. Griffin et al (2002) and Richards (2005) find that net equity flows into the emerging markets in their samples respond positively to both external market performance (eg returns in mature markets) and local market performance. Certain normal portfolio management practices may also induce correlated equity flows. For instance, international investors who are interested in diversifying into emerging market equities (possibly in response to the "push" factors mentioned above) are likely to make purchases in multiple markets, instead of investing in only one particular market. Purfield et al (2006) mention diversification as one explanation for the large influx into multiple Asian markets in recent years. By the same token, when international investors wish to reduce their exposure to emerging markets or to a region, they may opt to cut back across the board. At times, the need to cover losses from poorly performing markets means that investors have to liquidate even investments in profitable markets, in turn inducing positive cross-market correlations.

All in all, our paper is perhaps the most similar to Richards (2005) in terms of coverage (emerging Asian markets), data frequency (daily), data source (public data from stock exchanges) and the focus on the non-crisis period. However, in our longer sample, both the bear-market phase (2000-2002) and the subsequent bull-market phase (2003-2006, not covered by Richards (2005)) are represented. Our paper also let the exchange rate play a bigger role. Not only do we consider currency returns as a potential factor affecting net equity flows, we are also interested in whether flows help to explain exchange rate changes. Most importantly, in using a variety of approaches, we examine not only individual market behaviour but also cross-market co-movements.

3. Looking at the data: preliminary diagnosis

All the analyses in this paper are derived from three basic ingredients: daily net equity purchases, equity market returns and currency returns (ie returns from exchange rate

[5] Evans and Lyons (2002) suggest that order flows are a proximate determinant of exchange rate movements, as they convey a variety of information that currency markets need to aggregate. Froot and Ramadorai (2002) find that currency flows are important for understanding transitory deviations of exchange rates from fundamentals, but not the longer-term levels of exchange rates. Perhaps a gap in Richards' argument that remains to be filled is how tight the link is between portfolio flows and foreign exchange order flows.

changes). In this section, we take a preliminary look at the data to get a sense of their general properties.

The foreign investor equity purchases/sales data for India, Indonesia, Taiwan and Thailand are from the CEIC database,[6] while those for Korea and the Philippines are sourced directly from the Korea Stock Exchange and the Philippine Stock Exchange. The stock market indices and spot exchange rate data with which we calculate market and currency returns are from Datastream International and the CEIC database, respectively. The sample period starts 1 January 1999 and ends 29 December 2006. The number of observations ranges between 1,942 and 1,987 due to the different number of market holidays in the six markets.

3.1 Foreign investors' net equity purchases

Foreign investors' net equity purchases in each market (sometimes also referred to as "net equity flows" or "net flows" in this paper) are defined as the value their purchases of local stocks minus the value of their sales thereof.[7] Since the raw data are denominated in local currencies, where appropriate, we scale net purchases by the previous day's market capitalisation ("scaled net purchases") to facilitate easier cross-market comparison.[8]

Figure 1 shows net flows in the six Asian equity markets during the sample period in both nominal (bars) and scaled terms (lines). To de-emphasise noise and highlight the general pattern, monthly data are shown here. Two main observations are worth highlighting. First, nominal net flows in all markets have to various extents increased in absolute magnitude since 2003.[9] Even after adjusting for market-size growth over time, net flows in India, Indonesia, Taiwan and Thailand are still on average larger in the second half of the sample. Second, Korea, Taiwan and Thailand tend to see alternating phases of inflows and outflows, with relatively few extreme spikes. This smooth alternating pattern is less obvious in India, while net flows in Indonesia and the Philippines tend to be both smaller and more erratic.

[Figure 1: Monthly net equity purchases]

Table 1 gives some indication of the relative size of the six markets and the significance of foreign investor transactions as of 2005. In terms of market size, as measured by market capitalisation in US dollars, Korea ranks first, followed by Taiwan, India and at a distance Thailand.[10] As for the relative importance of foreign investor activity, as measured by average daily turnover in relation to market size, Korea, Taiwan and Thailand again rank high. If foreign investors were to have any impact on the equity market, the impact might be expected to be more obvious in these three markets. Nonetheless, foreign investor turnover

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[6] The underlying sources are Securities and Exchange Board of India (data for foreign institutional investors), Jakarta Stock Exchange, Taiwan Stock Exchange and Stock Exchange of Thailand.

[7] The equity purchases and sales data only capture transactions done directly by registered non-resident investors in the local stock exchanges. They therefore do not cover deals done by non-residents under the guise of (or via) resident entities. They also do not cover transactions in equity futures or in American Depositary Receipts. And in markets where non-resident investors can switch between equities and other financial assets onshore, net purchases (sales) of equities may not automatically become net inflows (outflows) in the balance of payments sense.

[8] The market capitalisation data (as well as the stock indices) used here are calculated by Datastream using the largest stocks in each market, accounting for more than 70% of the actual total market capitalisation.

[9] The increased activity coincided in timing with bullish equity markets and heightened appreciation expectations for the renminbi and other Asian currencies.

[10] India's market used to be very much smaller than Taiwan's but had caught up by around 2005. The various analyses in this paper show that the four larger markets tend to behave similarly, while the smaller markets, Indonesia and the Philippines, tend to march to a different beat.

tends to be outsized by domestic investor turnover, except in Taiwan, where foreign investors are on average more than twice as active as domestic investors.[11] Taiwan also stands out for its foreign investor turnover in relation to foreign exchange market turnover. If equity transactions were to have any impact on short-term exchange rate fluctuations, the impact might be expected to be the most significant in Taiwan, and the least in the Philippines.[12]

[Table 1: Asian equity markets: Size and foreign investor participation]

Table 2 presents some descriptive statistics of the daily net equity purchases data. The sample means are positive in all cases, indicating that all six markets on net had more inflows than outflows during the sample period. The mean absolute magnitude of daily net purchases is the largest in Korea and Taiwan (over US$90 million or 0.036% of market cap), and the smallest in the Philippines (only US$3.5 million or 0.012% of market cap). The standard deviations all tend to be large compared to the means. Furthermore, daily net purchases show economically and statistically significant positive autocorrelation in India, Korea, Taiwan and Thailand. This persistence – as illustrated in Figure 1 – suggests that foreign investors tend to move in or out of these markets in a gradual fashion.[13]

[Table 2: Daily net purchases: descriptive statistics]

3.2 Market returns and currency returns

Market returns have two forms: local returns and total returns. Local returns are defined as the daily percentage changes of the stock market index (in local currency terms).[14] Total returns are defined here as local returns evaluated in US dollar terms at the current exchange rate. The difference between the two forms of market returns reflects the local currencies' daily gains or losses vis-à-vis the US dollar. We use the daily percentage changes in the exchange rate (US dollar per local currency) to approximate such currency returns.

Table 3 shows some descriptive statistics of market and currency returns. The sample means of daily stock market returns are positive in all six markets, indicating that, notwithstanding a bear-market period (2000–2002), the market indices on net rose over the sample period.[15] In absolute terms, daily moves of 1% to 2% are typical in all markets except

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[11] Even in the more active markets, foreign investor turnover is typically less than 0.3% of market value. However, as pointed out in a survey of Asian equity markets by Purfield et al (2006), scaling turnover by total market value may underestimate foreign investors' importance because some of these markets have a significant portion of non-free-floating shares.

[12] More broadly, in relation to overall portfolio capital flows (balance of payments data), non-resident net equity securities flows are also considerably larger in absolute magnitude than non-resident net debt securities flows in Korea, Taiwan and Thailand (similar data breakdown is not available for India).

[13] Gradual adjustment in multiple steps may be partly explained by the informational disadvantage of foreign investors, as suggested by a number of previous studies (see section 2). Alternatively, gradual adjustment could also be a result of constraints such as illiquid markets. "Block trades" or execution of trades in small batches can also explain such behaviour.

[14] The stock market index is valued at the closing price for each trading day. We ignore dividends, which are negligible at the daily frequency.

[15] However, mean daily stock market returns are not significantly different from zero. Plotting stock returns over time suggest mean-reverting behaviour. Augmented Dickey-Fuller test finds no sign of unit roots in all stock returns and currency returns

the Philippines. Stock returns exhibit statistically significant positive autocorrelation in India, Indonesia and the Philippines, though the coefficients tend to be small.[16]

[Table 3: Market and currency returns: descriptive statistics]

The sample means of daily currency returns are mildly negative in all markets except Korea. This indicates that, notwithstanding the considerable appreciation against the US dollar in the second half of the sample period, most Asian currencies were on net still somewhat weaker at the end of 2006 than at the beginning of 1999.[17] The mean absolute magnitude of daily currency moves is well below 1% in all markets, with that in Indonesia being relatively large while those in India and Taiwan being among the smallest. Small daily exchange rate movements are suggestive of official interventions that dampen day-to-day volatility, though not necessarily prevent longer-term exchange rate trends.

It is notable that, across the board, daily currency returns are on average smaller and less volatile than daily stock market returns. This is normally the case even for major industrial economy currencies and equity markets. The difference in volatility implies that total returns are on average driven more by local returns than by the exchange rate. So while potential currency gains may have at times been a factor attracting foreign investors to Asia, stock market gains are, at least on average, the more dominating factor. Finally, currency returns tend not to show any significant autocorrelation.

3.3 Bivariate correlations: a preview of the key relationships

How do stock market and currency returns correlate with net equity purchases? Table 4 reports the contemporaneous correlation coefficients. Net purchases (scaled by market capitalisation) and local market returns show significant positive correlation in all six markets. Korea, Taiwan and Thailand, in particular, have similarly sizeable correlation coefficients. Scaled net purchases also correlate positively with currency returns. Again, the correlation coefficients in Korea, Taiwan and Thailand are large compared to the others, but are smaller than the correlations between net purchases and market returns. Finally, market returns and currency returns exhibit similarly positive correlation in all markets, except the Philippines. The direction of causality (in the time series sense) among these three variables will be investigated in section 4.

[Table 4: Biavariate correlations]

As one can reasonably expect, these bivariate correlations could vary over time. Rolling correlations show notable variations across markets and across time. One striking observation is that, in all markets except the Philippines, there are three clear episodes of tightened co-movements between net purchases and currency returns: around mid-2000, and more notably, in 2004 and 2006. The 2004 episode could be related to the rise in

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[16] Autocorrelation in returns has been linked to the presence of positive feedback trading, but the sign varies with assumptions. For example, Cohen and Shin (2003), applying Hasbrouck (1991) to study order flows and prices in the US Treasury securities market, find evidence of stronger positive feedback trading at times of heightened market volatility, implying more positive (or less negative) autocorrelation in prices. In contrast, the model used by Bohl and Siklos (2004) to test for the presence of feedback traders in developed and emerging stock markets suggest that positive feedback trading would imply *negative* autocorrelation in returns and the extent of autocorrelation also depends on volatility. Therefore, autocorrelation per se cannot be read as a conclusive indicator of positive feedback trading.

[17] The Indonesian rupiah and the Philippine peso were on net 12% and 21% behind. The New Taiwan dollar, the Thai baht and the Indian rupee more or less broke even over the sample period, while the Korean won advanced by around 30%.

speculative pressure on Asian currencies against the backdrop of heightened speculation over the renminbi's revaluation. The 2006 episode is consistent with both the search-for-yield mode of global investors during most of the year as well as the temporary retrenchment in May and June (the May-June retrenchment will be discussed in more details in section 6).[18]

4. Time-series analysis of individual markets

The bivariate correlations above suggest strong relationships between foreign investors' net purchases and both stock market and currency returns in a number of Asian markets. Certainly, it is reasonable to think that foreign investors' demand for Asian stocks is in part driven by both local market returns and currency returns. However, where foreign investor transactions constitute a significant portion of stock market activity or capital flows, influence in the reverse direction is also plausible. What can the data tell us about the direction of "causality", at least in the time series sense? And what do the data reveal about the dynamic interaction among the three variables? In this section, we explore these relationships in the six markets with standard time-series analysis. We first conduct a series of Granger causality tests to see which variable contains information for predicting which other variable. We then use a vector auto-regression (VAR) framework to examine the dynamic interactions.

4.1 What "causes" what: Granger causality tests

We conduct Granger causality tests on various pairs of variables to assess which variable contains information to help predict ("Granger-cause") which other variable. We use the Akaike Information Criterion (AIC) to determine the optimal lag length.[19] The results (assuming a 0.05 p-value threshold) are summarised in Table 5 with the following main features:

- Past total returns Granger-cause net purchases in all markets except Indonesia, but past net purchases do not Granger-cause total returns in most markets (except for Taiwan and, to a lesser extent, India).
- Parallel to the first result, past local market returns Granger-cause net purchases in all markets, but the reverse does not hold (again except for Taiwan and India).
- In contrast, past currency returns Granger-cause net purchases in only two markets (India and Korea), but past net purchases Granger-cause exchange rate changes in most markets (except for Indonesia and the Philippines).
- Finally, past local returns Granger-cause currency returns in all markets, but the reverse does not apply.[20]

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[18] By contrast, the correlations between net purchases and market returns are much less in synch across markets. The only notable common feature is the across-the-board decline in the second half of 2001. Against the background of the burst of the "dot com" bubble, stock returns in the region were relatively low during this period, while net equity inflows were small, dampening the correlation.

[19] See the technical appendix for more details on the set up. The results are found to be quite robust to the number of lags used.

