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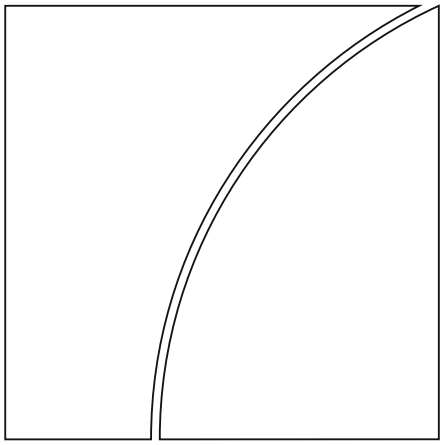

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by Chang Shu, Dong He, Jinyue Dong and Honglin Wang

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Regional pull vs global push factors: China and US influence on Asia-Pacific financial markets[1]

Chang Shu, Dong He, Jinyue Dong and Honglin Wang[2]

Abstract

This paper compares spillovers from the US and Chinese financial markets to the rest of Asia-Pacific. Structural VAR analysis points to the growing influence of Chinese equities and currency movements. In normal times China's influence in the equity market has risen to a level close to that of the United States, although the relative impact of the United States became stronger in crisis periods. Nonetheless, China's bond market remains a negligible player. The influence of China may be interpreted as a "regional pull" factor, while that of the United States remains a key "global push" factor.

Keywords: China's impact, spillovers to Asian financial markets, US, structural VAR, sign restrictions.

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Introduction

Large international capital flows have brought about growing financial market integration across the world and, with it, greater financial market spillovers across countries. Such flows, driven by international investors' need for diversification and enabled by the increasing opening-up of individual countries, have made any geographical division of markets increasingly irrelevant. In this environment, fluctuations in one economy's financial markets can arise from external factors as much as, if not more than, from domestic factors.

Understanding drivers of such spillovers is important from the perspective of investors and policymakers alike. Investors, largely based in advanced economies, need to assess the gains from an internationally diversified portfolio. To the extent that individual markets are driven by common, external factors in global markets, the gain from diversification is diminished. From the policymakers' point of view, market volatility has implications for financial stability, and thus better understanding of the drivers of financial market volatility and international spillovers is conducive to the better design of policies intended to address financial stability issues.

One recent development in international financial market spillovers is the increasing influence of major emerging market economies, most notably China. Chinese financial markets have been making the headlines frequently over the past few years: "China's 'Black Monday' sends markets reeling across the globe", "World markets plunge as China stocks crash", "Stock collapse in China sparks world markets sell-off" and so on. Such global prominence used to be ascribed mostly to the US markets. The financial crisis of 2007–09 and the market volatility during the 2013 "taper tantrum" are a reminder of how strong the US influence is. However, increasingly, market moves in China have been causing shock waves in Asia and beyond. In the summer of 2015 and at the beginning of 2016, the extremely high world market volatility triggered by events in China brought China's impact on the world's financial markets sharply to the fore.

Assessing the influence of Chinese financial markets is particularly critical for Asia. The economic success of Asian economies and their growing importance in global financial markets have attracted a large fraction of international capital flows to this region, and China is a crucial part of the attraction. China's rising influence in Asian markets reflects its strong trade ties and growing financial linkages in the region. Such linkages have always been strong between the United States and Asia. In the last two decades, however, economic and financial linkages within Asia have strengthened significantly. China is playing an important role in this evolution: it has become the second largest economy in the world; and it is a key player in intraregional trade.

These developments naturally raise the question of how the US and Chinese impact compares in Asian financial markets: how big and how fast are the spillovers from the United States and China to Asia-Pacific? How does the external influence compare with domestic influence? Does the US and Chinese influence vary in different financial markets, ie bond, equity and currency markets? How has the influence from the US and Chinese markets evolved over time? Do they differ in times of stress and in more tranquil times?

These questions have been the object of very little formal study. The US influence on global financial markets has been well documented;[3] and China's real economy linkages to the rest of the world have been extensively studied and better understood.[4] Yet China's impact on the financial markets remains largely in the form of eye-catching news stories, and formal studies are only beginning to emerge.

This study aims to investigate spillovers from the United States and China to regional financial markets. A structural vector autoregression (SVAR) model is used in the empirical work to address the questions raised above. This model includes the financial transmission between different markets (stock, bond and foreign exchange markets) and among different country blocks (the United States, China and other Asian economies). For identification of the SVAR, we follow the sign restriction approach for its flexibility in allowing two-way contemporaneous interactions, rather than the traditional recursive scheme.

The study yields a number of important insights. First, the analysis confirms that the drivers for Asian financial markets have changed. China's stock markets and exchange rates have significant spillovers to Asia and the spillovers have gathered strength in recent years, pointing to a significant role of China as a "regional pull" factor. Second, the US markets remain a significant driving force across all asset classes in Asia, including stocks, bonds and currencies. Their influence is particularly dominant during periods of market stress. Third, the benefits of international diversification gained from investment in Asia might have diminished, as considerable fractions of its market movements are now driven by external factors.

Formally establishing China's impact on Asian financial markets enriches the discussions on drivers of international capital flows and market fluctuations.[5] The debate is traditionally set up as to whether "push" factors – factors related to developments in advanced economies, notably the United States – or "pull" factors – factors that are specific to the recipient countries – are key drivers of flows. Our findings confirm that the United States is an important global "push" factor in that its monetary and macroeconomic developments, reflected as shocks to its financial markets, affect financial markets elsewhere; in the meantime, "pull" factors are also playing a role, more so in some markets than in others. Yet there appears to be influence from a third factor – a regional "pull" factor represented by China: its developments can affect investors' assessments of the region's economic fundamentals, and lead to fluctuations in capital flows and financial markets.

The interaction of the "regional pull" factor represented by China and the "global push" factor represented by the United States may change the dynamism of capital flows to the region. Conceivably, the Chinese influence could provide some degree of a counterfactor to capital movements if the US and China markets move in opposite directions. This can help moderate the intensity of capital movements to the region.

Yet the China factor seems to have moved in the same direction as the US factor in some key moments in the last few years, and thus acted to accentuate "risk-on,

[3] See, for example, Arshanapalli and Doukas (1993), Ehrmann et al (2011) and Dimpfl and Jung (2012) for spillovers from the US financial markets to other mature markets, and Yang et al (2003) and Nam et al (2008) for spillovers to emerging economies.

[4] See, for example, the IMF's spillover report for China (2011).

[5] The literature is huge. See Fratzscher (2012) for a recent example.

risk-off" flows to emerging economies. The strong performance of Chinese equities following the announcement of the massive economic stimulus package in China in 2008 coincided with the first round of US quantitative easing. The confluence of the events set in train the strong multi-year capital flows to Asia. The reverse occurred in mid-2013 in the "taper tantrum" episode. While the period of heightened market volatility was triggered by speculation over an earlier than expected US tapering, concerns over China's growth prospects are also likely to have contributed. Such herding behaviour may arise mostly from investors based in advanced economies. They might subscribe to a dominant view regarding the global and Asian conditions and associated investment strategies; they can have common funding sources. These factors could drive them in and out of certain markets at the same time.

Such developments are not desirable from the point of view of both investors and policymakers. For investors, the gain from international diversification is considerably reduced when Asian financial markets are driven to a large extent by external factors, predominantly from the United States and China. Further, their collective behaviour often leads to the "global push" and "regional pull" factors working in the same way for Asia, which reduces the diversification gain even more. In the meantime, the "risk-on, risk-off" flows, aggravated by the same directional moves of the "global push" and "regional pull" factors, will undermine macroeconomic and financial stability, and pose severe challenges to policymakers.

Looking forward, cross financial holdings in Asia could rise. Lane and Milesi-Ferretti (2008a) find that the cross-border holdings of financial assets grow with rising income and financial developments, and relaxation in capital outflows is associated with greater overseas investment by private sector entities across different investment categories. These could help cultivate the growth of private sector institutional investors in Asia. Under the influence of gravity factors, increased cross-border flows may be regionally focused (Lane and Schmukler (2007), Lane and Milesi-Ferretti (2008b), Park (2013), Park and Mercado (2013)). Intraregional financial flows may be further promoted by internationalisation of major regional currencies, especially that of the renminbi.

