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SPILLOVER NOTES

SPILLOVERS FROM CHINA:

Financial Channels

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SPILLOVERS FROM CHINA: FINANCIAL CHANNELS

Overview

China has embarked on a journey to transform its economy from an export- and investment-driven to a consumption-driven economy. This transition will put the economy on a slower, yet safer and more sustainable, growth path, which would over the medium to longer term benefit global growth and reduce tail risks. However, while the much needed transition to the new growth path is proceeding broadly as expected, the transition is still fraught with uncertainty, including on the Chinese authorities' ability to achieve a smooth rebalancing of growth and the extent of the attendant slowdown in activity. Thus, in the short run, the transition process is likely to entail significant spillovers through trade and commodities, and possibly financial channels.

This note sheds some light on the size and nature of financial spillovers from China by looking at the impact of developments in China on global financial markets, with a particular emphasis on differentiation across asset classes and markets. The note shows that economic and financial developments in China have a significant impact on global financial markets. But these effects reflect primarily the central role the country plays in goods trade and commodity markets, rather than China's financial integration in global markets and the direct financial linkages it has with other countries.

In particular, the empirical analysis shows that the external impact of economic and financial developments in China on global financial markets is more pronounced for bad news than for good news, increases with the size of the shock, and works largely through risk aversion and global commodity prices. While no asset market is immune to economic and financial developments in China, effects are felt most acutely in foreign exchange (FX) and equity markets. Countries most affected are those with deeper trade ties with China, especially Asian countries integrated in the global supply chain, commodity exporters, and emerging markets (EMs) with weaker fundamentals.

We are grateful to Gillian Adu, Wang Ruosi, and Tessy Vasquez Baos for excellent assistance. The note benefited from useful discussions with Patrick Balgrave, Vikram Haksar, Petya Koeva Brooks, and Esteban Vesperoni; we also thank the IMF Spillover Taskforce for their insightful comments.

Introduction

Financial spillovers from China are typically thought to be small, if not nonexistent.[1] This belief is owed in part to the fact that China maintains a closed capital account regime. But recent episodes of volatility in global financial markets following news about the Chinese economy raised questions about the size and nature of financial spillovers from China. In particular, concerns about the speed at which China's economy is slowing, in the context of a challenging environment for EMs, were associated with higher global risk aversion and volatility, especially during the summer of 2015 (these were particularly acute following the large corrections in the Chinese stock market on June 10 and August 24, 2015, and the sharp adjustment in the renminbi-to-dollar exchange rate on August 11, 2015).

At the same time, adjustments in China's international portfolio assets and liabilities within the boundaries of its capital account regime may have increased China's direct financial linkages with the rest of the world. Thus, while China's capital controls limit the spillover effects through financial channels on the rest of the world, developments that increase uncertainty about the rebalancing process in China have the potential to impact global markets, including through volatility, equity prices, exchange rates, and bond yields. Furthermore, irrespective of the nature of China's direct financial linkages with the rest of the world, its size and large footprint in global commodity markets means that economic developments in China will entail global spillovers through trade channels that, in turn, are likely to be reflected in exchange rates and asset markets.

This note sheds some light on the size and nature of financial spillovers from China by looking at the impact of developments in China on global financial

[1]International Monetary Fund (2016a).

markets, with a particular emphasis on differentiation across asset classes and markets. The key findings are the following:

- Despite capital controls, capital flows in and out of China are substantial, even when compared with recipient/source countries' GDP, and have been rising in recent years.[2] The size and nature of countries' exposure to capital flows from and into China vary with the level of development, financial market development, and commodity dependence. Commodity exporters (mostly EMs and low-income developing countries, or LIDCs) are mainly exposed to foreign direct investment (FDI) flows from China; advanced economies with deep capital markets are exposed to cross-border bank flows and holdings of U.S. treasuries; while countries' exposure to portfolio flows from and out of China are limited.
- Economic and financial developments in China affect financial markets in both emerging and advanced economies. The impact is more pronounced for bad news than for good news, increases with the size of the shock, and works largely through risk aversion and global commodity prices. While no asset market is immune to economic and financial developments in China, effects are felt most acutely in FX and equity markets.
- Countries most affected by financial developments in China are those with deeper trade ties with China, especially Asian countries integrated in the global supply chain and commodity exporters. This differentiation in the external effects of developments in Chinese financial markets seems to suggest that the estimated financial spillovers from China reflect primarily concerns about China's growth prospects rather than specific news about Chinese markets that would trigger a substitution of Chinese for foreign assets.

The remainder of the note is organized as follows: The first section looks at the size and nature of capital flowing in and out of China and the countries that are most exposed to these flows, to give a sense of China's integration in global financial markets. The second section uses various econometrics techniques to assess financial spillovers from China, focusing mainly on asset prices. The third section concludes the note.