[20] Ramasamy and Yeung (2005) study the Granger causality between stock returns and exchange rates in nine East Asian markets using daily data from 1997-2000 and find the same in Indonesia, Taiwan and Thailand, but not in Korea and Philippines over the full sample period. However, they also show that results are sensitive to the definition of the sample period.

Taken all together, there is a general pattern: past local market returns have predictive power over foreign investors' net purchases, which in turn contain information to predict exchange rate changes (but not so much stock price changes). However, this general pattern has weak links in Indonesia and the Philippines. Furthermore, bi-directional causality is detected in India, Korea and Taiwan.

[Table 5: Summary of Granger-causality test results]

4.2 How everything interacts: VAR analysis

The Granger causality test results hinted at possible dynamic interactions among market returns, net purchases and exchange rate changes. However, they did not yet tell us anything about the sign and magnitude of these interactions. In this section, we follow earlier works such as Griffin et al (2002) and Richards (2005) in using the vector auto-regression (VAR) framework to estimate the interaction as a system and assess how shocks to one variable impact other variables.[21] We start off with a simpler two-variable system with only total returns and scaled net purchases. We then expand it into a three-variable system, separating total returns into its two components: local market returns and currency returns.

4.2.1 Two-variable VAR: net purchases and total returns

In this setup, we estimate a two-variable VAR system

$$Y_t = k + B_1 Y_{t-1} + ... + B_L Y_{t-L} + e_t$$

where the Y_t vector contains only scaled net purchases and total returns, in that order. We check for the optimal lag length for each market using a number of information criteria. Where the criteria disagree, we adopt the lag length as suggested by the Akaike Information Criterion (AIC). The optimal number of lags is one for Indonesia, two for the Philippines, four for India and Thailand, five for Taiwan, and thirteen for Korea.[22]

To conserve space, the full set of estimated VAR coefficients is not reported here but is available upon request. The main qualitative results are summarised in Table 6, with two notable points. First, across the board, date t net purchases are positively and significantly associated with date t-1 total returns. That net purchases tend to follow past returns in the same direction suggests that the much-documented return-chasing behaviour (see section 2) may be prevalent among foreign investors. Second, date t returns are positively associated with date t-1 net purchases in all markets except Indonesia, and significantly so in India, Korea and Taiwan. This result, together with the return-chasing result, can be interpreted as an indication of "positive feedback trading": yesterday's returns drive today's net purchases, which in turn drive tomorrow's returns, all in the same direction.

[Table 6: Two-variable VAR: summary of results (first lags only)]

The impulse response functions are computed using the standard recursive scheme (Cholesky decomposition) to identify the contemporaneous relationship between the two variables. We assume that net purchases can affect returns contemporaneously, but returns

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[21] Refer to the technical appendix for details of the set up.

[22] Griffin et al (2002) also apply the AIC to check for the optimal lag lengths but use five lags for all countries for the convenience of interpretation, reporting no major changes in the results. Similarly, we find that our main results are little changed if we use a common lag length of two across all six countries. However, we prefer to allow different lags in order to capture the optimal dynamic adjustment for each country.

affect net purchases only with a one-day lag.[23] The impulse responses are shown in Figures 2a and 2b. The impulses are 1 standard deviation innovations. The responses are expressed in percentage point terms in cumulative form. We analyse here two of the four responses.

First, by the chosen ordering of variables, net purchases do not respond contemporaneously to innovations in returns (Figure 2a). In the following period, however, a positive and statistically significant response is detected in all markets except Indonesia. Taiwan, in particular, shows a relatively sizeable and persistent response. That net purchases respond positively to past returns is again suggestive of return-chasing.

Second, our chosen ordering allows contemporaneous response of total returns to innovations in net purchases (Figure 2b). Indeed, total returns respond positively and significantly in all markets except Indonesia. The responses in Korea, Taiwan and Thailand are especially sizeable. This result can be jointly interpreted with the result above as indicating the presence of positive feedback trading in the four larger markets.

[Figures 2a and 2b: Two-variable VAR impulse responses]

4.2.2 Three-variable VAR: net purchases, local returns and exchange rate changes

We then decompose total returns into local returns and currency returns (ie exchange rate changes) in order to examine their respective interaction with net purchases. The Y_t vector for this three-variable VAR system thus contains scaled net purchase, local market returns and currency returns, in that order. In the extended system, the optimal lag lengths for Thailand and Korea change to three and five, respectively. The optimal lag lengths for other markets remain unchanged.

We summarise the main qualitative results in Table 7 (again, the VAR coefficients are not reported here but are available upon request). There are two parallels to the results obtained in the two-variable case. First, date t net purchases are significantly associated with date t-1 local market returns in all markets. In fact, the coefficients are very similar to those on date t-1 total returns in the two-variable VAR. This suggests that the currency returns only have relatively marginal influence, showing statistical significance only in India. The statistical insignificance of currency returns may surprise those who believe that foreign investors are drawn to Asian markets by the prospects of currency appreciation, especially in recent years. However, this result does not necessarily dismiss the role of currency returns in investor decision: it may simply point to their relative insignificance in the presence of stock market returns, especially over a day-to-day horizon. The second parallel is that date t local returns, like total returns, are also positively associated with date t-1 net purchases in all markets except Indonesia, and significantly so in India, Korea and Taiwan. The predictive power of foreign investor activity over market prices has been interpreted by some authors as a reflection of foreign investors' information on future market movement (see Box 1).

Beyond these two parallels, the three-variable VAR can tell how daily currency returns (or exchange rate changes) relate to past local returns and net purchases. In the exchange rate equation, the coefficients on date t-1 local returns are positive and significant in all markets, while the coefficients on date t-1 net purchases are positive and significant in India, Korea and Taiwan. The latter result, in particular, suggests that foreign investors' activities in the larger Asian equity markets have some detectable influence over exchange rate changes in the near term. This finding may seem obvious to those who hold the view that foreign investors are "big fish" in the "small ponds" of Asian currency markets. Nonetheless, it may

[23] This is the ordering assumption typically used in the related literature. If we switch the order of the variables, of course the contemporaneous responses will differ, but the other qualitative results of the VAR will still hold.

still be surprising to some, given that there is no unique view on how foreign investors in Asian equities deal with their foreign exchange exposure and thus how equity flows per se might systematically translate into foreign exchange flows and exchange rate changes. One way to reconcile the unsurprising and surprising sides of this result is to interpret the act of buying/selling equities not necessarily as the proximate cause of exchange rate changes, but as a proxy for factors such as currency expectations and market sentiment, which are ultimately relevant for short-term foreign exchange market dynamics. In any case, the detected influence on near-term exchange rate changes seems relatively small, possibly reflecting the effect of official intervention in the foreign exchange market.[24]

[Table 7: Three-variable VAR: summary of results (first lags only)]

For the impulse response analysis, we assume the following recursive contemporaneous relationships: net purchases do not respond contemporaneously to the other two variables, local returns respond only to net purchases, and currency returns respond to both net purchases and local returns. Figures 3a to 3d present the four sets of impulse responses that we focus on. Two main observations are in order.

First, net purchases' response to innovations in local returns (Figure 3a) turns out to be very similar to their response to innovations in total returns (Figure 2a). This suggests that the influence of currency returns is marginal, compared to that of local returns. Indeed, net purchases show virtually no response to currency returns innovations in all markets except India (Figure 3c).[25] As discussed above, statistical insignificance does not necessarily dismiss the role of currency returns in investor decision: it may simply mean currency returns are not as important as market returns over a day-to-day horizon.

Second, the response pattern of local returns to innovations in net purchases (Figure 3b) is also virtually the same as the response of total returns in the two-variable VAR (Figure 2b). However, it is interesting to note that currency returns per se do respond significantly and persistently to innovations in net purchases, albeit with a small magnitude, in India, Korea, Taiwan and Thailand (Figure 3d). This finding is suggestive of the influence of non-resident equity investor activity on Asian exchange rates over a daily horizon, even though the impact may have perhaps been muted by official foreign exchange intervention.

[Figures 3a-d: Three-variable VAR impulse responses]

[24] For Korea and Taiwan, the two markets with the largest coefficients, a one percentage point rise in scaled net purchases is associated with a 0.59% appreciation on the following day. However, given that the absolute size of daily net purchases in these two markets is only about 0.036% of market capitalisation on average (see Table 2), the exchange rate impact of net purchases on a typical day is indeed rather small.

[25] Historical decomposition analysis (eg using the technique proposed by Enders and Lee (1997)) also confirms the relatively small contribution of currency returns innovations (compared to local market returns innovations) to net purchases' fluctuations over time. All in all, it is net purchases' "own-fundamentals" – or factors other than market returns or exchange rate – that play the largest role in driving net purchases' deviation from its mean. Section 5.1 will touch on how other factors such as external market returns and volatility influence foreign investors demand for Asian equities.

Box 1: Do net purchases have predictive power over future returns?

A number of authors (eg Froot and Ramadorai (2002)) have interpreted the predictive power of foreign investor activity over market prices as a reflection of foreign investors' information on future market movement. According to this strand of research, if t-1 net purchases have predictive power over date t market returns beyond their forecasting power over date t net purchases, then in a regression, t-1 net purchases should remain a significant predictor, even if date t net purchases are included among the explanatory variables. However, if t-1 net purchases merely forecast date t net purchases, which in turn have a contemporaneous impact on returns, the significance of t-1 net purchases is expected to decline once the influence of date t net purchases is controlled for.

Griffin et al (2002) attempt this type of investigation and find that foreign past net purchases only signal future purchases, which have a contemporaneous price impact. As a sidebar, we conduct a similar test here for not only market returns, but also currency returns. We re-run the market returns and currency returns equations from the VAR, but with date t net purchases added to the right-hand-side.

Table A: Coefficients on current and lagged net purchases

	India	Indonesia	Korea	Philippines	Taiwan	Thailand
Market returns equation						
Date t	3.424*	0.780*	16.88**	2.115**	12.65**	20.35**
Date t-1	3.046*	-0.524	-2.032	0.587	0.390	-5.844**
Date t-2	0.655	-	-1.718	-1.238*	-2.026*	-3.152**
Date t-3	1.632	-	-1.445	-	-2.662**	-0.620
Date t-4	-2.935	-	-1.496	-	-0.117	-
Date t-5	-	-	-1.403	-	-0.582	-
Currency returns equation						
Date t	0.551**	-0.055	1.392**	-0.230**	0.889**	1.597**
Date t-1	0.374*	-0.033	0.178	-0.129	0.331*	0.314**
Date t-2	0.497**	-	-0.121	0.250	-0.002	0.719**
Date t-3	-0.230	-	-0.260	-	0.007	-0.252
Date t-4	-0.040	-	-0.131	-	-0.066	-
Date t-5	-	-	-0.439	-	0.061	-

Table A reports the coefficients on net purchases only, as the other variables in the system are not the focus in this test. Our results are consistent with those of Griffin et al (2002). Net purchases on date t have a significant positive association with local returns in all six markets, and with currency returns in all except Indonesia and the Philippines. However, date t-1 net purchases are significant in explaining local returns only in India (and Thailand but in the opposite direction), and in explaining currency returns only in India, Taiwan and Thailand. These results suggest that foreign investor behaviour have limited predictive power over future returns.

5. Cross-market co-movement of net equity flows

So far, we have examined the full-sample relationships in each market separately. As such, our analysis has not yet addressed questions such as whether foreign investors tend to move in and out of Asian markets simultaneously, or whether foreign investors tend to exacerbate regional sell-offs. In this section, we take a closer look at net equity flows (as

proxied by foreign investors' net purchases) and examine their cross-market patterns. We first assess the correlations of net equity flows among the markets in our sample. The role of external market factors as a common driver of foreign investor demand for Asian equities is highlighted. We then examine how common it is to see net flows in the same direction simultaneously in multiple markets on a given day.

5.1 Cross-market correlation

To begin assessing the cross-market co-movement of net equity flows, we calculate pair-wise correlations of net flows using daily data. Since we are more interested in the cross-market properties rather than in the time-series properties in this exercise, we eliminate from the sample days in which not all six markets are operating. We end up with a common-size sample of 1599 observations for each of the six markets.

Table 8 reports the full-sample correlations of scaled net flows for each of the possible market-pairs. The correlations are positive in all cases except one. Overall, the market-pairs with the strongest correlations are Korea-Taiwan, Taiwan-Thailand and Korea-Thailand. This is not surprising, given that these three markets have been shown in the earlier sections to behave quite similarly. India also has significant, albeit lower, positive correlations with the three typically well-behaved markets. The Philippines shows only modest correlations with Thailand and, to a lesser extent, Korea. Indonesia shows no significant correlation with any of the other markets.[26]

As mentioned in section 2, one possible explanation for the positive correlation of net equity flows in Asia is that the fundamentals in each market that serve to "pull" in foreign investment are themselves highly correlated. The positive and sizeable correlations of local market returns among the six markets in our sample could be interpreted as an indicator to that effect (Table 8).[27] To the extent that foreign investors respond systematically to these pull factors, net flows in the different markets would to some extent become correlated as well.