Increases in intraregional holdings may help to reduce capital flow volatility by dampening the relative importance of influence from the United States while raising that of regional factors. Asian investors, particularly institutional investors, could be more greatly influenced by regional economic and financial factors, as well as have views different from those of investors from advanced economies on global and regional developments. Thus it may constitute a useful counterforce for "risk-on, risk-off" flows driven predominately by investors based in advanced economies at present.

The rest of paper is structured as follows. Section 2 reviews the literature on international financial market spillovers. Section 3 discusses the transmission channels of US and Chinese shocks to financial markets in Asia-Pacific. Section 4 introduces the empirical framework and data, with a focus on the sign restriction approach for identifying the SVAR used in this study. The estimation results are reported in Section 5. The final section summarises the major findings.

Literature review

A large strand of literature on international financial market spillovers tends to focus on individual asset classes, mostly on equity markets.[6] Different angles of international transmission have been studied. Some examine return spillovers, eg Eun and Shim (1989), and others volatility spillovers, eg Hamao, Masulis and Ng (1991). Earlier studies tend to look at two or three stock exchanges at a time, eg King and Wadhwani (1990) on the interaction of New York, London and Tokyo stock exchanges, while later studies often expand to more stock exchanges, eg Diebold and Yilmaz (2009) uncovering different patterns of return and volatility spillovers across 19 stock markets across the world. Drivers of spillovers have been investigated, including real and financial linkages, market factors as well as relative importance of these factors (eg. Kaminsky and Schmukler (1999); Connolly and Wang (2003)). Market contagion – an intense form of spillovers – has been documented for previous financial crises, (eg. Calvo and Reinhart (1996) on the Mexican crisis; Baig and Goldfajn (1998) on the Asian crisis) and the global financial crisis in 2008-2009 (Cheung, Fung and Tsai (2010)).[7]

Spillovers in other asset classes are less studied. Borio and McCauley (1996) undertake an earlier study on bond market interaction among a number of advanced economies. Work by Felices, Griss and Yang (2009) quantifies the co-movements between the US government bond yields, US high-yield bond spreads and emerging market bond spreads following the outbreak of the global financial crisis. Research by Engle, Ito and Lin (1990) is among the better known earlier studies on the FX market. Fratzscher (2009) investigates the global transmission of US shocks to FX markets for a broad set of advanced and emerging market economies.

Even fewer studies have investigated several markets simultaneously. Hartmann, Straetmans and de Vries (2004) study shock propagation mechanism between stock and bond markets during crisis periods for a number of advanced economies. To address the question whether gold can be a safe haven asset, Baur and Lucey (2010) examine the relationships between gold returns and US, UK and German stock and bond returns.

Interest on spillovers from major financial markets to emerging markets (including Asia) has been rising. Earlier studies examined transmission among equity markets, eg Eun and Shim (1989), Koch and Koch (1991), Ng (2000) and Cohen and Remonlona (2008). Research has been done for different asset classes in more recent years. The IMF (2009) compiled financial stress indices based on stock, bond and FX market indicators, and studied the transmission of financial stress from advanced to emerging economies. The impact of developed markets on Asia has also been studied in the context of transmission of the US unconventional monetary policy in the last few years, eg Chen, Filardo, He and Zhu (2015) and Tillmann (2014).

China's influence in the financial markets is beginning to receive recognition. A number of studies point to the rising impact of the renminbi on regional currencies, eg Shu, Chow and Chan (2007), Fratzcher and Mehl (2011), Henning (2012) and Subramanian and Kessler (2012). Shu, He and Cheng (2015) further suggest that the offshore renminbi exchange rate can influence Asian currencies in addition to the

[6] See Gagnon and Karolyi (2006) for a comprehensive review.

[7] See Dorbusche, Classens and Park (2001) for reviews.

onshore rate. Limited studies have been done for other asset classes for Asia in general. He, Zhang and Wang (2009) compare the influence of US and Chinese financial markets on Hong Kong, including the stock, bond and FX markets. They conclude that Hong Kong's financial markets are more aligned with the US markets in turbulent times, but more integrated with the Chinese markets during the tranquil periods. From a slightly different angle, Baum, Kurov and Wolfe (2015) investigate how China's macroeconomic news impact global stock, currency and commodities markets. More research is underway in the light of significant turbulence in the world markets triggered by volatility in Chinese markets in the summer of 2015 and January 2016.

This paper is in the spirit of Ehrmann, Fratzshcer and Rigobon (2011), but expands it. Ehrmann, Fratzshcer and Rigobon (2011) use SVAR models to study financial transmission within and between the United States and euro area. Emphasising the importance of modelling different markets simultaneously, the study covers a number of markets (including the money, bond, equity and FX markets), and examines spillovers both within and across asset classes. This paper follows this approach, but focuses on international transmission. The modelling is complex: three country/region blocks, ie the United States, China and the Asian block, are included in the models; there are interactions between markets in the three blocks.

How do China and the US influence Asian financial markets

Financial market spillovers across countries occur when shocks in one market trigger re-assessment of economic and financial fundamentals of another market or a change in risk appetite, resulting in re-pricing in a second market.

Such shock transmission may arise from direct and indirect trade linkages between the economies. For example, stock prices of exporting firms will be affected by the news on economic growth of the export destination market. A devaluation of a country's currency will make that country's exports more competitive, and thus trigger exchange rate adjustment in both competitor countries and partner countries in the same production chain.

Financial linkages also play an important role. Interest rate movements in a major economy will change financial conditions in the home economy, thus affecting capital flows to other economies. The resultant changes in monetary conditions in these economies can lead to an adjustment in their bond yields. The presence of common investors in two countries can be sufficient to generate spillovers even in the absence of real-economy linkages. For example, investors may re-assess fundamentals of a whole region in response to weakness in one country, an effect referred to as the wake-up call that could transmit shocks in the presence of common investors. Herding by international investors may lead to the propagation of shocks beyond that is warranted by fundamentals.

US and China's linkages with Asia

China's linkages with the rest of Asia have started to catch up with those between Asia and the United States. The linkages are strong on the trade side, and developing on the financial side.

The United States have long been an important destination for Asian exports. Of the USD 2.8 trillion of US imports in 2014, close to one third came from Asia. Exports to the United States account for a significant part of total Asian exports. China's close trade ties with Asia reflect the country's role both as a partner in production and as a destination of Asian exports. China has grown into the largest trading nation in the world in the last three decades, accounting for 11% of global trade. A large fraction of its trade is with other Asian economies. With China being a hub of the Asian production chain, substantial trade takes place between China and regional economies in the production process. China also increasingly generates final demand for Asian exports. At end-2013, exports to China accounted for around one fifth of total trade for major economies in the region.[8]

International investment position

End-2013[1], as a percentage of GDP Table 1

	PI Asset	PI Liability	PI Total	FDI Asset	FDI Liability	FDI Total
China	3	4	7	7	26	32
IFCs						
Hong Kong SAR	408	190	598	493	527	1,020
Singapore	295	59	354	169	284	453
Selected Asian Economies						
Indonesia	2	20	22	1	24	26
Korea	13	47	60	17	13	30
Malaysia	20	63	83	48	51	100
Philippines	4	29	32	4	11	15
Thailand	8	36	44	15	51	66
Advanced Economies						
United States	55	92	147	42	34	77
United Kingdom	161	159	321	74	63	137
Germany	85	97	182	54	38	92

[1] End-2012 figures for Indonesia, the Philippines and Thailand.

Sources: IMF, Balance of Payments Statistics and World Economic Outlook, Balance of payment; CEIC; authors' calculations.

China's direct financial linkages with Asian-Pacific economies have been growing rapidly, but remain modest particularly when compared to the United States. Cross border financial flows are more limited compared to international trade flows given the largely effective, albeit leaky, capital controls (Ma and McCauley, 2007). A comparison of the international investment positions of China and the United States illustrates the big gap in the two economies' global financial linkages (Table 1). China's liability in foreign direct investment as a percent of GDP is close to that of the United States, as inward foreign direct investment inflows is the earliest liberalised category under capital account. Yet, China has little relation with the rest of the world in other types of financial transactions, reflecting much tighter controls in these capital account categories. Measured against GDP, China's foreign direct investment assets, assets and liabilities in portfolio investment are not only much smaller than

[8] The average for Australia, Hong Kong, India, Indonesia, Korea, Malaysia, New Zealand, the Philippines, Singapore and Thailand.

advanced economies, but also below the levels of other emerging Asian economies in many cases.