China's Integration in Global Financial Markets

China's capital account remains subject to restrictions, but there have been significant steps toward liberalization.

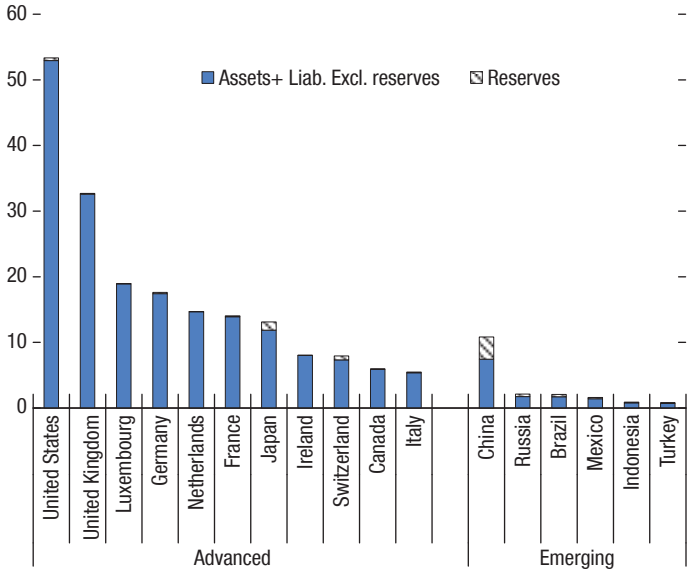
- Outward FDI has been largely liberalized, but inward FDI continues to be subject to approval requirements. Foreign investors must have a minimum of $100 million in offshore assets, be financially sound, and have expertise investing in China. Inward direct investments in strategic sectors are subject to a three-year holding period. Approval from the State Administration for Foreign Exchange (SAFE) is required for the repatriation of funds from liquidation of direct investment, except for investment and repatriation in the renminbi. Repatriation of profits requires only verification by the bank conducting the transfer.
- There are quotas on portfolio investment under various schemes: the Qualified Foreign Institutional Investors (QFII) scheme has an annual limit of $80 billion; the Renminbi-QFII (R-QFII) scheme, which has a limit of $30 billion, was introduced as part of the Chinese government's broader push for internationalizing the renminbi; and the Qualified Domestic Institutional Investors (QDII) scheme aims to promote the acquisition of securities by domestic residents.
- Lending abroad is largely liberalized, but foreign borrowing by domestic residents is subject to a ceiling (for short-term borrowing) or approval from SAFE (for long-term borrowing).

China's foreign assets and liabilities stood at nearly US$11 trillion at end 2015, on par with holdings of Japan or France, and higher than those of Russia, Mexico, Brazil, Indonesia, and Turkey combined (Figure 1). And to the degree there is any correlation between a country's foreign assets and liabilities and its stage of development, the small size of China's cross-border holdings compared with other countries at a similar stage of development but with an open capital account suggests a potential for these holdings to increase.

China's external position is long debt and short equity. In terms of composition, assets are dominated by official reserves holdings while liabilities are mainly

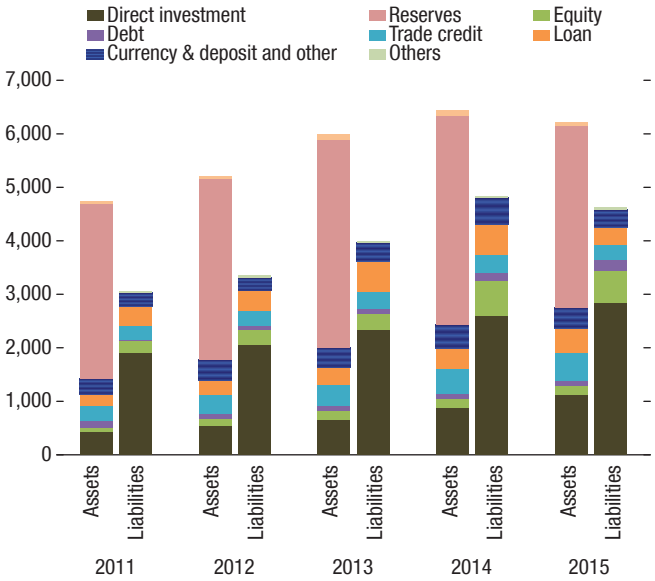
[2]Errors and omissions were relatively small until recently, when they reached about –1¾ of GDP, suggesting even larger outflows.

Figure 1. Total International Investment Position
(Trillions of U.S. dollars, 2015)



Sources: IMF, *World Economic Outlook;* CEIC; and IMF staff calculations.