[Table 8: Cross-market correlations: flows and returns]

Role of external market factors

Another possibility, which may not be inconsistent with the first, is that the correlation in net flows is a result of foreign investors responding to common external factors, thus "pushing" capital into various host markets at the same time.[28] Building upon our VAR analysis in section 4, we re-estimate the net purchases equations with the inclusion of some exogenous "push" variables. As done by Richards (2005), we choose MSCI World and MSCI Emerging Market returns to proxy for external market returns.[29] In addition, we include the widely used

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[26] Rolling correlations reveal considerable time-variation in the cross-market co-movement of net flows that may help to explain the difference between our full-sample correlations and those reported in earlier studies. Overall, the Korea-Taiwan correlation is the only one that stays relatively strong and stable throughout the sample period. This suggests that the two markets are regarded as similar in the eyes of international investors. But even there, the correlations weakened somewhat in 2003-05 before picking up again in 2006.

[27] Froot et al (2001) report a similar finding.

[28] Griffin et al (2002) and Richards (2005), for example, investigate the role of external market returns, in addition to that of local market returns, as a predictor of equity flows in emerging markets. Richards (2005) tests the influence of foreign returns such as S&P, Nasdaq, Philadelphia Semiconductor index and MSCI indices. Griffin et al (2002) use regional returns indices to capture the influence of such "push" factors.

[29] S&P 500 and Nasdaq returns are also tested. But since they are highly correlated with MSCI World returns, their results are very similar to the MSCI World results and thus are not shown in the table.

VIX index to proxy for global capital market volatility.[30] We experiment with including only one exogenous variable at a time as well as adding all three variables simultaneously. The full set of coefficients for the various specifications is not shown here but is available upon request. The main observations are summarised as follows:

- The inclusion of the new variables mostly does not affect the original results. At the very least, the date t-1 coefficients remain similar to those in the original VAR equations.
- But the inclusion of these variables generally improves the adjusted R^2. This suggests that external market factors have additional explanatory power over foreign investors' demand for Asian equities.
- In most markets, at least one of the three variables would show up as significant. However, in Indonesia and the Philippines, none of them is significant, implying that domestic concerns tend to dominate external market factors in these two markets.
- Where they turn out to be significant, MSCI World and MSCI Emerging Market returns have positive t-1 coefficients. This could be interpreted as a kind of "wealth effect": strong performance of global equity markets makes international investors feel richer and invest more everywhere.
- Where significant, the VIX index has a negative t-1 coefficient. This suggests that higher US market volatility tends to discourage international purchases of Asian equities. To the extent that Asian equities are seen as risky assets, this negative association between external market volatility and net flows into Asian equities seems reasonable.
- But when all three variables are included, the VIX index tends to drop off in significance, leaving one or both external returns significant. This could be because MSCI World or MSCI Emerging Markets already embody some information contained in this indicator of US equity market volatility.

All in all, the common response to external market factors is a plausible explanation for the observed positive correlation in net equity flows, especially among Korea, Taiwan, Thailand and, to a lesser extent, India. Given the different magnitudes of response, different levels of correlation would result.

5.2 Coincidence of inflows and outflows: three different notions

Although the absolute magnitude of the correlation of net flows is not very large, it is notable that the sign is almost uniformly positive. Thus, it would be interesting to look more closely at how often foreign investors move into or out of multiple Asian equity markets simultaneously. We consider in this subsection three different notions of "coincidence": frequency, joint probabilities and conditional probabilities. Examining the cross-market coincidence of net equity flows should help shed light on questions such as whether foreign investors tend to see and treat Asian markets as all alike – and whether they do so all the time, only on the way in, or only on the way out.

Frequency: How often do Asian markets see same-direction net flows?

A simple way to assess the cross-market coincidence of equity flows is to count the number of days in which multiple markets simultaneously experience net flows in the same direction.

[30] The Chicago Board Options Exchange Volatility Index (VIX) is a measure of market expectations of near-term volatility, as conveyed by S&P 500 index option prices. It has been used by many as a barometer of investor sentiment and market volatility.

Table 9 presents the number of days in which at least a given number of markets have inflows or outflows at the same time. Out of 1599 days, there are, for example, 844 days (53%) in which four or more markets experience inflows at the same time, and 431 days (27%) in which four or more markets see outflows simultaneously. Naturally, the frequency decreases as we consider coincidence in larger number of markets.

The results have two notable features. One is that the actual frequencies recorded are higher than the theoretical frequencies computed with the assumption of a 50-50 chance of inflows or outflows and statistical independence across markets. For instance, such assumptions of randomness would imply that there should be only about 25 out of 1599 days of simultaneous inflows/outflows in all six markets. The fact that there are 129 simultaneous inflow days (54 outflow days) in all six markets indicates that the observed "coincidence" of net flows in Asian equity markets is more than just random coincidence. Another notable feature is that coincidental inflows happen more frequently than coincidental outflows – well more than what the overall ratio of inflow and outflow market-days in the sample implies.[31] The more-probable-than-average occurrence of coincidental inflows suggests that, during the sample period, inflows are more often a regional phenomenon, while outflows are in comparison more idiosyncratic or market-specific than regional in nature. Instead of counting days of inflows and outflows, this exercise can be repeated with weeks, months, or even episodes (somehow defined; see Box 2), and the qualitative results will still hold.

[Table 9: Frequency of same-direction net flows simultaneously in x markets]

Joint probabilities: Checking for statistical independence

To assess more formally whether net flows in the different markets are indeed not independent of each other, we calculate the joint probability of q markets getting inflows (or outflows) simultaneously on the same day.

For the case of q = 2, for instance, we find that the probability of two markets seeing net inflows on the same day ranges between 0.27 and 0.45 (Table 10a), while the probability of two markets experiencing net outflows on the same day is ranges between 0.13 and 0.29 (Table 10b). We then compared these actual joint probabilities with the "theoretical" joint probabilities computed under the assumption of statistical independence (ie product of the marginal probabilities). We find that in all cases, the actual joint probabilities are higher than the theoretical ones, refuting the independence assumption.[32] If we repeat this exercise for q = 3, 4, 5 or 6, the joint probabilities naturally decline, but the gap between the actual and the theoretical probabilities persists. This result confirms that whether a market experience inflows or outflows on any given day is not independent of what happens in other markets on the same day.[33]

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[31] In the whole sample, the occurrence of inflows is 1.3 times as frequent as the occurrence of outflows. But the ratios of inflow and outflow days in at least four or more markets are close to or more than 2.0.

[32] The pairs with the smallest gaps between the actual and theoretical joint probabilities are Indonesia-India and India-Thailand.

[33] If we count only the days with larger-than-average net flows, the joint probabilities naturally decline further. The pattern of statistical non-independence still holds in the case of inflows, but becomes weaker for outflows. This result could imply that larger-than-average outflows tend to be relatively more idiosyncratic or market-specific (less coincidental) than small/average size outflows. Repeating this exercise of calculating joint probabilities using weekly data yields very similar results.

[Table 11a: Joint probabilities of inflows days]
[Table 11b: Joint probabilities of outflows days]

Conditional probabilities

Yet another way to view the coincidence of net flows is through conditional probabilities. The upper panel of Figure 4 shows the probabilities of n other markets experiencing inflows, conditional on the market on the x-axis getting inflows on the same day. The lower panel shows the conditional probability distributions for outflows.

The inflow distributions are quite similar in shape across markets. They tend to have very short bars for n = 0 but relatively long bars for n = 3 or 4. This "pointy" and left-skewed shape indicates that while it is unlikely to observe days of idiosyncratic inflows (ie n = 0 or 1), it is quite likely to see three or more markets having inflows given that one market is already seeing inflows. The outflow distributions are also quite similar across markets. However, compared to the inflow distributions, they are less "pointy" and more symmetric, with peaks around n = 2 or 3. The contrast in distribution shapes makes two related points. First, it is more probable to see coincidental inflows in large number of markets (right half of distribution) than to see coincidental outflows in many markets. Second, it is more probable to see idiosyncratic outflows than to see idiosyncratic inflows (left tail of distribution).

Taken all together, the three notions of coincidence suggest that foreign investors are more likely to flock into multiple Asian equity markets at the same time on a given day than to rush out en masse. If and when they do exit Asia, it is not necessarily more likely that they exit a large number of markets simultaneously. In other words, while inflows tend to be more often a regional phenomenon during the sample period, outflows are relatively more idiosyncratic or market-specific in nature.

This conclusion could admit various explanations. One possibility is that during the sample period, factors that affect the attractiveness of the region as a whole (eg external market returns, renminbi speculation) tend to go in the direction that favours inflows into Asia, while factors that inspire outflows tend to be more market-specific in nature. Another possible explanation pertains to the portfolio management behaviour of foreign investors. When they want to increase their exposure in Asia, they tend to allocate funds to multiple markets (a diversified portfolio). But when they reduce exposure, they tend to sell only specific markets rather than dumping all markets at the same time. Such selective selling behaviour seems especially plausible during a time when international investors are keen to maintain some exposure in Asia.

[Figure 4: Conditional probabilities]

Box 2: Inflow and outflow episodes

Another way to characterise the pattern of equity flows is to look at, not just individual days, but episodes of net inflows or outflows. To cut down on noise, we first aggregate the daily data into weekly data and then define an inflow (outflow) "episode" as four or more consecutive weeks of net inflows (outflows). Using this definition, we find that there are more inflow episodes than outflow episodes in all markets except Thailand. In India, Indonesia and Taiwan, there are four to five times as many inflow episodes and there are outflow episodes. In terms of duration, inflow episodes on average last longer than outflow episodes in all markets except the Philippines and Thailand. The average duration of inflow episodes is the longest in India. Outflow episodes last on average the longest in the Philippines. As for intensity, inflow episodes are on average more intense than outflow episodes in all six markets. Taiwan has the strongest average magnitude of inflows and outflows (in relation to market size), both in per episode terms and in per episode-week terms.

Table B: Frequency, average duration and average intensity of episodes

	IN	ID	KR	PH	TW	TH
Inflow episodes						
Frequency	24	31	21	25	28	19
Duration (weeks)	10.46	7.58	6.86	7.24	7.86	5.74
Intensity per episode	0.87	0.68	1.12	0.47	1.30	0.86
Intensity per week	0.08	0.09	0.16	0.06	0.17	0.15
Outflow episodes						
Frequency	7	6	17	14	6	22
Duration (weeks)	5.00	5.17	5.88	7.71	5.00	6.46
Intensity per episode	0.24	0.20	0.64	0.33	0.81	0.69
Intensity per week	0.05	0.04	0.11	0.04	0.17	0.11

Consistent with the average relationships obtained earlier, inflow episodes are, most of the time, associated with positive market returns and/or local currency appreciation and/or positive US market returns. There are nonetheless a number of inflow episodes that are associated with negative returns and/or currency depreciation, suggesting that other factors (eg specific events) could be at play. Also confirming the average relationships obtained earlier, most outflow episodes are associated with negative local market returns and/or local currency depreciation and/or negative US market returns. Some outflow episodes are associated with positive returns, but such occurrences are less likely than seeing negative returns during the inflow episodes.

How often does one see concurrent episodes? Applying the concept of coincidence to the identified episodes, we find that, parallel to the daily-basis results obtained in section 5.2, concurrent inflow episodes in multiple markets occur with higher frequency than concurrent outflow episodes, even after adjusting for the larger total number of inflow episodes in the whole sample. Given the distribution over time of inflow and outflow episodes in individual markets, concurrent inflow episodes tend to happen more in the second half of the sample period, while concurrent outflow episodes tend to occur more towards the earlier years of the sample.

6 Event study analysis: Do average relationships still hold?

To tie the various analyses together, we ask in this section whether the average relationships observed over the whole sample still hold in specific episodes of heightened market volatility. We zoom in on four events and examine how foreign investors' net purchases of equities, market returns and exchange rates in all six markets evolved under the specific circumstances. The four events are chosen for their different natures. The first is the 11 September 2001 attacks, an extra-regional event but with potential financial market impact in Asia. The second and the third events are both specific to Thailand – the military coup in September 2006 and the institution of new capital controls in December 2006 – but they had very different regional consequences. The fourth is a global event, the May-June 2006 multi-market sell-off, which had particular relevance to emerging equity markets. Figure 5 shows the six markets' net equity flows and the group's average daily market return on the days in each episode.

September 11 attacks

The attacks occurred in the morning New York time, while all Asian markets had already closed for the day. On the following day (12 September 2001), the stock exchanges in Taiwan and Thailand (and Malaysia) were closed in response to the incident overnight. The Indian, Indonesian and Philippine bourses were open and saw moderate net outflows of US$1 to 2 million and a fall in their main market indices of about 3%. This observation is consistent with the on average positive association between net purchases and market returns detected over the full sample.

In Korea, however, there was a more sizable net outflow on 12 September, after a three-hour delay in market opening. The US$88 million (0.064% of market cap) net selling by foreign investors was accompanied by an 11.9% fall in the market index. The negative market commentary on that day expressed concerns that the attacks might adversely affect US demand for Korean goods. At the time, exports to the United States constituted about 20% of total Korean exports. About US$20 million per day would be at stake if there were to be any delay in shipments of electronic goods to the United States. Foreign investors were not the only group net selling. Individual investors at home were also net selling, leaving mainly institutional investors as net buyers.

On 13 September, the Korean market rebounded by over 4%, but other markets continued to decline. Nonetheless, contrary to the "return chasing" characterisation, foreign investors actually returned to Asia. Net inflows into Indonesia, Korea, Taiwan and Thailand on that day more than offset the net outflows on the previous day. This observation suggests that foreign investors were in Asia bargain-hunting while domestic investors were still selling. The extra-regional shock of September 11 appears to have on net pushed international capital into Asian equity markets.