Channels of impacts from the US to Asian markets

The US impact on Asian markets derives from its extensive economic and financial linkages with Asia-Pacific as well as the importance of the US dollar as a funding currency. The impact can come through the interest rate, risk taking, portfolio rebalancing and sentiment channels.

A fall in US treasury yields, for example, lowers US dollar funding costs. Given the dollar's dominant position as a funding currency, this will lead to a loosening of global liquidity conditions, a powerful channel of international spillovers (McCauley, McGuire and Sushko (2015)). In addition, investors' risk appetite may rise and global banks may leverage up when costs are low for risk taking. The risk-taking channel then amplifies the initial impact of the interest rate channel (Bruno and Shin (2014, 2015)). Plentiful liquidity, combined with higher risk appetite, can induce capital flows to financial markets in other economies, including Asia, pushing up stock and bond prices. The situation reverses when the dollar cost rises (McCauley (2012)).

Declines in treasury yields can lower yields in other markets through the portfolio re-balancing channel. Investors in the US bond market, when facing a sudden decline in yields, may seek to achieve target yields by switching to invest in other bond markets. Asian economies, with their generally strong fundamentals and higher bond yields, have been large recipients of such search-for-yield bond flows, which lead to compressed yields in local currency bond markets. There is evidence that since 2005 bond yields in other economies have moved more closely with US yields (Miyajima, Mohanty and Chan (2012) and Turner (2013)).

There could be policy spillovers too. Hofmann and Takats (2015) show that policy spillovers can be a factor making financial conditions less independent in economies that are closely integrated into the global economy and global financial markets. When a centre country loosens monetary policy, other countries may have to follow suit for fear of appreciation pressures from larger interest rate differentials with the centre country.

International spillovers through the channels discussed above are associated with cross-border capital flows. These flows can affect currency movements in Asia. Large capital flows put intense appreciation pressures on the currencies, while sudden outflows could lead to a plunge in these economies' exchange rates.

Asian markets can also be affected by changes in sentiment in the US markets. Higher US equity prices, reflecting expectations for higher growth for example, might lead domestic investors in Asia to expect that higher global demand will lead to a pick-up in economic growth in the home country. The boost in sentiment can push up equity prices in Asian stock markets. Such boosts to the market can occur even in the absence of cross-border capital flows.

Channels of impacts from China to Asian markets

China's more limited financial linkages with other Asia-Pacific economies imply that some transmission channels may be weaker, while some additional factors might be at play.

The interest rate channel may play a limited role. Changes in liquidity conditions in China due to changes in monetary policy may not affect significantly overseas liquidity as the renminbi is not yet a widely used international funding currency.

Portfolio re-balancing is one channel to transmit shocks. Given the importance of the Chinese economy, an improvement in China's prospects could lead to upward revisions of the region's outlook. This will increase the attractiveness of Asian assets relative to other regions and increase the risk appetite of international investors, thus bringing capital inflows into the region. In addition, Asian markets with better access for foreign investors could receive more funds, as their assets may be used as proxies for getting exposure to renminbi assets and having more flexible investment positioning. In the case of a negative shock, Asia could see capital outflows, particularly from those 'China play' assets.

The sentiment channel can also be significant. China's significance for growth in the region means that China's macroeconomic, financial and policy developments can affect regional economies. Thus, to the extent that market movements in China reflect changes in assessment of Chinese economy and policy, there could be sentiment spillovers to other markets in the region. Thus, a positive shock to Chinese markets may boost confidence in domestic investors in other Asian countries, leading to price co-movement with China even in the absence of any cross-border flows.

Interaction between the US and Chinese market impact

The channels of influence from the United States and China can interact with each other. Monetary policy in advanced economies, particularly the United States, is a central driver of global liquidity – a set of global factors associated with credit availability and risk premium (Bekaert et al., (2012), Rey (2015)). As discussed above, these factors can drive the direction and magnitudes of capital flows to emerging markets, and affect financial market developments and credit growth in those economies (BIS (2011), He and McCauley (2013)). Global banking and the bond market can be the mechanisms of propagating global liquidity (Bruno and Shin (2014, 2015), Shin (2013)). As such, developments in the United States can be a key 'global push' factor for Asian financial markets.

On the other hand, China can represent an important 'regional pull' factor in that macroeconomic and financial market developments in China can also lead investors to re-assess the region's economic outlook and thus change risk appetite towards investment in Asia. This may counteract or reinforce the impact of global conditions emanating from advanced economies. For example, positive developments in China will further compress risk premium, pulling in more search-for-yields flows from advanced economies to Asia.

The relative importance of the US and Chinese impact may differ in crisis and non-crisis time. While there has been an uptrend in international capital flows to Asia in recent years, these flows have also been volatile and strongly correlate with risk appetite (Lane (2013)). The volatile nature of capital flows can be related to an important asymmetry in international investment positions in the case of Asia. Many Asian economies' foreign assets are dominated by the official sector's investment in advanced economies' government bonds. The foreign liabilities side tends to be foreign direct and portfolio investment held by the private sector. Portfolio investment in Asia is often made by institutional investors based in advanced economies who can buy and sell on a hair trigger (McCauley, 2012), contributing to

'risk-on, risk-off' flows. As the US dollar is the dominant funding currency and reserve currency, developments in the US financial markets at times of market stress will have a particularly strong influence globally, overriding that of regional and domestic factors.

Empirical methodology and data

To study the the complex interaction among the US, Chinese and Asian financial markets, we assume a behavioural model of the following structural form:

$$\mathbf{A}\mathbf{y}_t = \Pi(L)\mathbf{y}_t + \mathbf{e}_t, \quad (1)$$

where $\mathbf{A}$ is the matrix of structural parameters capturing the contemporaneous effects, and:

$$\mathbf{y}_t = \begin{pmatrix} US\_bond_t \\ US\_stock_t \\ China\_bond_t \\ China\_stock_t \\ RMB_t \\ Asian\_bond_t \\ Asian\_stock_t \\ Asian\_currency_t \end{pmatrix}.$$

In the model, there are three country/region blocks with eight endogenous asset prices – the United States, China and Asia. Each block contains the long term bond yield (*US_bond*$_t$, *China_bond*$_t$ and *Asia_bond*$_t$) and stock price (*US_stock*$_t$, *China_stock*$_t$ and *Asia_stock*$_t$). In addition, both the China and Asia blocks include the exchange rate variable (*RMB*$_t$ and *Asia_currency*$_t$). $\Pi(L)$ captures the lagged effects of the endogenous variable $\mathbf{y}_t$. In the model, $\mathbf{e}_t$ is the 8×1 vector of normalised and orthogonalised disturbances of the structural form, and:

$\mathbf{e}_t \sim N(\mathbf{0}, \mathbf{I}_K)$ and $E[\mathbf{e}_t\mathbf{e}_s'] = \mathbf{0}_K$ (for all $s \neq t$, where s and t indicates time).

We will discuss later in detail the interpretation of the structural errors.

The starting point to uncover the structural relationship is to estimate a reduced form of Equation (1) via ordinary least squares:

$$\mathbf{y}_t = \mathbf{B}(\mathbf{L})\mathbf{y}_t + \boldsymbol{\varepsilon}_t, \quad (2)$$

where, $\mathbf{B}(\mathbf{L})$ is the reduced-form parameter matrix capturing the interaction of the endogenous variables with their own lags and lags of other variables in the system. Also, $\boldsymbol{\varepsilon}_t$ is the 8×1 vector of innovations of the reduced form in Equation (2), and:

$\boldsymbol{\varepsilon}_t \sim N(\mathbf{0}, \boldsymbol{\Sigma})$ and $E[\boldsymbol{\varepsilon}_t\boldsymbol{\varepsilon}_s'] = \mathbf{0}_K$ (for all $s \neq t$, where s and t indicate time).