Figure 2. China's Assets and Liabilities
(Billions of U.S. dollars)



Sources: IMF, *World Economic Outlook;* CEIC; and IMF staff calculations.

made of FDI inflows. Over half of China's foreign assets are official reserves holdings; about 20 percent are outward FDI, and about 25 percent are "other investments" including bank claims (loans, trade credit, and deposits). Liabilities feature predominantly higher-return equity instruments, with 60 percent of liabilities in the form of inward FDI (Figure 2).

The composition of China's foreign assets and liabilities reflects its export-oriented growth strategy that initially relied on long-term foreign capital to finance investment and exports, supported by limited exchange rate flexibility. Portfolio assets and liabilities are small, reflecting the authorities' capital account liberalization strategy, which favors longer-term, safer flows over shorter and more volatile ones—a strategy in line with best practice.[3] As of June 2015, portfolio investment in China stood at US$940 billion (CPIS), compared with US$1 trillion bank exposures ($1.8 trillion if Hong Kong SAR and Singapore are included), and to US$2.3 trillion inward FDI.

Direct Financial Exposure to China

We now look at how the composition and geographical distribution of China's cross-border holdings—namely reserves, banking, and FDI—shape its direct financial linkages with other countries.[4]

Reserves Accumulation

China's reserves accumulation has the potential to influence global markets through its impact on U.S. Treasury bond yields, but this effect is not always evident in the data. With US$3.3 trillion in foreign reserves as at end 2015, China owns about 30 percent of global official reserves. A large chunk of these assets are low-yielding U.S. treasuries, which implies that China's reserves accumulation (i.e., exchange rate policy) has the potential to impact other countries through its effect on the price of those U.S. treasuries and, thus, on U.S. bond yields.

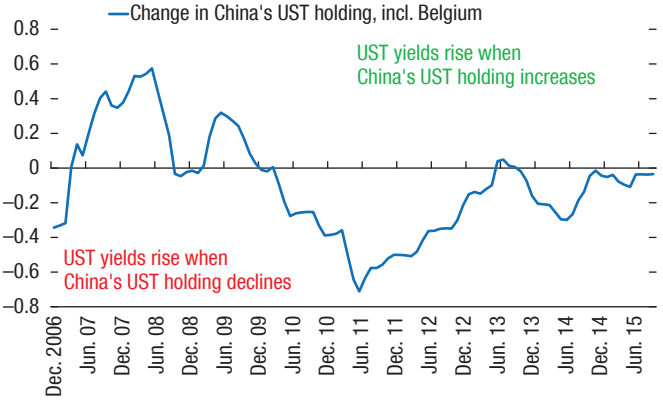
Indeed, the impact of China's reserves accumulation on U.S. Treasury bond yields has been and continues to be much debated (IMF, 2011) with some arguing that China's reserves accumulation during 2004–07 has contributed to keeping U.S. treasury bond yields lower than they would otherwise be, and others arguing that other factors have been

[3]See Rodlauer and N'Diaye (2013).

[4]Data used in this section may provide only a partial view of Chinese financial flows because these flows may be channeled through Hong Kong SAR and other financial centers.

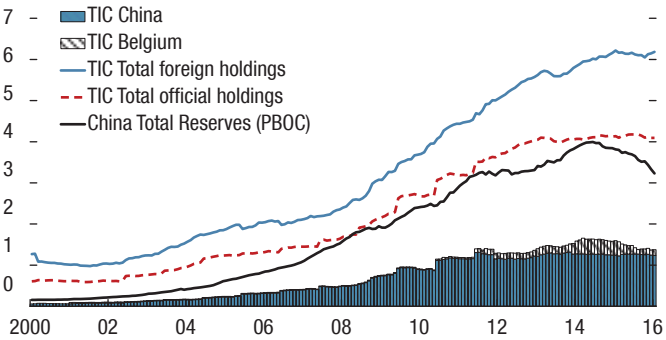
Figure 3. China's International Reserves and U.S. Treasury Market

1. China's Reserves, U.S. Treasury Holdings and 10-Year U.S. Treasury Yields
(Two-year rolling correlation with monthly changes in 10-year U.S. Treasury yields)



Sources: Haver Analytics; and IMF staff calculations.

2. China's Reserve and Foreign Holding of U.S. Treasuries
(In trillions of U.S. dollars, up to February 2016)



Sources: Haver Analytics; and IMF staff calculations.
Note: In recent years much of China's investment in U.S. Treasury securities was channeled through China's entities incorporated in Belgium. U.S. Treasury outstanding in 2016 is about $13 trillion.

the key drivers of U.S. bond yields. Partisans of the former camp show that U.S. Treasury bond yields rise by 10 basis points (bps) for every US$100 billion fall in demand (not necessarily from China).[5] Partisans of the latter camp point to factors, such as weaknesses in economic growth prospects, low inflation expectation, and expectations of protracted monetary accommodation as key factors behind the low U.S. Treasury bond yields.