Military coup in Thailand (19 September 2006)

The coup took place late in the evening of 19 September. On 20 September, the Thai market was closed. Other equity markets in the region seemed little affected by the incident. India, Indonesia, the Philippines and Taiwan all received net inflows. The Philippines, in particular, saw an inflow of US$219 million (equivalent to some 0.45% of total market value). However, this extraordinary inflow could be related to the sales of a 6.9-percent stake in Ayala Corp, a leading company, to foreign investors.[34] In contrast, Korea saw a US$367 million net outflow

[34] The deal was worth PHP 10.56 billion. Subtracting out this deal, net equity inflows on that day would amount to only 0.016 percent of total market value.

(0.06% of total market value) on 20 September – but this seemed to be unrelated to the coup.

The Thai stock market re-opened on 21 September. Although the market declined by 1.1% on that day, foreign investors on net bought US$197 million of Thai stocks (0.18% of the market's total value) in apparent contradiction to the full-sample positive association between net purchases and market returns. This strong positive reaction from foreign investors appears to be a collective sigh of relief, if not a vote of confidence, after months of protracted political tension and uncertainty in Thailand. The bloodless coup helped to clear the air. The Thai baht weakened to 37.9 baht per US dollar (over 1.6%) overnight on 19 September, but recovered to 37.4, close to the pre-coup level, in only three trading days.

Meanwhile, net outflows from the Korean market continued, but seemed to have no apparent link with the coup in Thailand. Korean daily market returns fluctuated between –1.4% and 1.2%, still within the average range, in the subsequent days. All in all, there is little evidence that the coup per se had any notable adverse impact on equity flows in the region, including Thailand.

Capital controls in Thailand (18-19 December 2006)

On the evening of 18 December 2006, the Thai central bank announced the imposition of a 30 percent reserve requirement on any non-resident inflows of more than US$20,000. This interest-free deposit could be withdrawn in full only if the capital stayed in Thailand for at least one year. Early repatriation would result in a penalty. The announcement came after a series of mild, loophole-plugging measures aimed at fending off non-resident investors' flows into short-term fixed income instruments. Nonetheless, the severe and broad-based nature of the 18 December announcement came as a surprise.

On 19 December, the Thai equity market opened with a deep plunge and saw US$703 million of net sales by non-residents. This net outflow amounted to about 0.6% of the total market capitalisation, the largest one-day outflow in the market's history thus far. The SET index closed 16% down from the previous day's close. Having already weakened overnight to above 35.9 baht per dollar (over 1.8%), the Thai currency remained weak in the range 35.6–36.0 on 19 December.

Although the capital control measures were specific to Thailand, other equity markets in the region also reacted negatively on 19 December. Korea experienced net outflows of US$65 million (0.01% of total market value), while India and Taiwan also had outflows of US$41 million and US$10 million (0.007% and 0.002% of total market value), respectively. This seemingly contagious exit could be a reflection of foreign investors' fear that other economies in the region might impose similar measures to alleviate the currency appreciation pressure that had prevailed for much of the year. Excluding Thailand, the other five markets on average declined by 1.4% on that day.

In light of the extreme market reaction, the Thai authorities revoked the control measures on equities inflows on the same day, after market close. Despite the revocation and a rebound in stock prices on 20 December, foreign investors continued to pull out from the Thai equity market, though in a smaller scale. India and, to a lesser extent, Korea and the Philippines also continued to experience some outflows, while Taiwan saw a sizable inflow (0.03% of market size). By 21 December, net inflows had also begun to return to Korea in full force.

In sum, while the Thai capital control measures did invoke some spill-over effect in other markets in the region, the effect was rather short-lived. Nonetheless, the impact on the Thai market itself was quite substantial. Outflows continued through the end of 2006. Despite some recovery, the SET index ended the year still some 7.8% down from just before the announcement of the measures.

May-June 2006 sell-off

In May 2006, there was a sudden shift in investor sentiment. Higher-yielding, riskier assets and currencies, which had until then benefited from a benign global volatility environment and investors' search for yield, were the most adversely affected. A popular interpretation of what happened was that the possibility at the time of a further US rate hike, the prospective end to Japan's zero interest rate policy and expectations of further tightening in the euro area led market participants to think that the days of abundant global liquidity – regarded as a main ingredient fuelling the search for yield – might be numbered, thus triggering the broad-based, multi-market sell-off.

Emerging Asian bourses started to decline at different times. The Philippine and Taiwanese markets began to fall as early as 9 May, while the Thai market also began to level off. India peaked on 10 May. The Indonesian and Korean markets started to turn after 11 May. The sell-off had engulfed most Asian markets by 12 May[35] and lasted well into June. The protracted slide among Asian equity markets mostly ended by mid-June. In retrospect, the sell-off was merely a correction, as many Asian bourses proceeded to rise to new highs in the second half of 2006.[36]

As for foreign investor behaviour in Asia, net equity flows turned pretty much simultaneously negative from 12 May on. There were two major bouts of outflows. In the first, the six markets saw a total of US$10 billion net outflows over 11 trading days (12–26 May). The second round of outflows was less severe, with US$4.6 billion of net outflows over eight days (6–15 June). Taken together, this was one of the largest episodes of equity net outflows since the Asian crisis.

The magnitude of outflows varied across markets. Taiwan saw US$3.3 billion and US$2.3 billion of net outflows in the two rounds, equivalent to 0.82% and 0.63% of the total market size, respectively. The Korean market lost US$3.3 billion and US$2.0 billion of net flows, equivalent to 0.55% and 0.37% of market size. The net outflows from Thailand were smaller in absolute size (US$0.9 billion and US$0.4 billion), but still considerable in relation to market size (0.85% and 0.39%). In India, however, there was only one bout of outflows (US$2.7 billion, 0.58% of market size) that lasted through 2 June. Outflows from Indonesia and the Philippines were considerably smaller.

While the onset of outflows was quite synchronised across markets, the winding down thereof showed more variation in timing. The Indian, Thai, Indonesian and Korean indices all bottomed out around 13–14 June, but the behaviour of equity flows varied. In India, net flows had already turned positive by early June, well before the rebound in prices. In Thailand, the large outflows subsided in mid-June after the market rebound and another phase of almost consecutive days of net inflows began on 22 June. In Indonesia, where the outflows were not as large as in other markets to begin with, the end to the outflow episode was not as clear-cut. Net flows remained somewhat erratic through the end of June. However, in Korea, outflows persisted, though in a smaller scale, well beyond the recovery of the market. The Philippine market bottomed out later on 21 June and net flows continued to trickle out through the end of June. In Taiwan, the market tentatively rebounded on 9 June, but

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[35] Using a different approach, Cairns et al (2007) also consider 12 May as the start date of the May-June 2006 global market turmoil. On this day, the VIX index rose to more than one standard deviation above its three-month moving average, indicating an extraordinary rise in global capital market volatility.

[36] Taking 11 May to 14 June as a reference timeframe, the Indian market declined the most (31%) followed by Indonesia (20.7%), Thailand (18.3%), the Philippines (16.4%), Korea (16.3%) and Taiwan (12%). The peak-to-trough declines are slightly larger in most markets but the relative ranking remains the same. This ranking roughly mirrors the degree to which these markets had risen between early January and 11 May: Indonesia had risen by the most, followed by India, the Philippines, Taiwan, Thailand and Korea.

subsequently declined again through 21 June. The outflow spell had started to dissipate by 16 June, though net flows remained mixed until early July.

[Figure 5: Event studies (4 panels)]

7. Concluding remarks

In this paper, we examine from various angles the behaviour of foreign investors' net equity purchases in six emerging Asian markets in the post-crisis period and their relationship with local market returns and exchange rate changes. We confirm results reported in earlier studies, including return-chasing, positive feedback, and the significance of push factors. In addition, we find that while currency returns tend to show little detectable influence over net equity purchases, net purchases do have some explanatory power over near-term exchange rate changes. Overall, these typical average relationships are the strongest in Korea, Taiwan and Thailand, and to a lesser extent India. They tend to be weak or absent in the two smaller markets, Indonesia and the Philippines.

Besides looking at the average statistical relationships in individual markets, we also investigate the cross-market co-movement of net flows. With various measures of co-movement, we confirm that foreign investors do quite often move in or out of multiple Asian markets at the same time. More interestingly, we find that coincidental inflows in multiple markets are more common than coincidental outflows. This suggests that, at least during our sample period, inflows are more often a regional phenomenon, while outflows are more often idiosyncratic or market-specific. Finally, if we zoom in on specific events, we observe some interesting deviations that the standard analysis of average relationships cannot show. For example, while foreign investors are deemed to be return-chasers on average, they sometimes do play contrarian in times of market volatility, potentially providing a stabilising influence over market prices.

There are arguably some important caveats. For instance, since data limitations did not allow us to include two of the more sizeable, open and active markets in the region (Hong Kong and Singapore), the conclusions obtained may not fully characterise emerging Asia as a whole. And as mentioned in section 3, the equity purchases and sales data we have only reflect transactions in the local stock exchanges and thus do not cover all forms of foreign investor participation in equities (eg futures), much less all forms of portfolio investments (eg bonds, money market). Moreover, net purchases are strictly speaking not necessarily the same as net capital flows in the balance of payments sense. This non-equivalence is especially relevant in markets where non-resident investors can switch between equities and other financial assets on-shore and/or where capital account restrictions provide disincentives to repatriate funds frequently.

Nonetheless, some policy implications may be drawn from this study, at least for the six markets included. The finding that foreign investors sometimes act as contrarian in episodes of heightened market volatility is suggestive of the potential benefit of allowing more different types of investors to participate in the local equity market – the divergence of views lessens the likelihood of a "one-sided" market. The observation that outflows tend to be more idiosyncratic than inflows could indicate some scope for Asian investors to diversify risk through more intra-regional cross-holding of stocks. Finally, the detectable influence of common external factors on foreign investment in Asian equities implies potential common challenges for policymakers in Asia. While the policy challenges or even dilemmas are similar, the preferred solutions may well vary with domestic circumstances.

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Figure 1: Monthly net equity purchases by foreign investors (1999-2006)

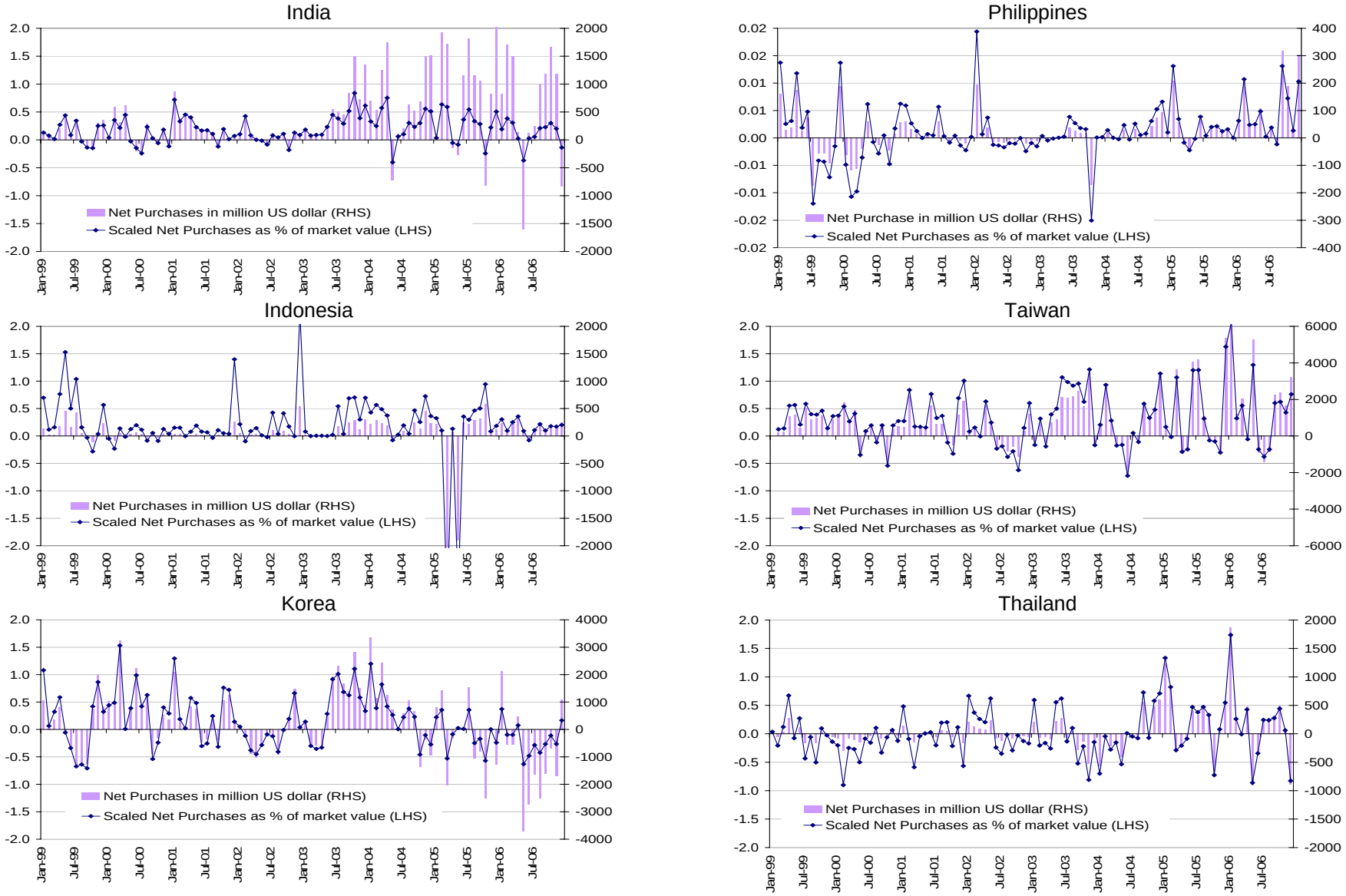


Figure 2a: Two-variable VAR impulse response functions

Cumulative response of scaled net purchases to a one-standard-deviation innovation in total returns