The error term from the reduced form $\boldsymbol{\varepsilon}_t$ permits the correlation among errors of endogenous variables, while the error term from the structural form $\mathbf{e}_t$ does not. That is, innovations in the individual SVAR equations need to be independent of each other.

Identification by sign restrictions

After re-arranging, Equation (1) becomes :

$$\mathbf{y}_t = \mathbf{A}^{-1}\Pi(L)\mathbf{y}_t + \mathbf{A}^{-1}e_t \,. \tag{1a}$$

Thus, the relationship between the reduced-form VAR and SVAR is given as:

$$\mathbf{A^{-1}e_t} = \boldsymbol{\varepsilon}_\mathbf{t} \,. \tag{3}$$

That is, structural shocks can be written as a linear combination of reduced-form shocks. Establishing the link between the reduced form and structural shocks, referred to as identification, allows us to analyse the dynamics of the system in terms of a change to a structural shock. There are many identification schemes used for establishing the relationship between the reduced form and structural shocks in a SVAR. The traditional Cholesky method relies on a recursive scheme which transforms $\mathbf{A}$ into a lower triangular matrix. This dictates that the variables that enter the system later do not have contemporaneous effects on those that enter earlier. Other parametric identification schemes have been developed, such as those relying on long-run effects (Blanchard and Quah, 1989), and short-run restrictions (Gali, 1992). These are useful when specific assumptions are made to impose parameter values on certain elements of $\mathbf{A}$.

This study employs sign restrictions to identify the SVAR. This is a non-parametric method which allows flexibility in that it permits pairwise interaction among all variables in contemporaneous terms. That is, unlike the recursive scheme, it is possible for each pair of variables to affect each other in the current period, instead of assuming that causation only runs in one direction in the current period and two-way interaction only occurring in subsequent periods. Identification is achieved by imposing assumptions on the relationship between some pairs of variables. After the introduction by Faust (1998), it has been further developed by Canova and De Nicolo (2002), Uhlig (2005) and Hau and Rey (2004). There have been many recent applications of this approach. Fry and Pagan (2011) and Baumerster and Hamilton (2015) provide critical reviews of this approach.

Structural shocks, shock transmission and signs for identification

In applying sign restrictions for identification in this study, signs need to be imposed on the $\mathbf{A}^{-1}$ matrix. Let us write:

$$A^{-1} = \begin{pmatrix} 1 & \alpha_{12} & \beta_{13} & \beta_{14} & \beta_{15} & \beta_{16} & \beta_{17} & \beta_{18} \\ \alpha_{21} & 1 & \beta_{23} & \beta_{24} & \beta_{25} & \beta_{26} & \beta_{27} & \beta_{28} \\ \beta_{31} & \beta_{32} & 1 & \alpha_{34} & \alpha_{35} & \beta_{36} & \beta_{37} & \beta_{38} \\ \beta_{41} & \beta_{42} & \alpha_{43} & 1 & \alpha_{45} & \beta_{46} & \beta_{47} & \beta_{48} \\ \beta_{51} & \beta_{52} & \alpha_{53} & \alpha_{54} & 1 & \beta_{56} & \beta_{57} & \beta_{58} \\ \beta_{61} & \beta_{62} & \beta_{63} & \beta_{64} & \beta_{65} & 1 & \alpha_{67} & \alpha_{68} \\ \beta_{71} & \beta_{72} & \beta_{73} & \beta_{74} & \beta_{75} & \alpha_{76} & 1 & \alpha_{78} \\ \beta_{81} & \beta_{82} & \beta_{83} & \beta_{84} & \beta_{85} & \alpha_{86} & \alpha_{87} & 1 \end{pmatrix}.$$

In order to distinguish the domestic and international spillovers in $\mathbf{A}^{-1}$, α_{ij} and β_{ij} represent the domestic and international impact of the structural shock i on variable j respectively.

The interpretation of the structural shocks and their transmissions internationally have implications for imposing signs in $\mathbf{A}^{-1}$. These will be discussed in turn.

In the model, the shock to the bond market in the individual economies can interpreted as a monetary shock. A fall in the bond yield corresponds to a loosening of monetary conditions in that economy. Such a shock may arise due to revisions in expected interest rates (ie. the expectation component of the long-term yield) as a result of actual policy action or perceived shifts in policy stance, or to changes in risk premium (ie. the term premium component of the long-term yield).[9] The error term in the stock market can be viewed as a shock to the real economy. A positive shock to the real economy would raise equity prices in the individual economies.

Exchange rate movements can be understood as reflecting changes in the relative demand across two economies (Ehrmann, Fratzshcer and Rigobon (2011)). Appreciation of the home currency vis-à-vis the US dollar would reflect a positive shock to demand for the economy relative to demand for the US economy. In China's case, exogenous policy shocks regarding the exchange rate can drive renminbi movements. The policy changes are often recognition of shifts in relative demand for China, which are present, yet unrealised in a regime with limited exchange rate flexibility. In July 2005, the People's Bank of China re-valued the renminbi by 2.1% in conjunction with a shift to a floating exchange rate regime, in recognition of intense appreciation pressures. More recently, the central bank guided the renminbi lower in a few consecutive trading sessions in August 2015 and January 2016 by setting a weaker exchange rate fixing, releasing some depreciation pressures on the currency.

Assumptions on spillovers between financial markets follow from the interpretations of the structural errors and discussions in the previous section on the transmissions between the US, Chinese and Asian markets. These will be used to impose on signs in matrix $\mathbf{A}^{-1}$ for identification of the SVAR. The key restrictions imposed for identification include 'cross-country, same-market' and 'cross-country, cross-market' spillovers.

'Cross-country, same-market' spillovers:

US bond impact on Asian bond: The US bond is expected to have positive spillovers to Asian bonds ($\beta_{1,6} > 0$). For example, a loosening of US monetary policy – reflected as a shock to the US bond yield – can induce capital flows to Asian bond markets with relatively open capital markets and push down bond yields, reflecting the effects of lower global funding costs and 'search-for-yield' effects (He and McCauley, 2013). The positive spillovers may also arise from policy spillovers: other countries may also loosen monetary policy for concerns that large interest rate differentials vis-à-vis the US dollar may lead to currency appreciation and speculative capital flows (Hofmann and Takats (2015)). The US bond market cannot directly affect the Chinese bond market which is closed to foreign investors.

US equity impact on Chinese and Asian equities: A positive real economy shock to the US economy – shown as a rise in US equity prices – is expected to raise external demand for the Chinese and Asian economies, thus also boosting their equities. $\left(\beta_{2,4} > 0, \beta_{2,7} > 0\right)$. Theoretical justifications for the positive international spillovers across equity markets across the world can be found in Pavlova and Rigobon (2007)

[9] See Hordahl and Tristani (2014) for a model decomposing the long-term bond yield.

who demonstrate that all stock markets move in the same direction in response to a supply shock in one country. These assumptions are also supported by substantial empirical evidence identifying the US stock market's leading role in global stock markets.

China's stock impact on US stocks: Positive spillovers from Chinese stocks to US stocks are assumed $\beta_{4,2} > 0$. For a largely domestic oriented economy such as the United States, a positive real economy shock in one foreign economy on its own may not constitute a significant boost to its total demand. Yet, with China's increasing contribution to world growth, a shock to its economy may reverberate across the global economy and thus have implications for the US economy. The influence of Chinese equities can also come through sentiment spillovers. The sign restriction approach permits two-way interaction between the US stock market and the Chinese stock market in contemporaneous terms. This differs from the recursive identification scheme which allows causation to run only from one market to another in the current period, and the impact of the second market on the first to only come through with lags.

China's stock impact on Asian stocks: With China's significant weight in Asia and its extensive trade linkages, its productivity shock could considerably affect total demand for Asian economies. This will likely lead investors to re-assess the region's economic outlook and induce fund flows to Asian stock markets from both domestic and foreign investors. Positive transmission from China's stocks to Asian stocks is thus assumed ($\beta_{4,7} > 0$).