Be that as it may, looking at recent data, it is hard to find a strong correlation between China's reserves accumulation and the evolution of U.S. treasuries. Of the US$800 billion fall in China's official reserves during June 2014–February 2016, about US$240 billion came from U.S. Treasury bonds holdings,[6] which has coincided with an 80 bps fall in U.S. Treasury bond yields, instead of the 25 bps rise that the empirical estimates above would have predicted. But this apparent lack of correlation (Figure 3, panel 1) may be due in part to the fact that as China was selling U.S. treasuries, other officials and private investors were buying more (Figure 3, panel 2), blunting the potential impact of the lower demand from China on U.S. bond yields. And, absent such offsetting factors, changes in China's reserves accumulation would impact U.S. bond yields and reverberate across the globe given the role U.S. Treasury bond yields play in the pricing of assets in and outside the United States.

Cross-Border Banking

Cross-border banking linkages are comparable in size to some Group of Seven (G7) countries, suggesting the world has a stake in a stable Chinese banking system. Foreign banks have exposures to China and Chinese banks have expanded their activities in Asia in the past several years, and these exposures could transmit shocks from China. Bank for International Settlements (BIS) data on cross-border bank holdings show that foreign banks' claims on Chinese entities stood at about US$1 trillion in 2015:Q3, including guarantees, derivatives contracts, and credit commitments. In dollar terms, the U.K., U.S., Hong Kong SAR, and Japanese banking systems are most exposed to China (Figure 4).

While the dollar figures are substantial, our stress tests suggest that these foreign banks' exposures to Chinese banks appear manageable, and their banking system average Tier 1 capital ratios would remain above the 6 percent Basel III requirement in the worst case scenario.[7] Nevertheless, such shocks could have a macroeconomic impact as banks could tighten credit conditions to restore the health of their balance sheets. Furthermore, the global banking systems could be significantly impacted if a credit event were to lead to major losses on U.K. banks' exposures to both China

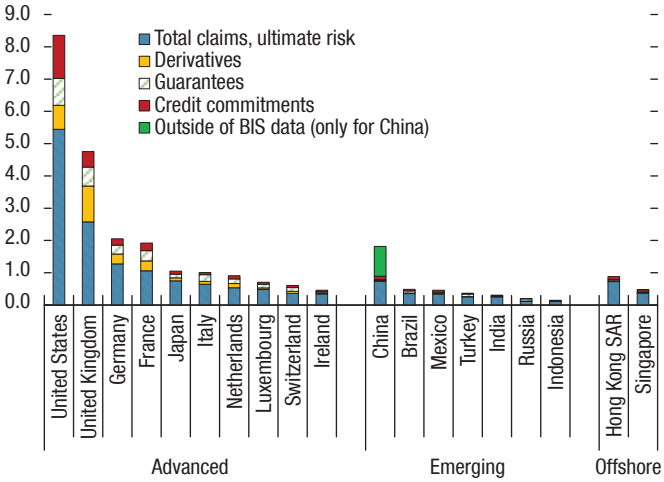
[5]Warnock and Warnock (2009), and IMF (2011, 2013).

[6]Based on Treasury International Capital data. Figure includes U.S. Treasury holding by China and Belgium, where most of the holdings are believed to reflect those of China.

[7]See Annex 1 for description of methodology and assumptions.

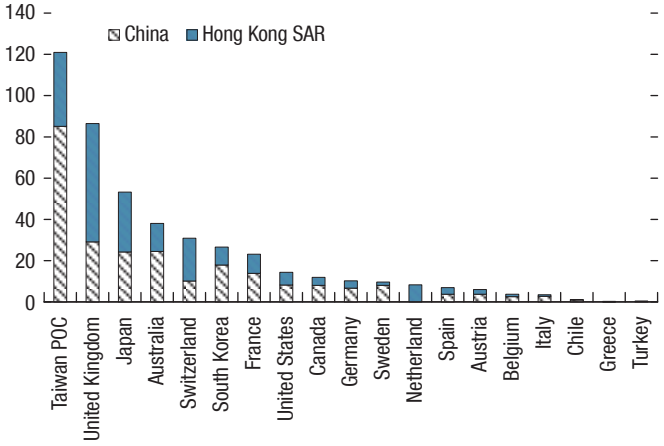
Figure 4. Cross-Border Bank Exposures to Greater China

1. Cross-Border Bank Exposures by Recipient Economies (In trillions of U.S. dollars, September 2015)



Source: Bank for International Settlements consolidated statistics.