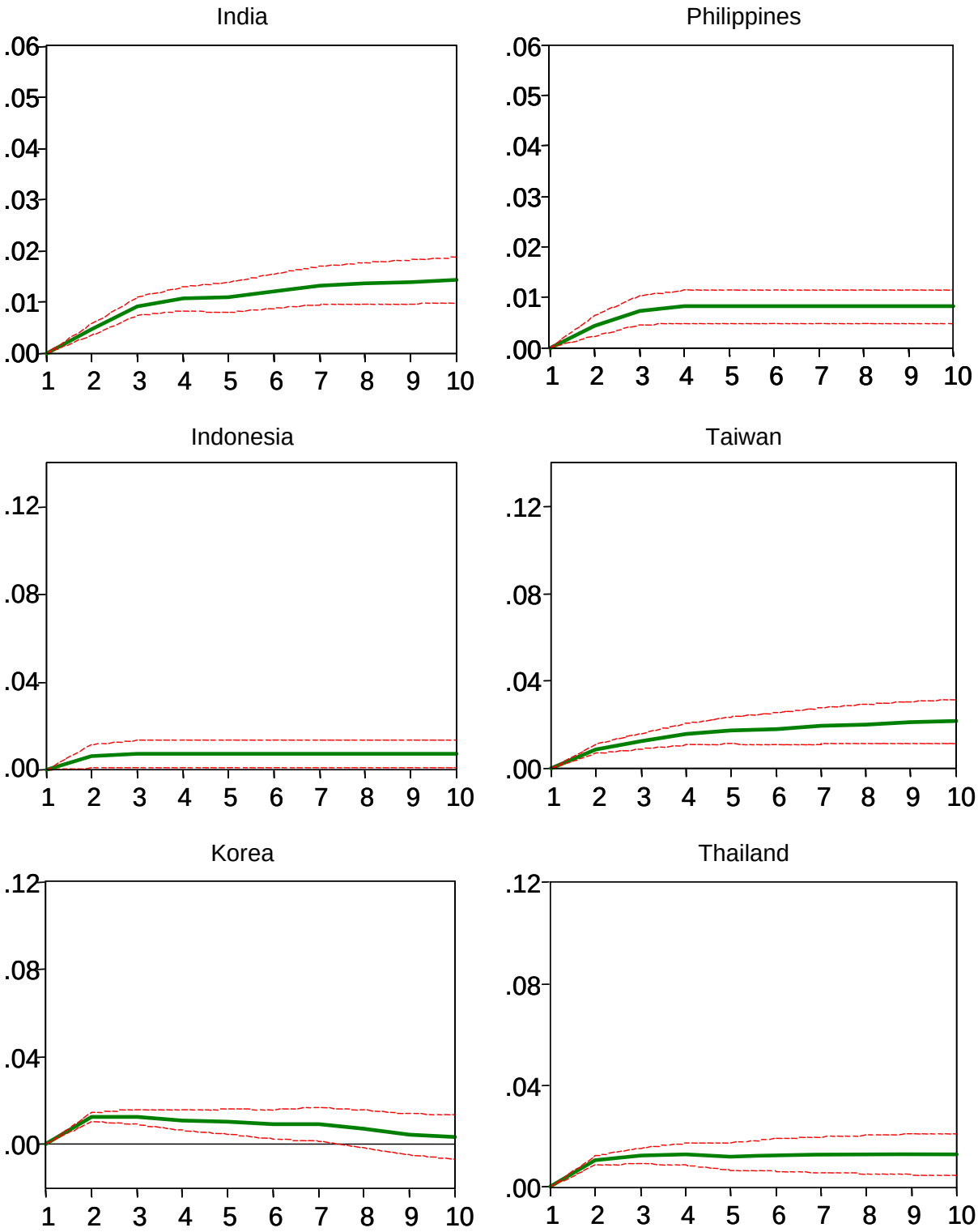


Figure 2b: Two-variable VAR impulse response functions

Cumulative response of total returns to a one-standard-deviation innovation in scaled net purchases

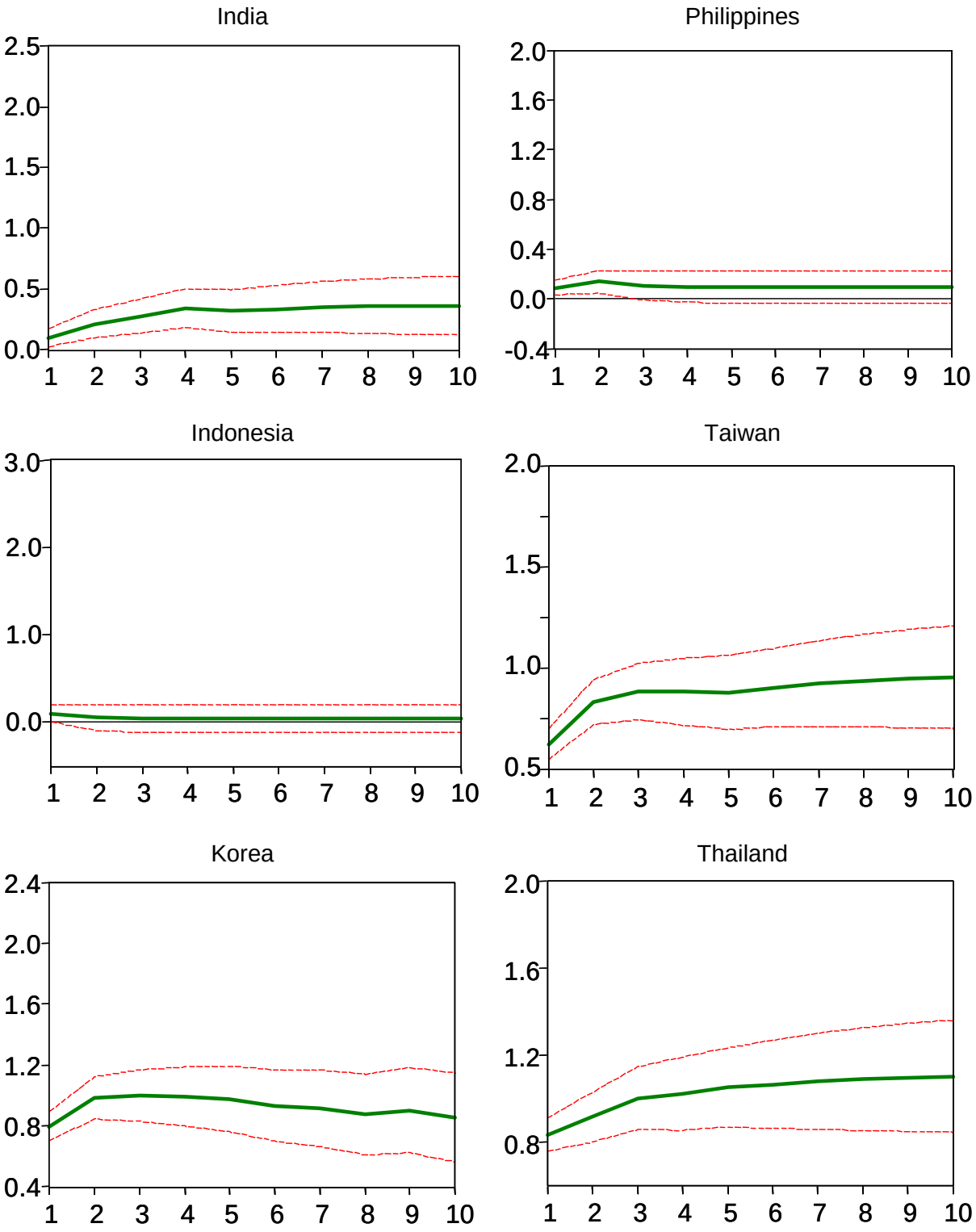


Figure 3a: Three-variable VAR impulse response functions

Cumulative response of scaled net purchases to a one-standard-deviation innovation in local market returns

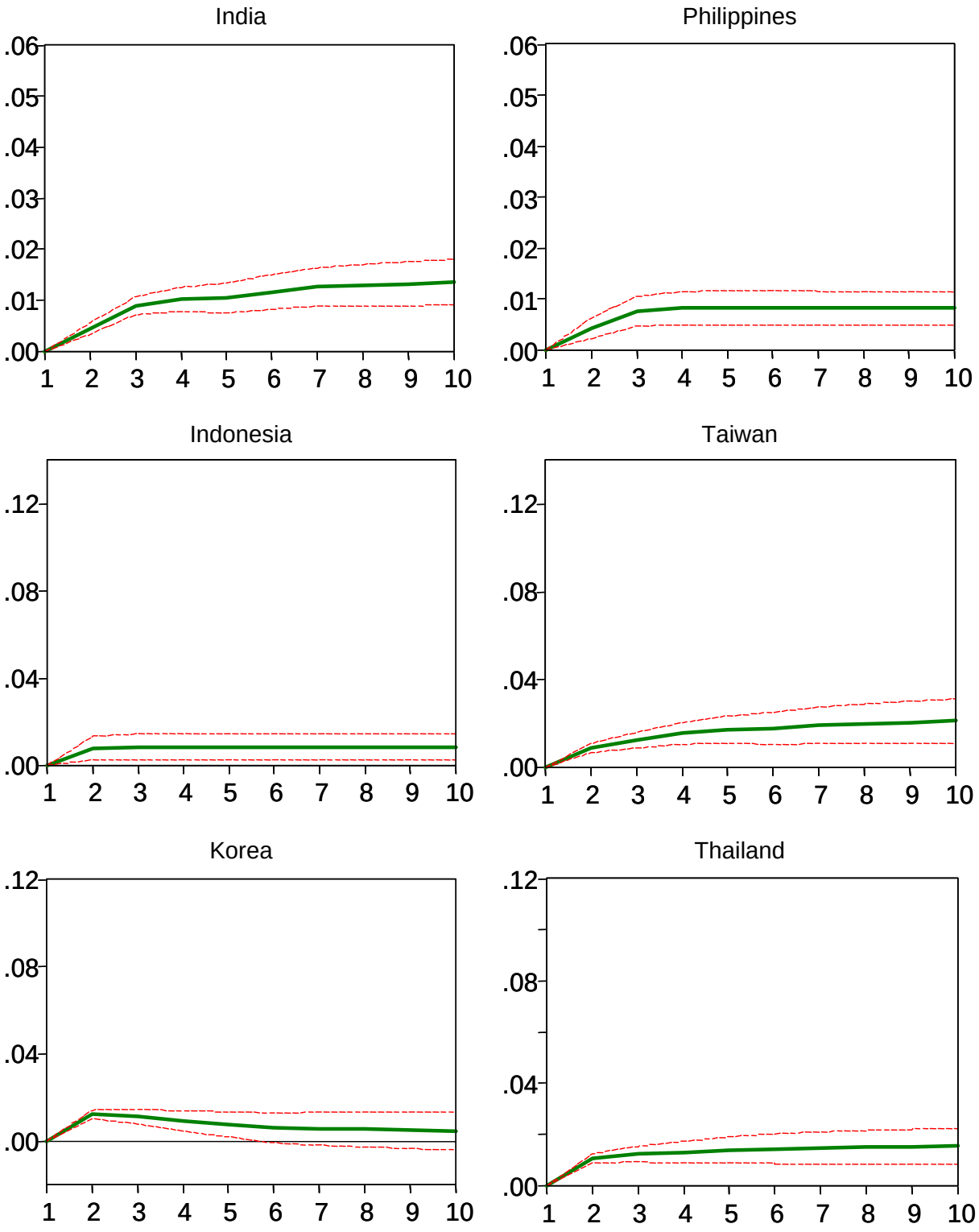


Figure 3b: Three-variable VAR impulse response functions

Cumulative response of local market returns to a one-standard-deviation innovation in scaled net purchases