Renminbi's impact on Asian currencies: In the same light, a rise in relative demand for the Chinese economy, reflected as renminbi appreciation vis-à-vis the US dollar, could also boost the relative demand for Asian economies. Thus, the renminbi would move Asian currencies in the same direction ($a_{5,8} > 0$). Pavlova and Rigobon (2007) provide a rationale for positive spillovers across exchange rates. Some earlier empirical evidence supports the renminbi's regional impact, eg Shu, Chow and Chan (2007), Fratzcher and Mehl (2011), Henning (2012) and Subramanian and Kessler (2012), and Shu, He and Cheng (2015).

'Cross-country, cross-market' spillovers

Spillovers from equities to currencies: Hau and Rey (2002 and 2004) show that a rise in the share of foreign assets due to higher foreign equity returns can trigger a relocation of equity funds away from the foreign country to the home country, leading to home currency appreciation. Such portfolio re-balancing reflects international investors' need to reduce foreign currency exposure in the face of imperfect FX risk-trading. By the same token, a rise in US equity prices might induce a portfolio rebalancing to foreign assets, leading to a strengthening of Asian currencies, ie $\beta_{2,8} < 0$.

In addition to restrictions based on economic theories, the diagonal elements are imposed to have positive signs. The additional restrictions help to tighten the estimates to a narrower admissible space. In all, fifteen restrictions are imposed on this matrix $\mathbf{A}^{-1}$ for identifying the SVAR (Table 2).

Table 2

	US bond	US stock	China bond	China stock	RMB/USD	Asian bond	Asian stock	Asian currency /USD
US bond shock	+					+		
US stock shock		+		+			+	–
China bond shock			+					
China stock shock		+		+			+	
RMB/USD shock					+			+
Asian bond shock						+		
Asian stock shock							+	
Asian currency/USD shock								+

Data

The eight-variable SVAR is estimated using daily data from January 1, 2002 to September 30, 2013. The data are obtained from the CEIC daily database. For all the country/region blocks, 10-year government yields are taken as the bond variable. The S&P 500 index is used for the US stock variable, and the Shanghai and Shenzhen Composite 300 for the Chinese stock index. The exchange rate is given as the renminbi and Asian currencies' bilateral exchange rate vis-à-vis the US dollar, and a rise in the exchange rate represents a depreciation. All the variables are expressed in percentage terms: bond yields are levels, and stock prices and exchange rates are given as percentage changes. Variables for the Asia block is taken as the regional (simple) average. The bond yield, equity prices and exchange rate for Asia are taken as the average of these variables across 11 Asian-Pacific economies. These economies are Australia, Hong Kong, India, Indonesia, Japan, Korea, Malaysia, New Zealand, Philippines, Singapore and Thailand.

One issue to address in the modelling is the different time zones of the US, Chinese and other Asian markets. As Asian trading is ahead of the US, shocks from China and other Asian markets are always incorporated into US asset prices, while shocks to US markets can only affect Asian trading the next trading day. Following the practice in the literature (eg. Forbes and Rigobon (2002) and Ehrmann, Fratzshcer and Rigobon (2011)), we use two-day rolling average returns in the analysis.

The unconditional correlation among the variables suggests that our interpretation of structural errors are consistent with the data (Table 3). The same markets display positive spillovers across countries: for the equity market, the three blocks (United States, China and Asia) are positive related; the US and Asian bond markets are positively correlated; and so are the renminbi and Asian exchange rates. One exception is the Chinese bond market, which has little co-movement with other bond markets. The US stock market has a negative correlation with Asian currencies, suggesting consistency with the prediction of Hau and Rey (2002, 2004).

Table 3

	US bond	US stock	China bond	China stock	RMB/USD	Asian bond	Asian stock	Asian currency /USD
US bond shock	1	0.39	0.01	0.06	0.01	**0.31**	0.20	-0.01
US stock shock		1	0.00	0.12	-0.04	0.09	**0.44**	**-0.20**
China bond shock			1	0.03	-0.01	0.00	0.02	-0.04
China stock shock				1	-0.06	-0.03	**0.32**	-0.20
RMB/USD shock					1	0.05	0.10	**0.30**
Asian bond shock						1	-0.05	0.25
Asian stock shock							1	-0.52
Asian currency/USD shock								1

Benchmark results

This section reports the spillovers from the US and Chinese markets (stock, bond and currency markets) to other Asian markets. These include both the same-market and cross-market spillovers.

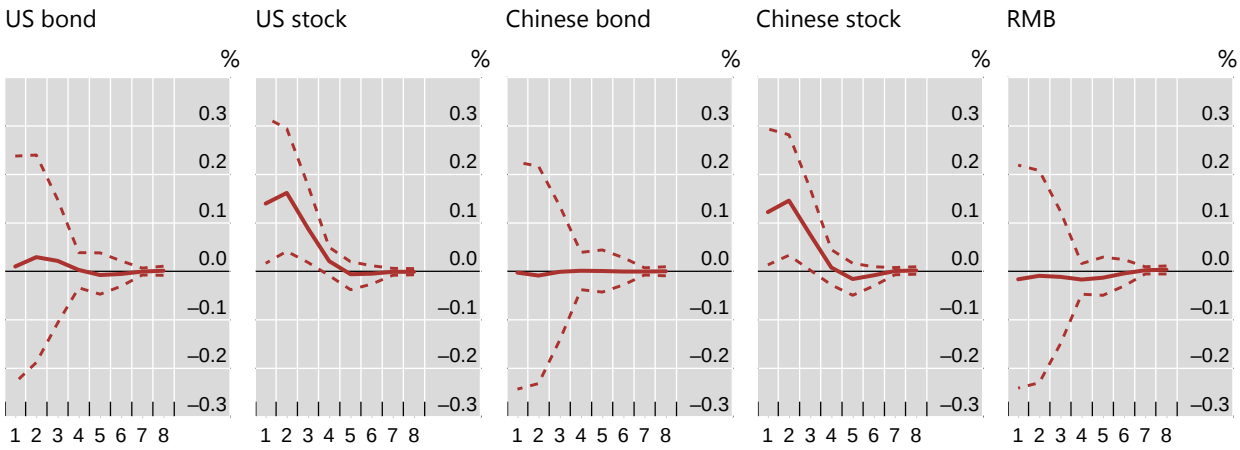
Impulse response

The impulse response results show that all Asian markets, including bonds, stocks and currencies, are affected by US factors; and there are same-market spillovers from Chinese stocks and currency. Transmission from the US and Chinese financial markets to other Asian markets is rapid, in line with general observations in the literature (Eun and Shim (1989)). Asian markets mostly respond within a day. The impact from different markets dissipates within 3 days.

In the case of Asian equities, the responses to US and Chinese equities shocks are positive (Graph 1). The findings confirm the positive same-market spillovers across countries. This positive spillover effect from the US stock market to other stock markets has long been recognised. Yet, it is interesting to formally establish the same positive spillovers from the Chinese stock market to Asian markets. As stock markets often reflect market expectations over the state of the economy, such positive spillovers are consistent with the hypothesis that, along with the US economy, the Chinese economy constitutes an important driver for the Asian economies. The response to the two source markets shocks are comparable with the US impact being slightly bigger. Based on the median estimates, one unit US equity shock (0.18%) will lead to a 0.14% rise in Asian equity prices upon impact, compared to a rise of 0.12% upon one unit Chinese equity shock (0.22%). Both impacts strengthen in the second day, and die down after 3 days. The cumulative impacts are 0.39% vs 0.35% respectively over the 3-day period.