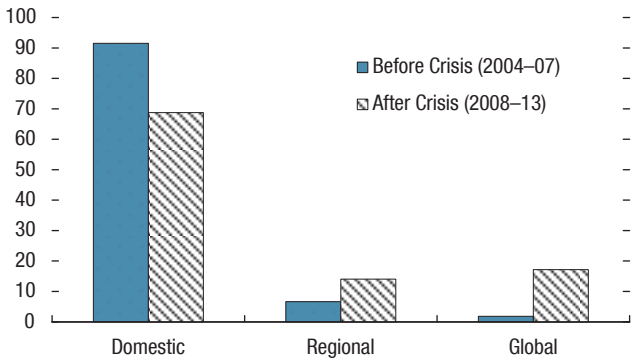
2. Cross-Border Bank Exposures to China and Hong Kong SAR (In percent of Tier 1 capital, September 2015)



Sources: Bank for International Settlements consolidated statistics (total claims on ultimate risk basis, guarantees, credit commitment, and off-balance-sheet items), Central Bank of Taiwan Province of China, *World Economic Outlook*, and IMF staff calculations. Data for Singapore are confidential.

Figure 5. Chinese Banks' Cross-Border Exposures

Chinese Banks' Assets by Region (In percent of total, sample of three-seven banks)



Source: IMF (2015), Chapter 2.

and Hong Kong SAR banking systems (losses of 70 percent on U.K. banks' holdings in the China).

Chinese banks' foreign exposure seems to have risen in recent years, but data limitations complicate the assessment of potential spillovers (Figure 5) as China does not report cross-border banking statistics to BIS.

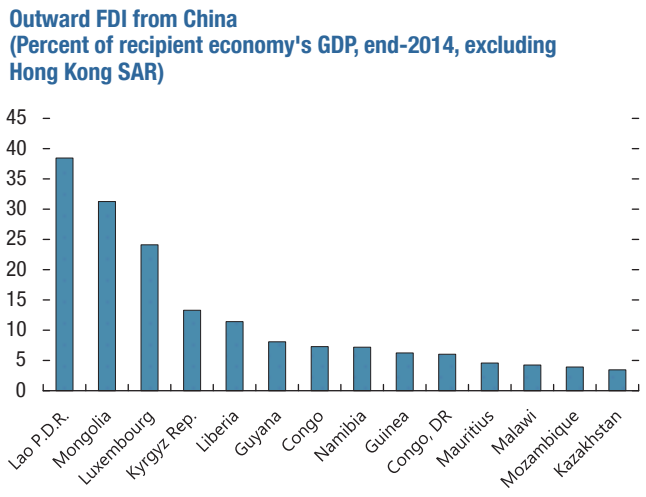
Concentration of Cross-Border Banking Links

Spillovers through banking linkages are concentrated within a few large systemically important financial institutions (SIFIs). Information on the concentration of bank linkages is scant, but available data suggest that, for U.K. banks, exposure to China is concentrated in a few large banking groups. But these conglomerates seem to have sufficient capital to withstand a credit event in China similar to the one envisaged above. For example, based on disclosed financial statements at end-2015, HSBC's exposure to China amounted to US$143 billion (110 percent of the group's total common equity Tier 1, or CET1, capital) and Standard Chartered's exposure amounted to US$50 billion (131 percent of the group's total CET1 capital). The combined exposures of these two banks (US$193 billion) accounted for almost all the United Kingdom's direct banking exposures to China. Failure of such large banks could reverberate to other banking systems, given their SIFIs status.

Outward FDI

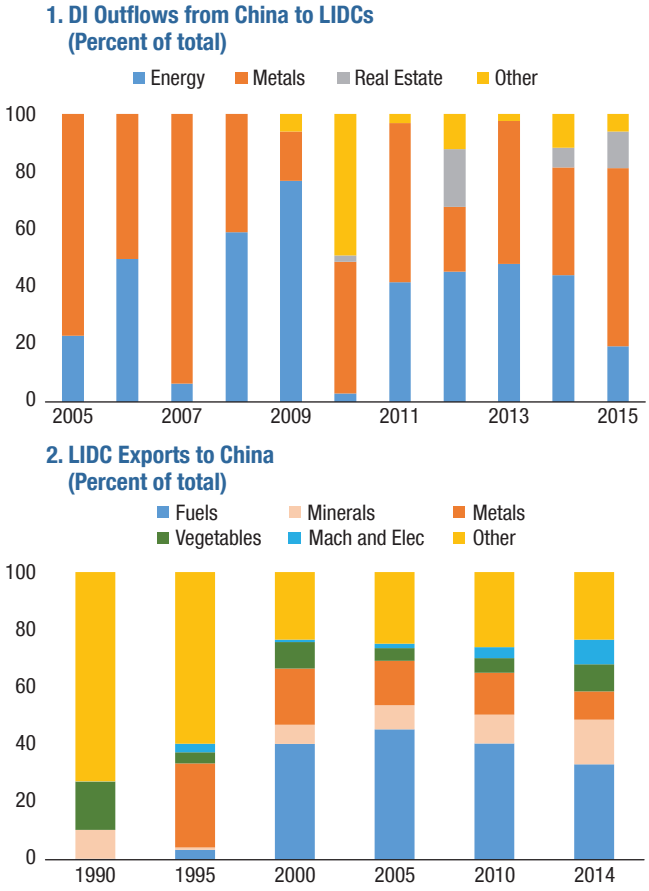
China's direct investment abroad is large, is rising rapidly, and represents a significant share of recipient countries' GDP, primarily in natural-resource-rich LIDCs. China's direct investment abroad stood at about US$1 trillion in June 2015 and accounted, on average, for over 10 percent of recipient countries' output in Hong Kong SAR (175 percent of GDP), Lao P.D.R., Mongolia, Luxembourg—a hub for Chinese investment into Europe—Kyrgyz Republic, and Liberia (Figure 6).