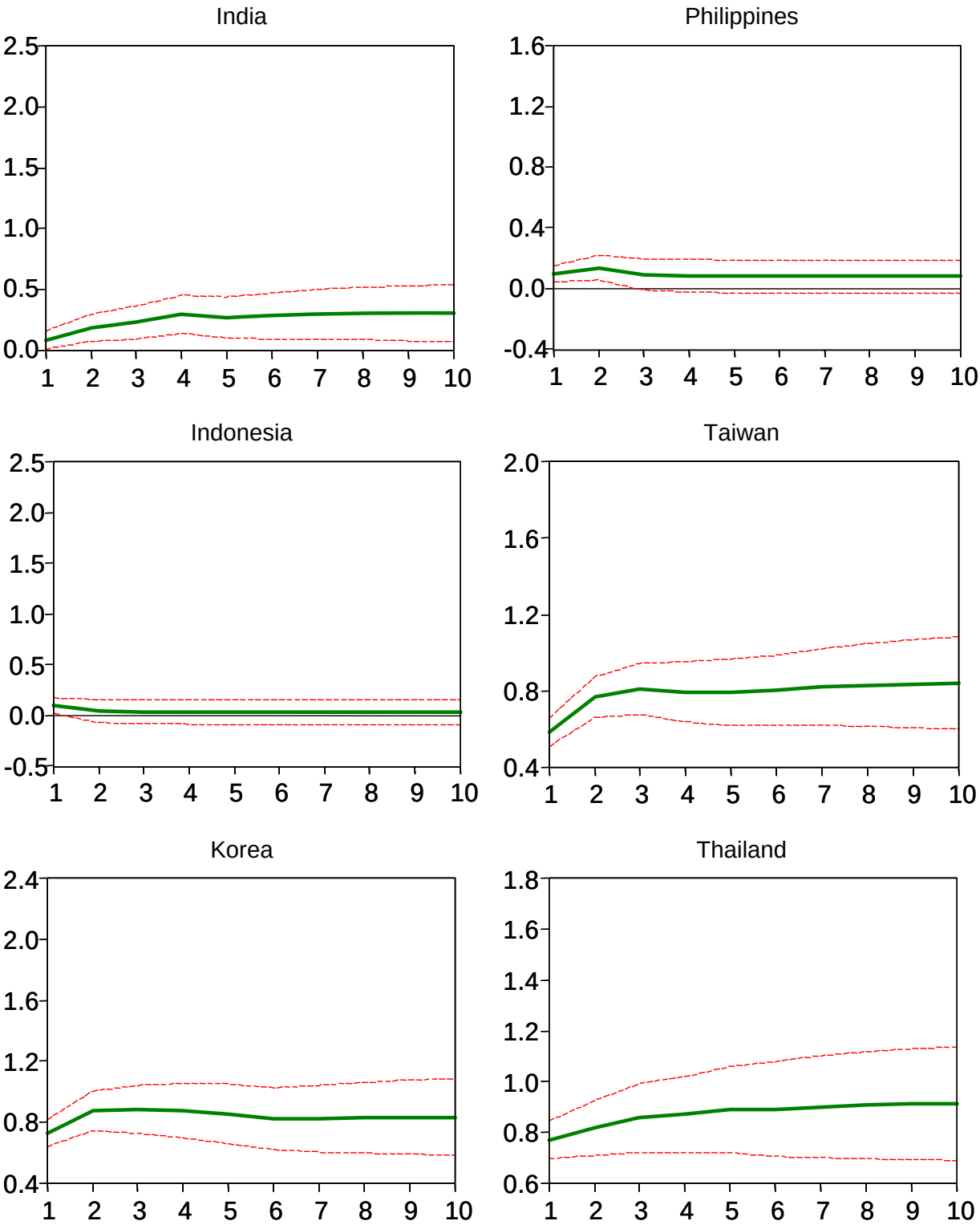


Figure 3c: Three-variable VAR impulse response functions

Cumulative response of scaled net purchases to a one-standard-deviation innovation in currency returns

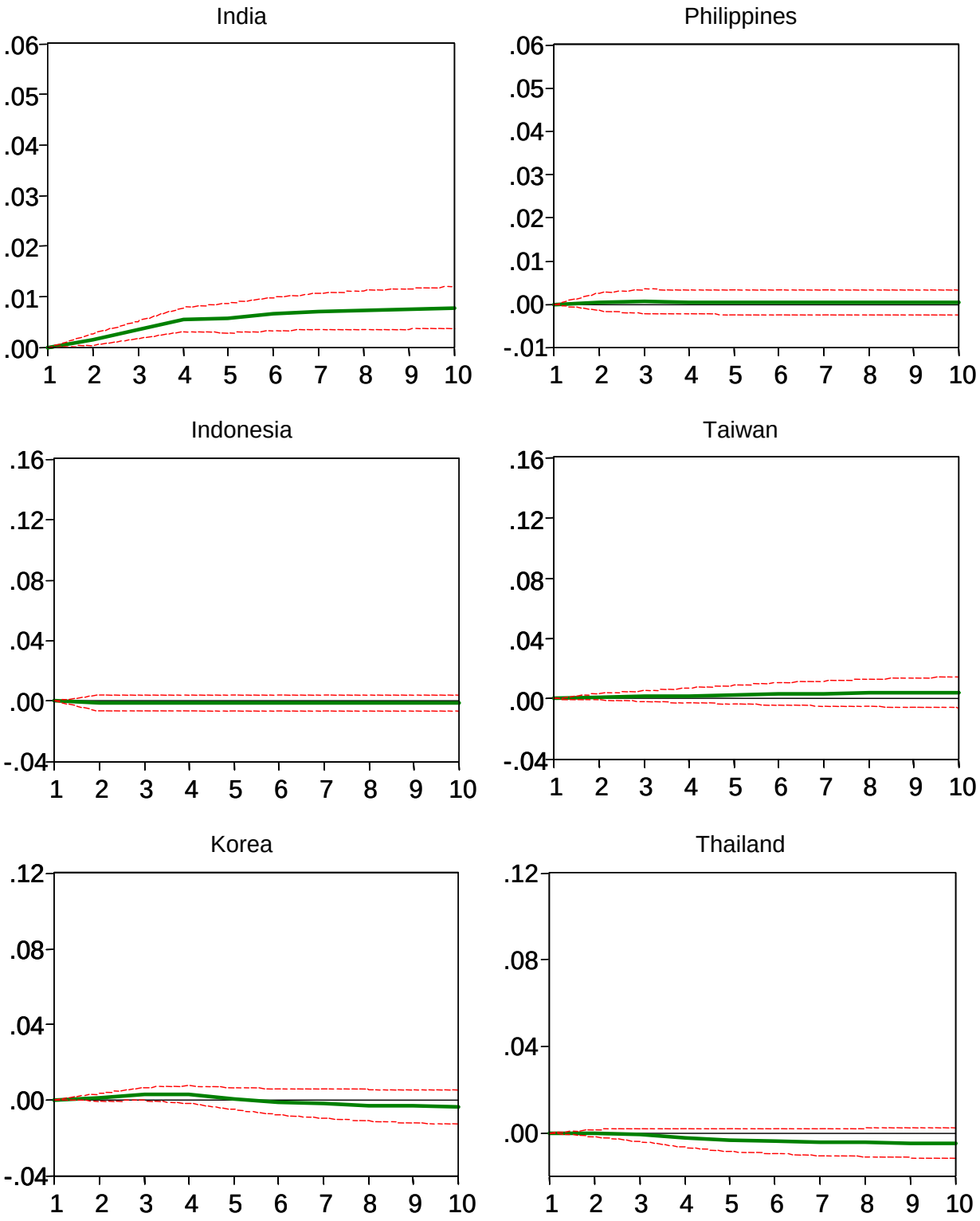


Figure 3d: Three-variable VAR impulse response functions

Cumulative response of currency returns to a one-standard-deviation innovation in scaled net purchases