Impulse response of Asian stock

Graph 1



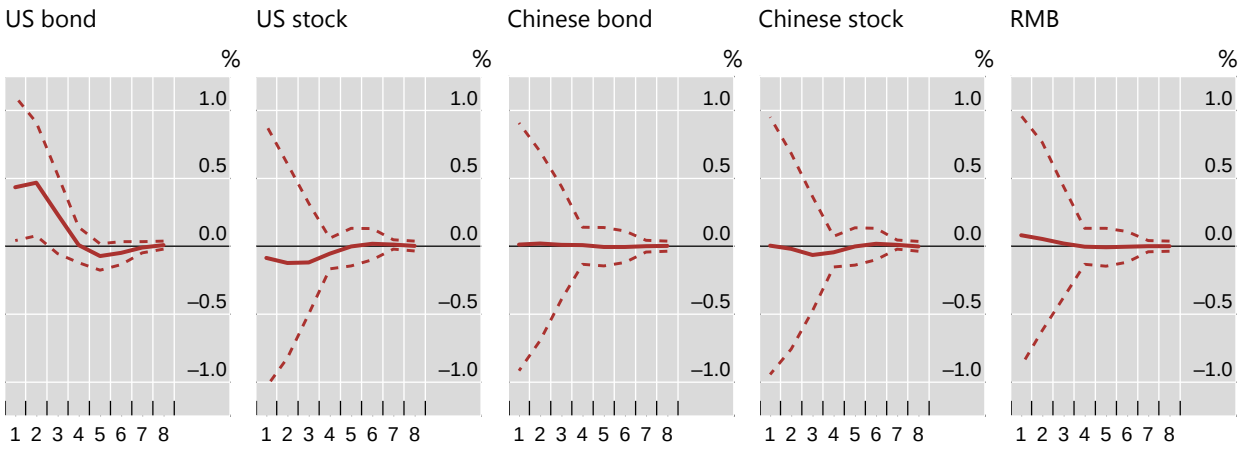
[1] Response to one unit of shock.

Source: authors' estimates.

Asian bonds respond positively to US bond shocks (Graph 2). One unit innovation in US bond yields (0.96 basis point) will lead to a 0.44 basis point change in Asian bond yields in the same direction, and the impact lasts for 2 days. This suggests that monetary loosening in the United States could lead to a loosening of monetary conditions in Asian economies, which can come through the interest rate, risk-taking, portfolio adjustment and policy spillover channels. As discussed earlier, the role of the US dollar as the dominant funding currency would make monetary spillovers very strong internationally. Unsurprisingly, China's bond shocks have no influence on Asian bonds. China is yet to fully open up its capital account, and its currency hardly has any role in global financing. As such, shocks to China's monetary policy are unlikely to be transmitted into Asian monetary shocks.

Impulse response of Asian bond

Graph 2

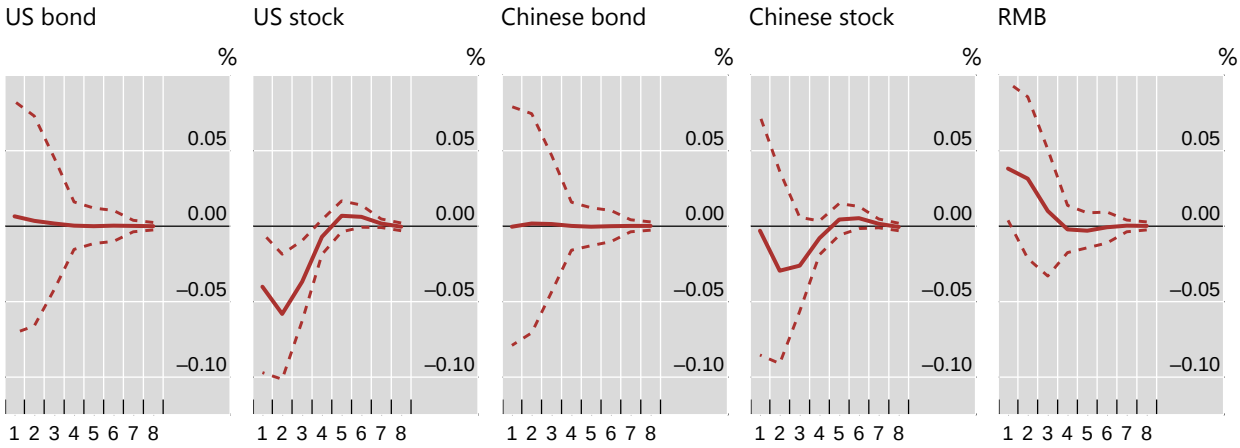


[1] Response to one unit of shock.

Source: authors' estimates.

Asian currencies can be affected by the US stock and renminbi shocks (Graph 3). Upon a one unit positive shock to the US stock market, Asian currencies will weaken by over 0.14% cumulatively over three days. The response to one unit shock in the RMB/USD rate (0.01%) is 0.04% and dies down in a day. The positive spillovers from the renminbi to Asian currencies indicate that China may be acting as a regional "pull" force: a rise in relative demand for the Chinese economy would also boost the relative demand for Asian economies, leading to appreciation of Asian currencies. The finding of the renminbi's impact on Asian currency movements corroborates that of earlier research by Shu, Chow and Chan (2007), Fratzcher and Mehl (2011), Henning (2012) and Subramanian and Kessler (2012), and Shu, He and Cheng (2015).

Impulse response of Asian bond — Graph 3



[1] Response to one unit of shock.

Source: authors' estimates.

Variance Decomposition

After examining the transmission of US and Chinese financial market shocks, we now use variance decomposition to assess the relative importance of these shocks in driving Asian stock, bond and currency movements.

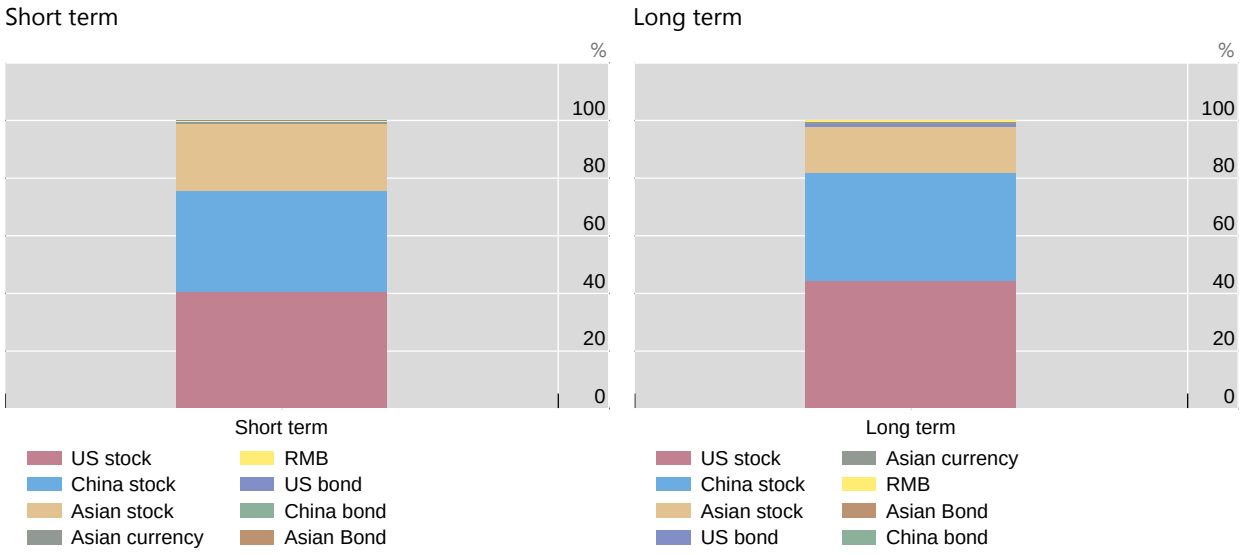
Graph 4 represents the standard reporting format for variance decomposition analysis in this paper. It shows how the volatility of Asian stock markets is driven by shocks to the eight endogenous variables, namely US bond yields, US equity prices, Chinese bond yields, Chinese equity prices, the RMB/USD rate, Asian bond yields, the Asian exchange rate and Asian equity prices itself over the whole sample. Variance decomposition for the first period is referred to as the short term, and that for the fifth period the long term. The selection of the reporting horizon for variance decomposition is based on impulse response and variance decomposition analysis: impulse responses suggest that the impact of all shocks tends to dissipate within 1-3 days; variance decomposition for all the variables mostly remains stable beyond 5 days.

Volatility of Asian stock prices is found to be mainly driven by spillovers from the US equities (40.3%), closely followed by Chinese equities (35.8%) in the short term (Graph 4). In the long term, the US and Chinese equities remain the two most

important drivers and their impact rises compared with the short term. Asian stocks' own shocks also account for a considerable fraction of its volatility in the short run, but their contribution declines in the long run. Variance decomposition analysis suggests that the US stock market still has the most significant influence on Asian stocks for the region as a whole, but China's stock market also plays a significant role.