Figure 6. Outward FDI from China



Sources: CEIC; *World Economic Outlook;* and IMF staff calculations.

Figure 7. Outward FDI from China to LIDCs and LIDC Exports to China: Sectoral Decomposition



Source: IMF staff estimates.

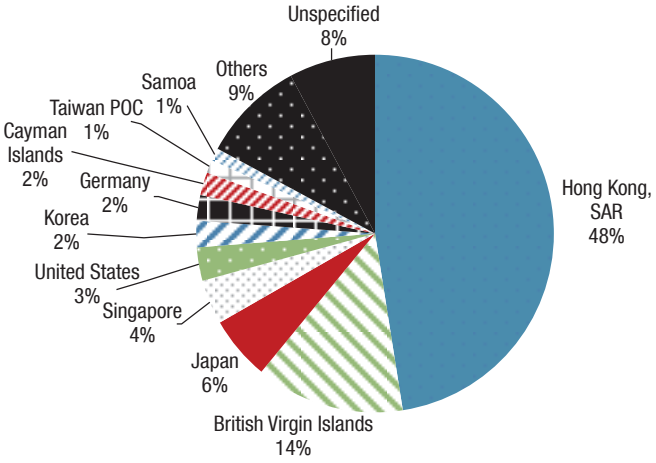
Importantly, outward FDI (and capital account liberalization more generally) represents a core part of China's transition to a new growth model with a more open capital account, including by allowing Chinese firms to seek new opportunities abroad. Furthermore, outward FDIs are also being influenced by the Chinese government's strategy to diversify its reserves and secure stable sources of energy. FDI flows from China are typically in metals and energy, and flow mainly to resource-rich LIDCs (Figure 7, panel 1). Those investments are channeled back into China through LIDCs' exports of metals and minerals (Figure 7, panel 2). Recently, there has also been greater direct investment from China into advanced economies, although the amounts are relatively limited. These investments are typically in technology, real estate, and finance. Looking ahead, lower demand for commodities or a bumpier-than-expected rebalancing of China's growth could conceivably entail a reduction of such investments. These amounted to US$10 billion in 2015 in addition to an estimated stock of investment of US$40 billion as at end-2014.

Inward FDI

It is hard to assess the direct exposure of the rest of the world to China through direct investment in China because the bulk of the inward FDI flows are channeled through offshore financial centers (Figure 8). Over 60 percent of the US$2¼ trillion stock of inward FDI into China came from Hong Kong SAR and the British Virgin Islands; about 20 percent came from Japan, Singapore, the United States, Korea, and Germany. Outside offshore financial centers, the direct exposure of countries to China through their FDI is somewhat limited relative to GDP (5 percent or less of source country GDP), suggesting limited potential losses from an adverse domestic Chinese credit event, though the extent of concentration in the holdings of and systemic risks associated with those assets is not known.

The evidence above suggests that despite having a relatively closed capital account, external effects could be manifested through direct financial linkages and, depending on the nature of the shock, developments in China could have far-reaching consequences. Commodity exporters (mostly EMs and LIDCs) are mainly exposed to FDI flows from China; advanced

Figure 8. Inward FDI into China
(Share in total stock, end- 2014)



Source: CDIS.

economies with deep capital markets are exposed to cross-border bank flows and holdings of U.S. treasuries; while countries' exposure to portfolio flows from and out of China are limited. That said, irrespective of the nature of China's direct financial linkages with the rest of the world, its size and large footprint in global commodity markets mean that economic developments in China will entail global spillovers through trade channels[8] that, in turn, are likely to be reflected in exchange rates and asset markets—a channel we explore below.