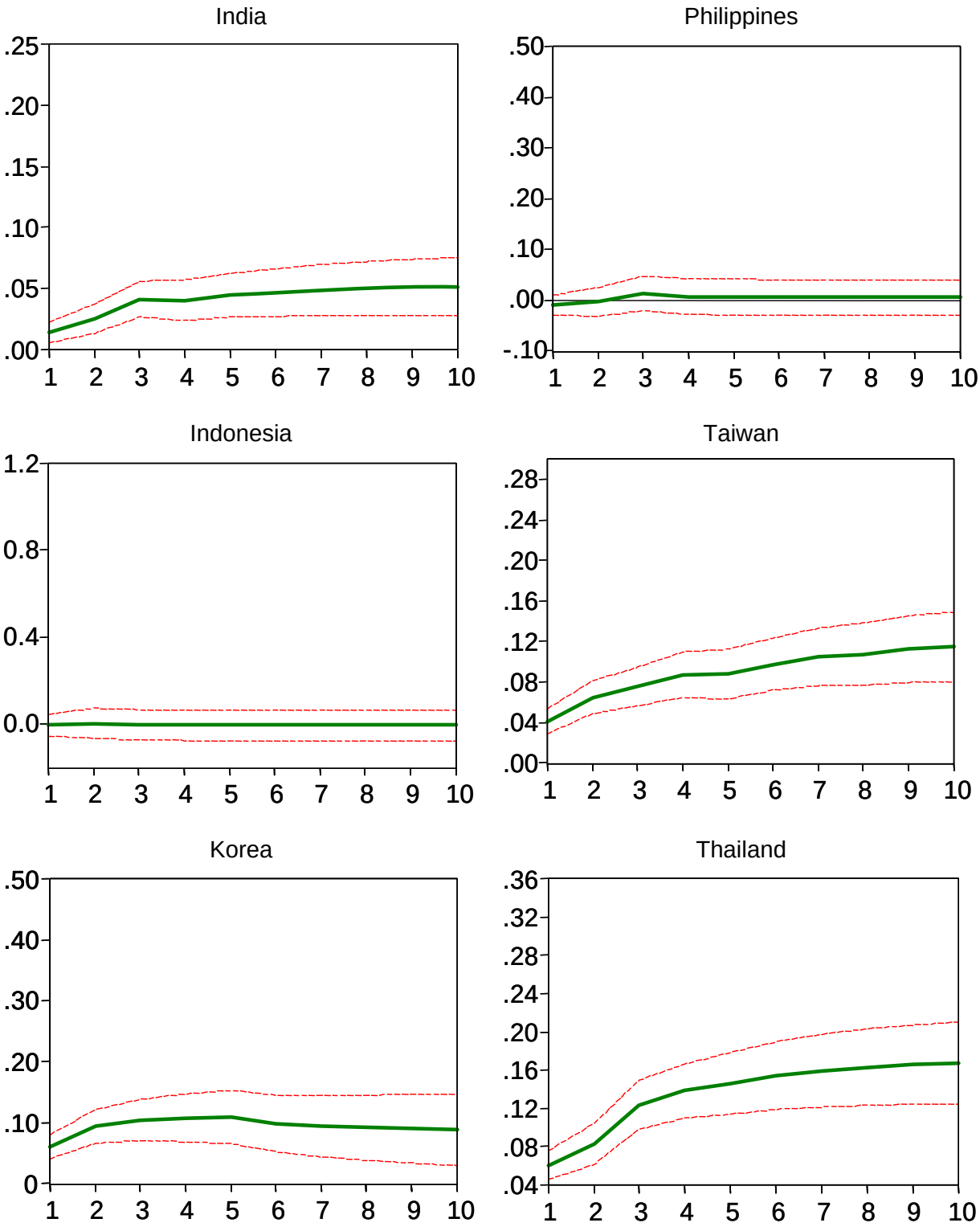


Figure 4: Conditional probabilities

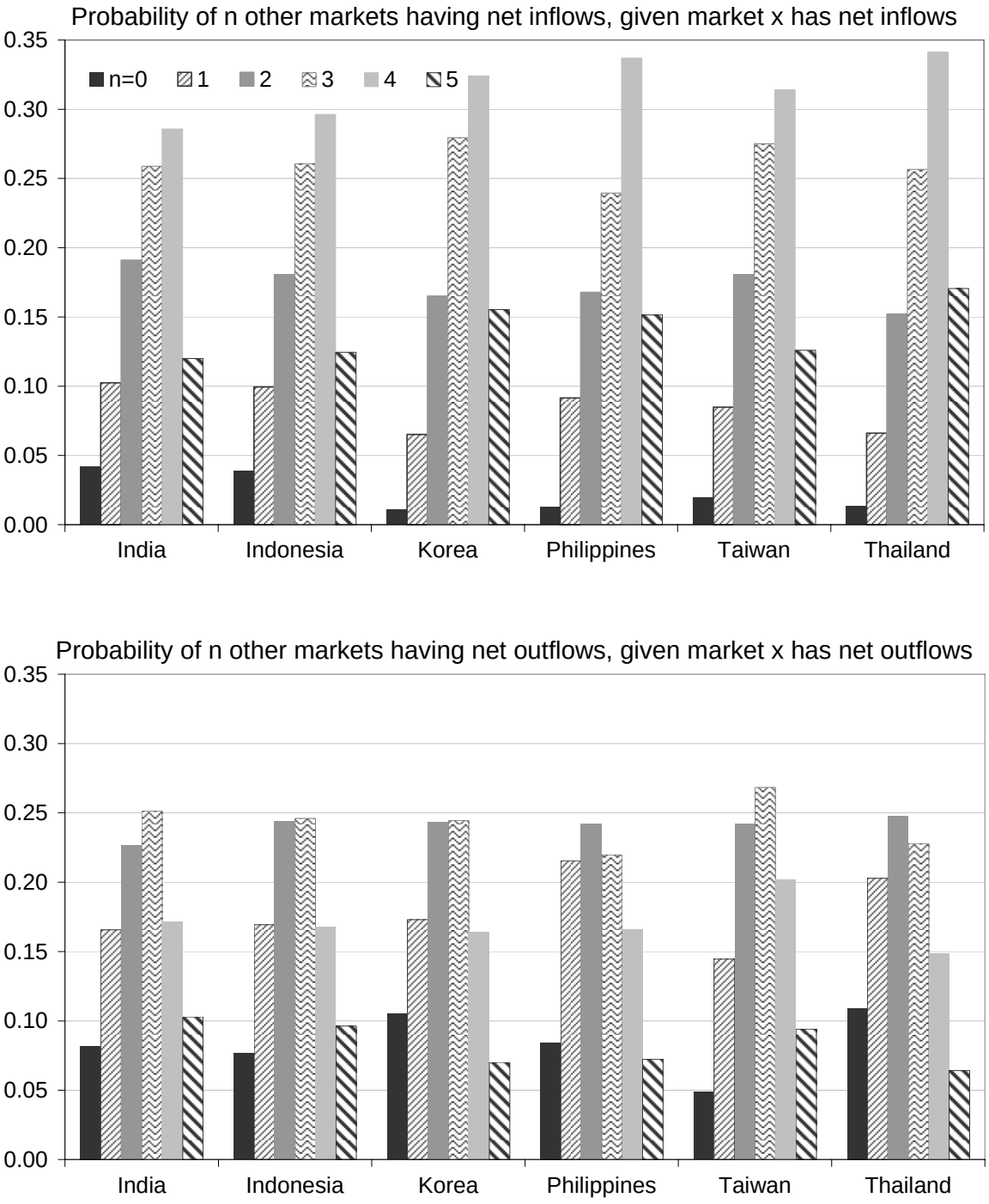


Figure 5: Events: net purchases and average market returns

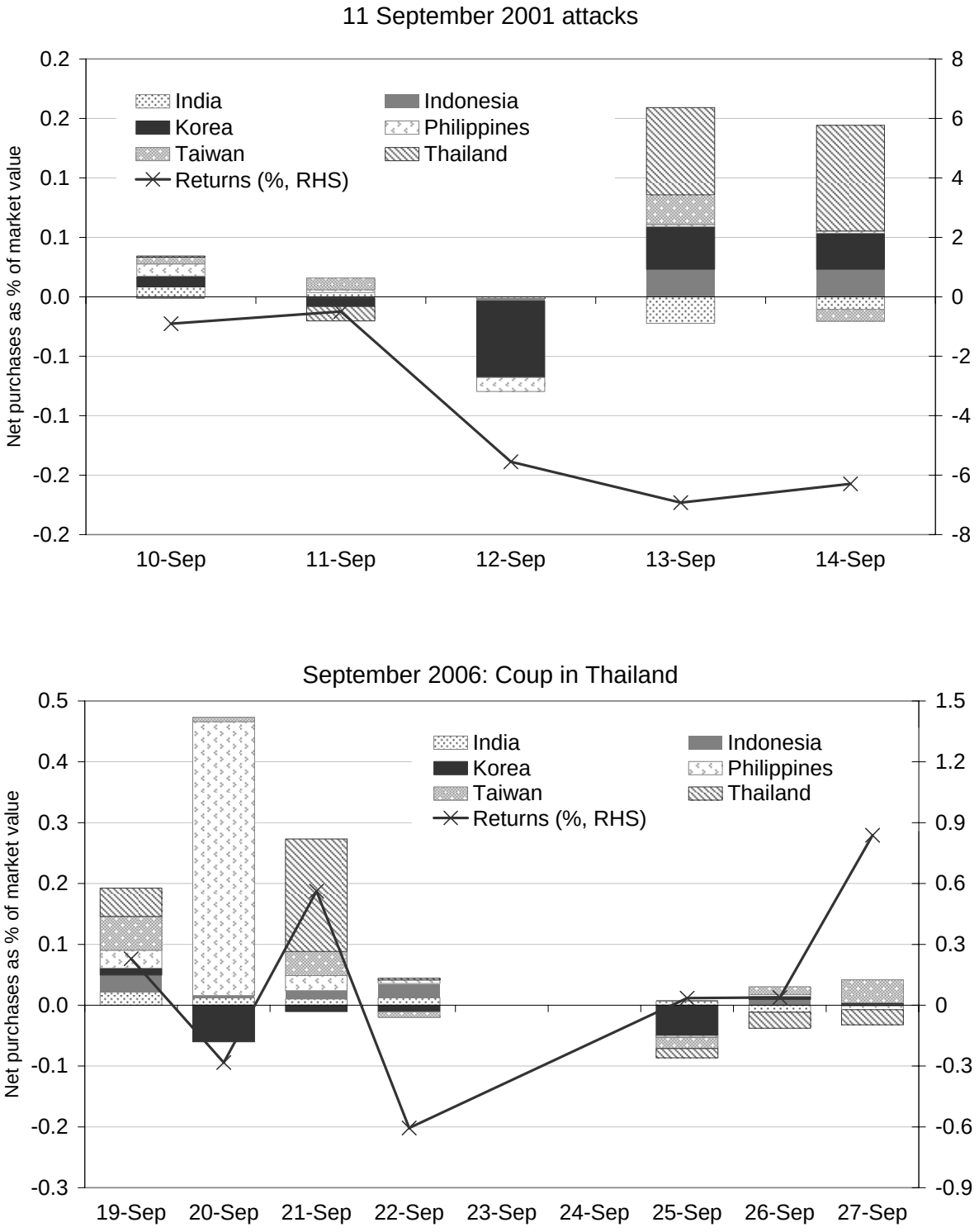
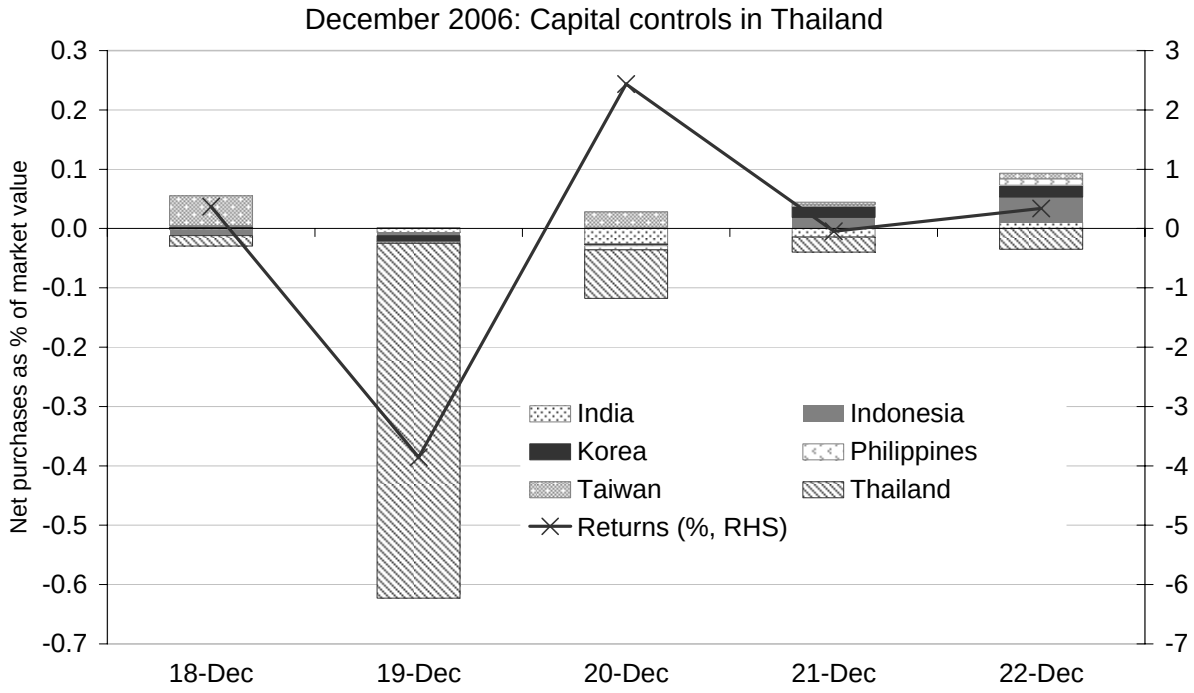


Figure 5: Events: net purchases and average market returns (cont.)



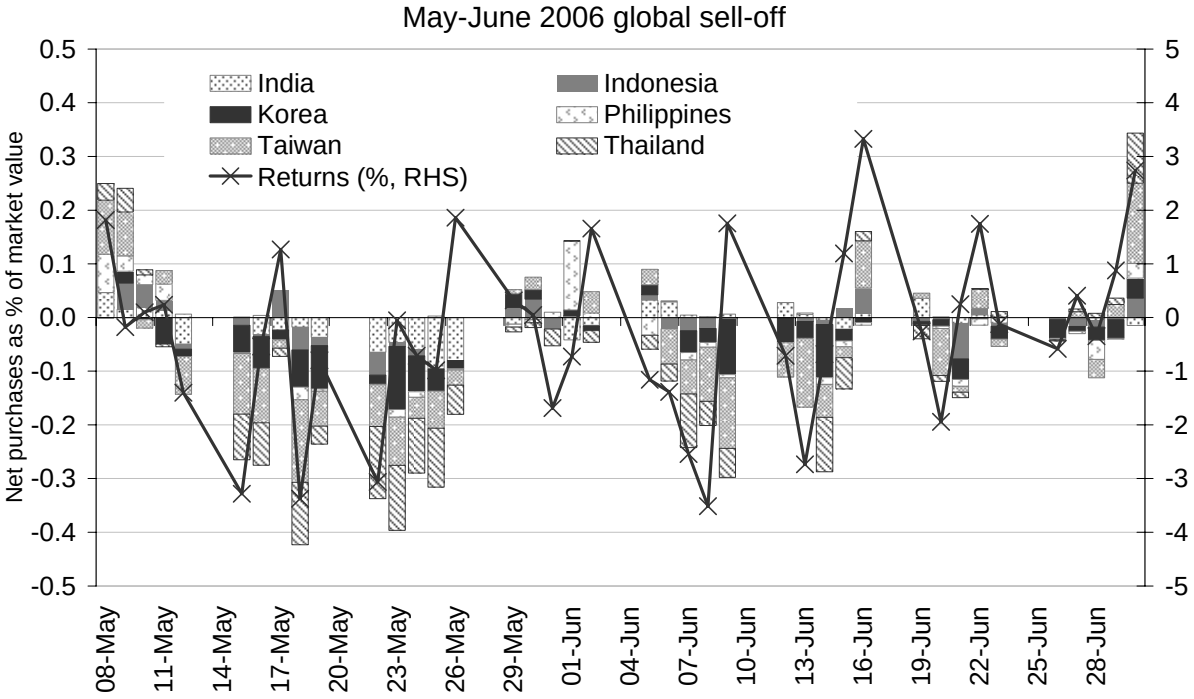


Table 1

Asian equity markets: Size and foreign investor participation in 2005

	IN	ID	KR	PH	TW	TH
Market value (in USD billion)[1]	326	66	418	33	331	91
Daily turnover (as % of market value)[2]						
Foreign investor	0.15	0.21	0.30	0.09	0.26	0.25
Domestic investor[3]	-	0.31	1.08	-	0.11	0.65
Daily foreign investor turnover (as % of FX turnover)[4]	7.84	6.86	5.92	3.76	11.79	6.56
Share of total holdings (%)[5]						
Foreign investor	8	-	40	-	16	28
Domestic investor	24	-	29	-	54	72

[1] Daily average over 2005. [2] Daily turnover is the sum of daily purchases and sales, averaged over 2005. [3] Domestic investor includes both individual and institutional investors; for Taiwan, major dealers and institutional investors. [4] FX turnover is the average daily traditional foreign exchange turnover of the respective domestic currency in April 2004, from the 2004 Triennial Central Bank Survey of Foreign Exchange and Derivative Market Activity. [5] As of end-2005; from Purfield et al (2006); for Taiwan, from the Taiwan Stock Exchange.

Sources: Datastream; CEIC; national stock exchanges; authors' calculations.

Table 2

Daily net equity purchases: descriptive statistics

1 January 1999 to 29 December 2006

	Mean	Mean absolute value	Standard deviation	Autocorrelation
India				
INR million	918.0	1,757.0	3,215.5	0.3036**
USD million	20.4	39.0	71.8	0.3023**
As % of market cap	0.009	0.019	0.027	0.2745**
Indonesia				
IDR million	29.0	99.7	650.8	0.0015
USD million	3.34	11.02	69.3	0.0032
As % of market cap	0.009	0.023	0.120	0.0096
Korea				
KRW million	13,179.0	103,488.0	148,599.0	0.4425**
USD million	9.67	90.52	132.8	0.4364**
As % of market cap	0.007	0.036	0.051	0.4354**
Philippines				
PHP million	61.2	170.4	634.5	0.0535*
USD million	1.18	3.54	13.0	0.0642**
As % of market cap	0.003	0.012	0.046	0.0215
Taiwan				
TWD million	1,455.0	3,437.0	5,375.0	0.4304**
USD million	44.1	104.3	163.2	0.4332**
As % of market cap	0.016	0.037	0.053	0.4451**
Thailand				
THB million	74.7	714.8	1,386.0	0.5146**
USD million	1.81	17.9	35.7	0.4993**
As % of market cap	0.001	0.029	0.046	0.5051**

* and ** denote significance at the 5% and 1% level, respectively.

Sources: CEIC; Datastream; national stock exchanges; authors' calculations.