Asian stock market: variance decomposition

Graph 4



Source: authors' estimates.

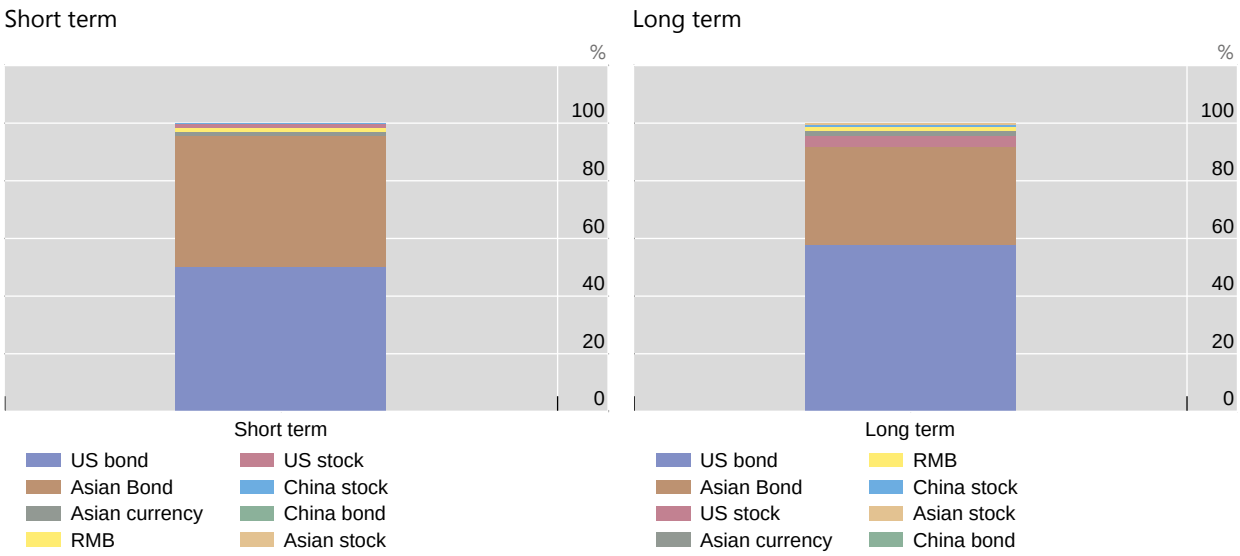
On the Asian bond market, the US bond market clearly dominates in its impact (Graph 5). This effect becomes even stronger in the long run (49.9% in the short run vs 57.6% in the long run). This adds evidence to a large body of recent literature which shows that monetary policy in centre countries can have significant influence on monetary conditions in other economies, eg Hau and Rey (2015). In a sharp contrast, all the Chinese financial markets, including equities, bonds and the exchange rate, barely have any influence on Asian bond movements. The Asian bond market's own shocks can explain a large fraction of its variance both in the short and long run, suggesting domestic monetary shocks are a key driver of Asian bond markets.

Shocks to US stocks and the RMB/USD rate are the key drivers of regional exchange rates, particularly in the short run (Graph 6). The renminbi's impact moderates in the long run (from accounting for over 30% of Asian currency movements in the short run to around 20%), but that of US stocks rises. This points to important cross-market spillovers from the United States. Other shocks also come into play over the long run, particularly Chinese equities. This may reflect that exchange rate movements are associated with capital flows induced by portfolio rebalancing. The impact of its own shocks in the current market accounts for a large fraction of variance in the short run, but diminishes in the long run.

Cross-market spillovers from equities are evident in the currency market. This could be because currency movements often reflect capital flows in and out of other markets, and thus the variance of exchange rates are also influenced by US and Chinese equities.

Asian bond market: variance decomposition

Graph 5

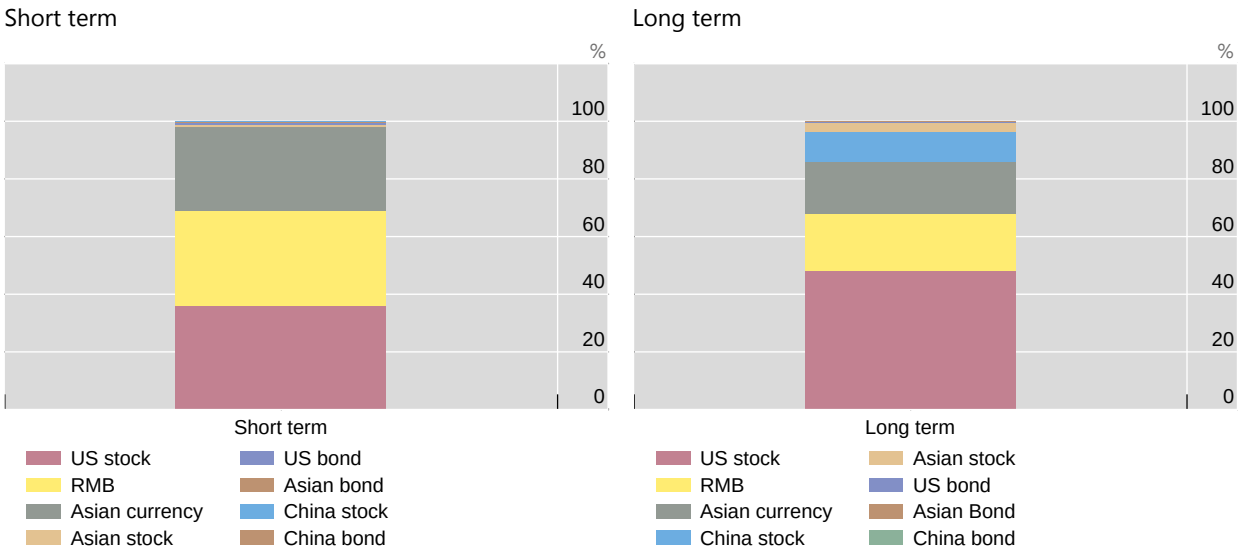


Source: authors' estimates.

In general, the results point to a strong US influence over Asian financial markets across all asset markets, including same-market and cross-market spillovers. This is consistent with the findings from impulse response analysis, and corroborates the findings in the literature examining financial market spillovers. The influence from China on Asian markets is confirmed in that movements in Chinese stocks and the currency have strong positive same-market spillovers to Asian markets. Asian markets' domestic factors are particularly important for bond market movements, but tend to have smaller impacts in the case of stock and currency movements, particularly in the long run.

Asian currency: variance decomposition

Graph 6



Source: authors' estimates.

Robustness checks

There could be concerns that the US and Chinese impact on Asian markets may be boosted by the imposition of the signs restrictions on those variables. We undertake a procedure similar to Rey and Hau (2004) to address this concern.

In this robustness check, we re-run the estimation for the SVAR, eliminating one imposed sign at a time while maintaining the remaining priors as discussed above. For example, when testing the impact of the Chinese stock on the Asian stock, we re-estimate the structural VAR using the signs in Table 2 but removing the restriction of $\beta_{4,7} > 0$. The number of restrictions is thus reduced to fourteen (the original fifteen less one restriction). Following the new estimation, we examine the sign of impulse response and variance decomposition. When we test the next restriction, eg the robustness of the US stock on the Asian stock ($\beta_{2,7} > 0$), estimation will be done with all signs in Table 2 except the one on $\beta_{2,7}$ and impulse response and variance decomposition will be analysed. The experiment is undertaken for the signs of the US and Chinese impact on Asian financial markets. These include $\beta_{1,6}$, $\beta_{2,7}$, $\beta_{4,7}$, $\beta_{2,8}$ and $\beta_{5,8}$. The number of restrictions is maintained at fourteen in testing each variable, ie the original fifteen signs in Table 2 minus the sign to be tested.

The repeated estimations show that earlier results are generally robust. Impulse response analysis based on the new estimations confirms the shape of the response of Asian financial markets to shocks from the US and Chinese markets. That is, the response of Asian stock, bond and currency carries the same signs as the prior when the restrictions for $\beta_{1,6}$, $\beta_{2,7}$, $\beta_{4,7}$, $\beta_{2,8}$ and $\beta_{5,8}$ are removed in each round of estimation. This suggests that the sign restrictions are consistent with underlying data.