Spillovers through Asset Markets

We now look at the external impact from any given development in China's real sector and exchange rate, equity, and bond markets. We do so by using three different approaches: Diebold and Yilmaz (2014) to measure interdependence of asset returns and volatility, event study analyses, and a standard vector autoregression (VAR) framework. The rationale for this multi-pronged approach is to (1) document co-movements in asset prices (equity and bonds including local currency, foreign currency, and sovereign bonds), (2) explain cross-country variation and differentiation via idiosyncratic factors (including countries' vulnerabilities and trade/financial link to China) versus global risk aversion, and (3) uncover empirical regularities between Chinese real and financial variables and foreign financial variables over a longer time span to ensure that the evidence from higher-frequency data is macro-relevant (meaning that the spillovers from events in China last beyond the day of the event).

We first focus on the events during the summer of 2015 through early 2016 to gauge the external impact of developments in China (both financial and economic) and then use data over a longer time span.

Co-movements in Asset Prices

Empirical evidence from Diebold and Yilmaz (2014) measures of total and directional spillovers (Annex 2) suggests developments in China's equity and foreign exchange markets since the summer of 2015 have had a significant impact on the returns and volatility of equity, foreign exchange, and bond markets abroad (Figure 9).[9] Foreign stock markets reacted to movements in the Chinese stock market returns, while exchange rate returns and bond yields reacted to movements in both Chinese exchange rate and stock prices. There was little movement in the Chinese bond market, and thus limited reasons for foreign markets to react.

There is tentative evidence of differentiation in the external impact of financial developments in China. These external effects were largest for foreign exchange markets of Asian EMs and commodity exporters (Figure 10)[10] who also saw the highest increases in bond yields. However, there is no indication of differentiation when looking at foreign stock markets' reactions to developments in China.

These external effects were smaller than those of the United States, but similar in size to those of Japan.[11] The external impact of developments in Chinese financial markets typically represent about 1/5 of that of the United States but is on par with Japan, contributing about 1½ percent of the average volatility in global markets. That said, the estimated absolute contributions of developments in Chinese financial markets are small, commensurate to the portfolio flows.

The small size of the estimated external effects of developments in Chinese financial markets seems at odds with markets' reactions following news about

[8]International Monetary Fund (2011, 2012, 2013), and Blagrave and Vesperoni (forthcoming).

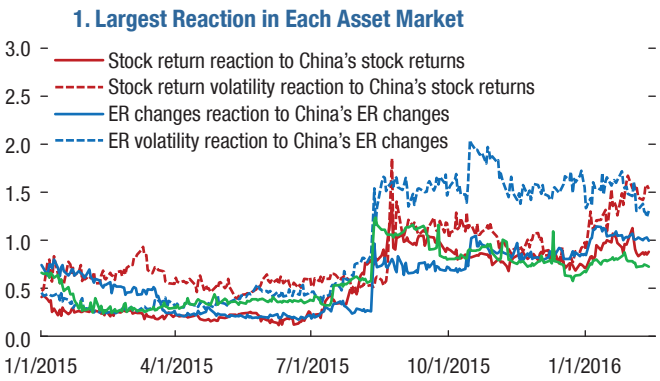
[9]See also IMF (2016a, 2016b).

[10]This result holds for an alternative identification scheme using Cholesky decomposition (Annex 1).

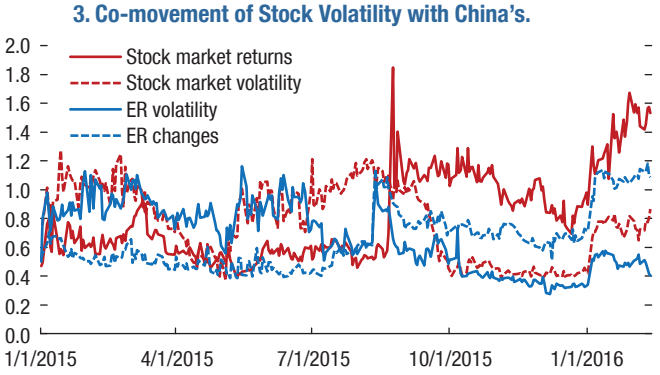
[11]See Shu and others (2015).

Figure 9. Financial Market Co-movement with China
(Share of forecast error variance due to China for an average country)

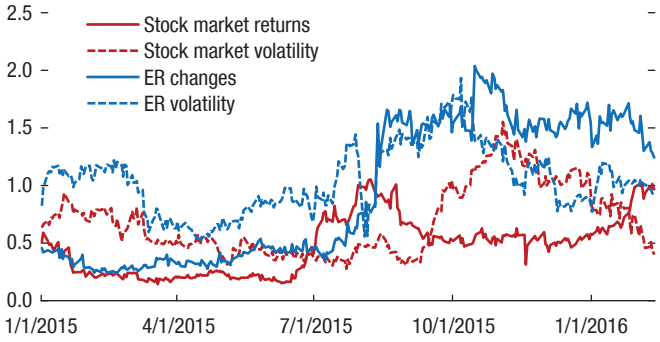
Co-movement with China jumped in August across asset markets, with exchange rate volatility showing the largest spillovers.