Table 3

Daily market and currency returns: descriptive statistics

1 January 1999 to 29 December 2006

	Mean	Mean absolute value	Standard deviation	Autocorrelation
India				
Total returns in USD	0.09	1.22	1.70	0.1258**
Local market returns	0.09	1.19	1.66	0.1201**
Currency returns	-0.002	0.11	0.19	-0.0372
Indonesia				
Total returns in USD	0.06	1.49	2.17	0.1490**
Local market returns	0.06	1.23	1.72	0.0842**
Currency returns	-0.006	0.60	1.09	-0.0164
Korea				
Total returns in USD	0.09	1.58	2.17	0.0593**
Local market returns	0.07	1.47	2.04	0.0411
Currency returns	0.02	0.30	0.44	0.0171
Philippines				
Total returns in USD	0.02	0.89	1.31	0.2317**
Local market returns	0.03	0.83	1.20	0.1477**
Currency returns	-0.01	0.24	0.47	-0.0267
Taiwan				
Total returns in USD	0.02	1.29	1.77	0.0376
Local market returns	0.02	1.23	1.70	0.0270
Currency returns	-0.001	0.14	0.29	-0.1868**
Thailand				
Total returns in USD	0.04	1.29	1.82	0.0559
Local market returns	0.04	1.23	1.74	0.0362
Currency returns	-0.003	0.24	0.34	0.0316

Total returns and local market returns are the daily percentage changes in the stock market index in US dollar terms and local currency terms, respectively.

Currency returns is the daily percentage changes in the local currency against the US dollar.

* and ** denote significance at the 5% and 1% level, respectively.

Sources: CEIC; Datastream; national stock exchanges; authors' calculations.

Table 4

Bivariate correlations

1 January 1999 to 29 December 2006

	Market returns and scaled net purchases	Currency returns and scaled net purchases	Market returns and currency returns
India	0.0810**	0.0990**	0.1829**
Indonesia	0.0592**	0.0077	0.1503**
Korea	0.3391**	0.1601**	0.1936**
Philippines	0.0929**	0.0127	0.0483*
Taiwan	0.3375**	0.1707**	0.1526**
Thailand	0.3966**	0.2296**	0.1691**

* and ** denote significance at the 5% and 1% level, respectively.

Sources: CEIC; Datastream; national stock exchanges; authors' calculations.

Table 5

Granger causality tests: summary of results

(p-value in parenthesis)	IN	ID	KR	PH	TW	TH
Dollar returns ➔ net purchases	Yes *(0.000)*	*(0.074)*	Yes *(0.000)*	Yes *(0.000)*	Yes *(0.000)*	Yes *(0.000)*
Net purchases ➔ dollar returns	Yes *(0.012)*	*(0.212)*	*(0.106)*	*(0.250)*	Yes *(0.000)*	*(0.538)*
Local returns ➔ net purchases	Yes *(0.000)*	Yes *(0.004)*	Yes *(0.000)*	Yes *(0.000)*	Yes *(0.000)*	Yes *0.000)*
Net purchase ➔ local returns	Yes *(0.017)*	*(0.109)*	*(0.100)*	*(0.084)*	Yes *(0.002)*	*(0.622)*
Net purchases ➔ currency returns	Yes *(0.000)*	*(0.712)*	Yes *(0.027)*	*(0.186)*	Yes *(0.000)*	Yes *(0.000)*
Currency returns ➔ net purchases	Yes *(0.000)*	*(0.954)*	Yes *(0.002)*	*(0.313)*	*(0.377)*	*(0.381)*
Local returns ➔ currency returns	Yes *(0.000)*	Yes *(0.000)*	Yes *(0.031)*	Yes *(0.000)*	Yes *(0.000)*	Yes *(0.000)*
Currency returns ➔ local returns	*(0.642)*	*(0.083)*	*(0.578)*	*(0.166)*	*(0.314)*	*(0.193)*

X ➔Y denotes "X Granger-causes Y" or, more formally, the rejection of the null hypothesis "X does not Granger-cause Y", assuming a 0.05 p-value threshold.

Table 6

Two-variable VAR: summary of results (first lags only)

	IN	ID	KR	PH	TW	TH
Net purchases equation						
t-1 net purchases	**		**		**	**
t-1 total returns	**	**	**	**	**	**
Total returns equation						
t-1 net purchases	**		**		**	
t-1 total returns	**	**		**		

* and ** represent positive coefficients that are significant at the 5% and 1% levels, respectively. (*) and (**) indicate negative coefficients that are statistically significant.

Table 7

Three-variable VAR: summary of results (first lags only)

	IN	ID	KR	PH	TW	TH
Net purchases equation						
t-1 net purchases	**		**		**	**
t-1 market returns	**	**	**	**	**	**
t-1 currency returns	**					
Market returns equation						
t-1 net purchases	*		**		**	
t-1 market returns	**	**		**		
t-1 currency returns						
Currency returns equation						
t-1 net purchases	**		*		**	
t-1 market returns	**	**	*	**	*	**
t-1 currency returns	(**)	(*)		(*)	(**)	

* and ** represent positive coefficients that are significant at the 5% and 1% levels, respectively. (*) and (**) indicate negative coefficients that are statistically significant.

Table 8

Cross-market correlations: local market returns and net equity flows

1 January 1999 to 29 December 2006

N = 1599		India	Indonesia	Korea	Philippines	Taiwan
Indonesia	Returns	0.2357**				
	Flows	0.0479				
Korea	Returns	0.2948**	0.2564**			
	Flows	0.1379**	0.0471			
Philippines	Returns	0.1327**	0.2329**	0.2261**		
	Flows	0.0218	-0.0305	0.0541*		
Taiwan	Returns	0.2304**	0.1714**	0.3902**	0.1656**	
	Flows	0.1593**	0.0113	0.3616**	0.0400	
Thailand	Returns	0.2113**	0.2639**	0.3148**	0.2099**	0.2410**
	Flows	0.1143**	0.0113	0.2319**	0.1015**	0.2646**

* and ** denote significance at the 5% and 1% level, respectively.

Table 9

Frequency of same-direction net flows simultaneously in X markets

1 January 1999 to 29 December 2006

	Number of days with simultaneous net inflows	Number of days with simultaneous net outflows	
In at least 3 markets	1,168	755	
In at least 4 markets	844	431	
In at least 5 markets	479	189	
In all 6 markets	129	54	

Table 10a

Joint probabilities of inflows

***N* = 1599**		**Indonesia**	**Korea**	**Philippines**	**Taiwan**	**Thailand**
India	Theoretical	0.4352	0.3486	0.3579	0.4306	0.3176
	Actual	0.4522	0.3784	0.3934	0.459	0.3352
	Difference	*-0.0170*	*-0.0298*	*-0.0355*	*-0.0284*	*-0.0176*
Indonesia	Theoretical		0.3363	0.3452	0.4153	0.3063
	Actual		0.364	0.3759	0.4447	0.3396
	Difference		*-0.0277*	*-0.0307*	*-0.0294*	*-0.0333*
Korea	Theoretical			0.2766	0.3327	0.2454
	Actual			0.2971	0.4059	0.2714
	Difference			*-0.0205*	*-0.0732*	*-0.026*
Philippines	Theoretical				0.3416	0.2519
	Actual				0.369	0.2964
	Difference				*-0.0274*	*-0.0445*
Taiwan	Theoretical					0.3031
	Actual					0.3452
	Difference					*-0.0421*

Note: The theoretical joint probability is the product of the marginal probabilities (assumption of independence).

Table 10b

Joint probabilities of outflows

***N* = 1599**		**Indonesia**	**Korea**	**Philippines**	**Taiwan**	**Thailand**
India	Theoretical	0.1152	0.1579	0.1534	0.1179	0.1731
	Actual	0.1313	0.1876	0.1889	0.1463	0.1907
	Difference	*-0.0161*	*-0.0297*	*-0.0355*	*-0.0284*	*-0.0176*
Indonesia	Theoretical		0.1687	0.1639	0.1259	0.1850
	Actual		0.1957	0.1939	0.1551	0.2176
	Difference		*-0.0270*	*-0.0300*	*-0.0292*	*-0.0326*
Korea	Theoretical			0.2247	0.1726	0.2535
	Actual			0.2452	0.2458	0.2795
	Difference			*-0.0205*	*-0.0732*	*-0.0260*
Philippines	Theoretical				0.1677	0.2463
	Actual				0.1951	0.2908
	Difference				*-0.0274*	*-0.0445*
Taiwan	Theoretical					0.1893
	Actual					0.2314
	Difference					*-0.0421*

Note: The theoretical joint probability is the product of the marginal probabilities (assumption of independence).

Technical appendix

Granger causality test

In order to carry out the Granger causality tests, we run bi-variate regressions of the form

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + ... + \alpha_l y_{t-l} + \beta_1 x_{t-1} + ... + \beta_l x_{t-l} + e_t$$

$$x_t = \alpha_0 + \alpha_1 x_{t-1} + ... + \alpha_l x_{t-l} + \beta_1 y_{t-1} + ... + \beta_l y_{t-l} + u_t$$

for various pairs of variables. For each regression, we test the joint hypothesis of

$$\beta_1 = \beta_2 = ... = \beta_l = 0$$

For a given pair of variables x and y, the first regression's null hypothesis is that "x does not Granger-cause y". In the second regression, the null hypothesis is that "y does not granger cause x". The null hypothesis is rejected if the F statistic is greater than a specific critical value.

Since the logic of this test is couched in terms of the relevance of all past information, it is in general better to use more rather than fewer lags. One should pick a lag length that corresponds to reasonable beliefs about the longest time over which one of the variables could help predict the other.

Vector autoregression analysis

The vector autoregression (VAR) is applied for forecasting systems of interrelated time series and for analyzing the dynamic impact of random disturbances on the system of variables. The VAR approach sidesteps the need for structural modelling by treating every endogenous variable in the system as a function of other endogenous variables and the lagged values of all of the endogenous variables in the system.

For example, a simple bivariate system

$$y_t = b_{10} - b_{12} z_t + \gamma_{11} y_{t-1} + \gamma_{12} z_{t-1} + \varepsilon_{yt}$$

$$z_t = b_{20} - b_{21} y_t + \gamma_{21} y_{t-1} + \gamma_{22} z_{t-1} + \varepsilon_{zt}$$

can be rewritten in matrix form as

$$\begin{bmatrix} 1 & b_{12} \\ b_{21} & 1 \end{bmatrix} \begin{bmatrix} y_t \\ z_t \end{bmatrix} = \begin{bmatrix} b_{10} \\ b_{20} \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix} \begin{bmatrix} y_{t-1} \\ z_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{yt} \\ \varepsilon_{zt} \end{bmatrix}$$

or

$$A_0 Y_t = C + A_1 Y_{t-1} + \varepsilon_t$$

where $A_0 = \begin{bmatrix} 1 & b_{12} \\ b_{21} & 1 \end{bmatrix}$, $Y_t = \begin{bmatrix} y_t \\ z_t \end{bmatrix}$, $C = \begin{bmatrix} b_{10} \\ b_{20} \end{bmatrix}$, $A_1 = \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix}$, $\varepsilon_t = \begin{bmatrix} \varepsilon_{yt} \\ \varepsilon_{zt} \end{bmatrix}$

For estimation purpose, the system can be transformed into a reduced form representation, by pre-multiplying by the inverse of the A_0 matrix:

$$Y_t = k + B_1 Y_{t-1} + e_t$$

Where $k = A_0^{-1} C$, $B_1 = A_0^{-1} A_1$ and $e_t = A_0^{-1} \varepsilon_t$.

Since only lagged values of the endogenous variables appear on the right-hand side of the equations, simultaneity is not an issue and OLS yields consistent estimates. Moreover, even

though the innovations may be contemporaneously correlated, OLS is efficient and equivalent to GLS since all equations have identical regressors.

To assess the response of one variable in Y_t to the *structural* innovations (ε) of the other variables, the reduced-form VAR system (shown here in a general form, with optimal lag length *L*)

$$Y_t = k + B_1 Y_{t-1} + ... + B_L Y_{t-L} + e_t$$

can be rewritten in its moving average representation (MAR).

$$Y_t = \mu + B(L)^{-1} e_t$$

where $B(L) = (1 - B_1 - ... - B_L)$ and $\mu = kB(L)^{-1}$

$$Y_t = \mu + e_t + R_1 e_{t-1} + R_2 e_{t-2} + R_3 e_{t-3} + ...$$

The (*i*,*j*) component of the coefficient matrix R_s represents the response of variable *i* in s days to a one-time impulse in variable *j*, with all other variables at the time of the impulse or earlier held constant. But in the general case where the different elements of the *e* vector can be contemporaneously correlated, both the coefficient matrix *R* and the variance-covariance matrix $\sum_e = E(e_t e_t^{'})$ would be required to calculate the response. Moreover, we know that $e_t = A_0^{-1} \varepsilon_t$. That means if we can identify A_0, then we can relate the structural shocks (not estimatable) to the reduced-form errors (estimatable) and, in turn, to the variables in Y_t.

We use here the standard recursive identification scheme, assuming that A_0 has a lower-triangular structure, with 1s along the diagonal. Under this assumption, A_0 can be derived by the Cholesky Decomposition of the reduced-form variance-covariance matrix, Σ_e. The transpose of the decomposition matrix yields the inverse of A_0 times the square root of the diagonal structural error matrix where A_0 can be solved, given some assumption about Σ_ε.

$$Chol(\sum_e)' = A_0^{-1} \Sigma_\varepsilon^{1/2}$$