Variance decomposition analysis mostly supports qualitatively the drivers for the Asian financial markets uncovered earlier: US bonds for the Asian bond market, US and Chinese stocks for the Asian stock market and US stock market for Asian currencies. One exception is the renminbi's impact on Asian currency movements which displays some fragility. After removing the restriction on $\beta_{5,8}$, the sign of the impulse response of the Asian currency to the renminbi remains as expected, but the renminbi appears to be explaining a rather small portion of Asian currency volatility.

Evolving impact of US and Chinese financial markets

Earlier discussions suggest that the relative importance of spillovers from the US and Chinese financial markets might differ in different financial conditions. Separately China's impact might also have evolved over time. This section explores the time varying nature of the US and Chinese influence on Asian markets.

Crisis vs non-crisis periods

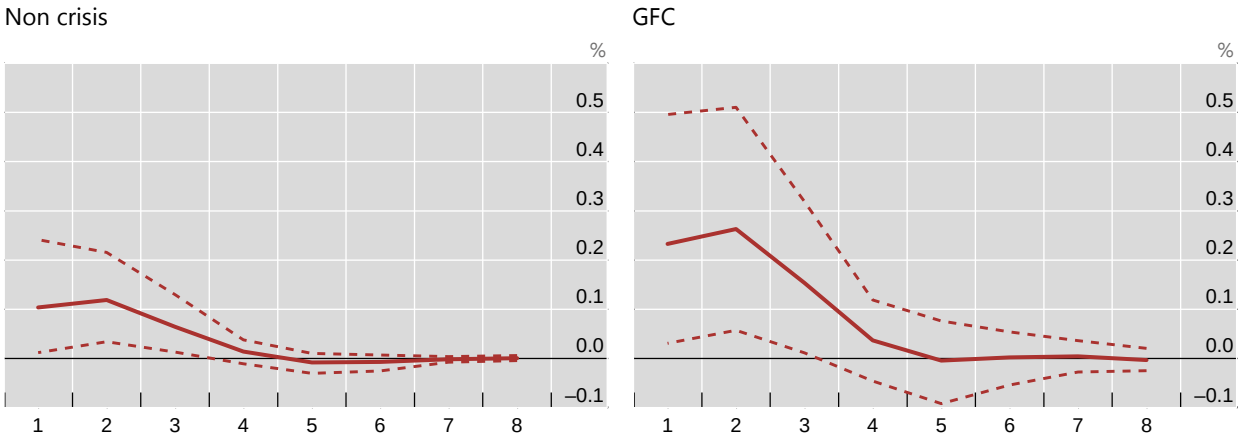
We undertake the same estimation for different sample periods to examine whether the relative importance of the US and Chinese financial markets might differ in different time periods. We consider three periods: 1) crisis periods consisting of the global financial crisis (from July 2007 to August 2009) and European debt crisis (from August 2010 to October 2012); 2) the global financial crisis; and 3) normal market

conditions (full sample excluding the global financial crisis and European debt crisis periods). The signs imposed are the same as shown in Table 2.

The US impact clearly rises during market stress periods, particularly the shock to US stocks on Asian stock markets (Graph 7). The impact of the US stock is stronger during the global financial crisis and European debt crisis compared to non-crisis periods. The rise is even sharper during the global financial crisis. In this period, Asian stocks rise by a cumulative 0.65% to one unit of shock over two days. This is over twice the size during non-crisis periods. There is also some increase in the influence of Chinese stocks on Asian stocks. However, the rise of the US impact is much greater, suggesting much more significant spillovers from US markets in relative terms during crisis periods.

Response of Asian stock to US stock

Graph 7



[1] Response to one unit of shock.

Source: authors' estimates.

These findings are consistent with earlier research, eg Cohen and Remolona (2008) and Dooley and Hutchison (2009), that shows US financial markets transmit shocks to global markets particularly strongly during the crisis periods. Such a rise in the US impact in market stress could be attributable to the US dollar's status as the dominant reserve currency as discussed earlier.

China's increasing impact

To examine whether China's influence has been changing over time, we estimate the periods before and since the global financial crisis.

The subsample estimation suggests that China's influence has been rising for the regional stock markets and currency movements. Since the global financial crisis, the response of the Asian stock market to a unit of shock from Chinese equities rose to a cumulate 0.42% over three days, compared to 0.26% before the crisis (Graph 8). Similarly, the renminbi impact has risen since the global financial crisis (Graph 9).

Response of Asian stock to Chinese stock

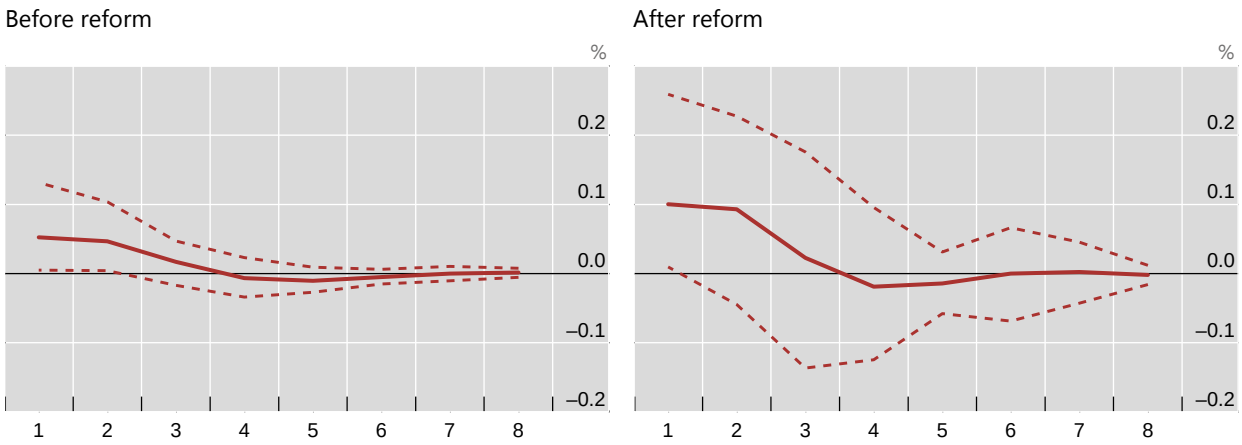
Graph 8

[1] Response to one unit of shock.

Source: authors' estimates.

Response of Asian currency to RMB

Graph 9



[1] Response to one unit of shock.

Source: authors' estimates.

Such a rise in China's influence may be due to some increase in China's financial linkages with Asian economies. Yet at China's current level of capital account opening, it is more likely a reflection of China's importance in the real economy such that developments in China's financial markets can be interpreted as shocks to its real economy and thus can drive investor sentiment towards regional financial markets.

Concluding remarks

The study represents the first attempt to systematically examine to what extent China has become a driver of Asian financial markets. To that end, SVAR models are employed to investigate spillovers from Chinese equity, bond and currency markets

to their Asian counterparts, and compare them with those from the United States. These models are estimated based on an identification approach that allows two-way contemporaneous interactions within the system. With a focus on international transmission in financial markets, "cross-country, same-market" and "cross-country, cross-market" correlation in markets is used for identification.

The analysis points to the rising influence of China on regional financial markets. In non-stress periods, China's influence on Asian stock markets has risen to a level close to that of the United States, although the United States tends to have stronger spillovers to Asian financial markets in stress periods. The renminbi has also risen in terms of its impact on regional currencies. Nonetheless, China's bond market remains isolated from both the United States and Asia.

The rise of China's influence can be cast in the light of a "regional pull" factor for Asian markets. The dominant influence of the United States on the world markets remains unquestioned: it represents a "global push" factor in that its market movements are one of the most important factors in shaping global liquidity conditions and risk appetite, particularly during times of stress. "Pull" factors – domestic developments – are also important in moving Asian markets, particularly for bond market developments. China's influence in Asian financial markets represents a third dimension – a regional dimension. Given its economic weight and integration in the Asian production chain, China's economic and financial developments affect investors' assessment of the region as a whole and fund flows to the region as a whole, thus driving financial markets in other Asian economies.

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