… and volatility.



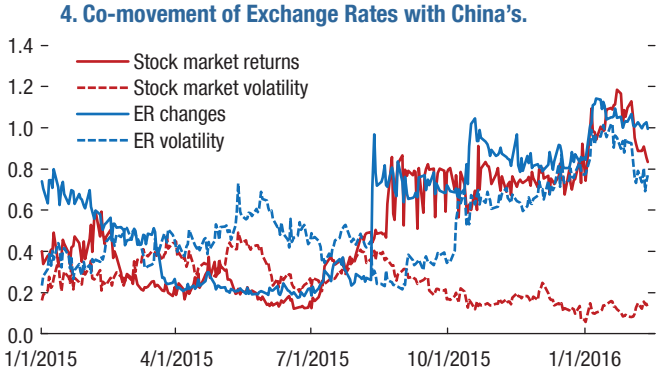
Exchange rate volatility was more sensitive to exchange rate developments.



Source: IMF staff estimates.

Stock markets reacted mostly to Chinese stock returns both in terms of changes…

While exchange rates reacted to both Chinese exchange rate and stock price moveme nts.



Bond yields reacted to China's stock and exchange rate movements.

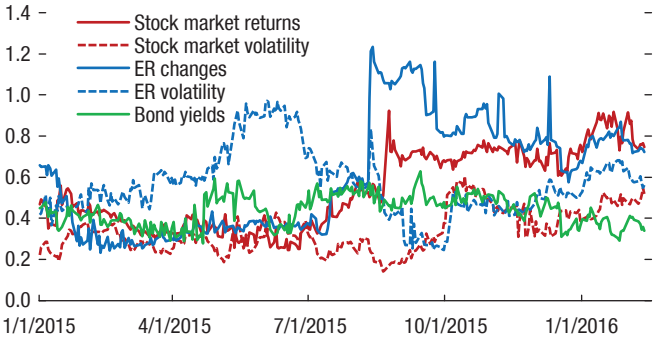
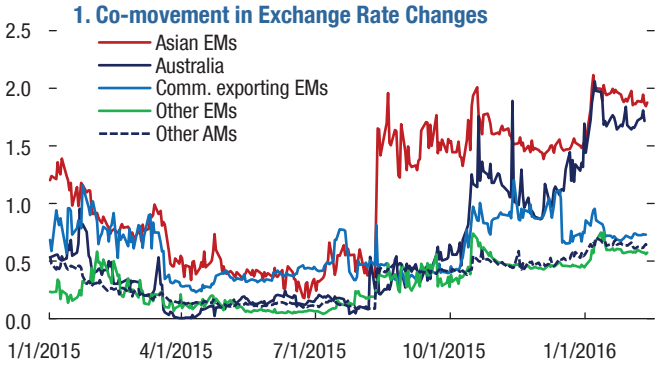
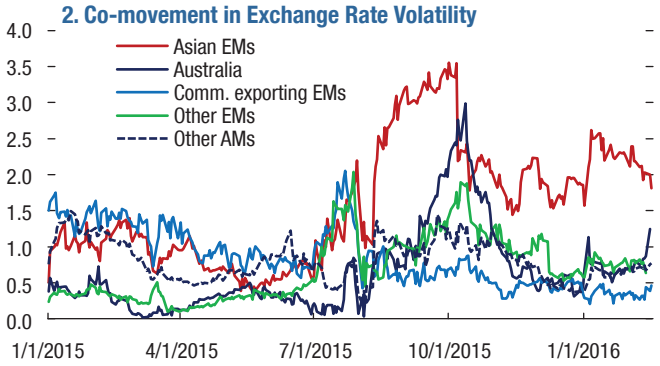


Figure 10. Which Markets Were Most Affected?
(Share of forecast error variance due to China on average for a country group; within asset class, except bonds)

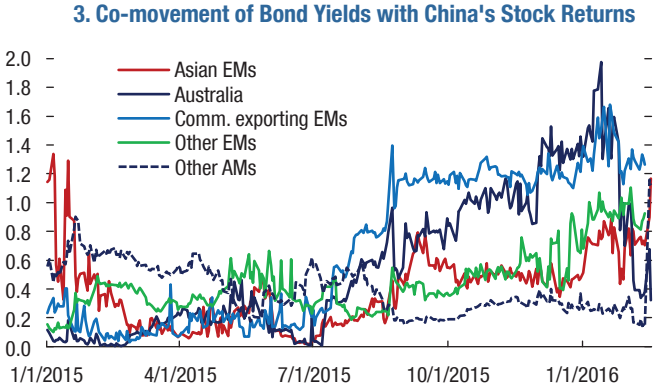
Asian EM and commodity exporters were most affected through exchange rate changes …

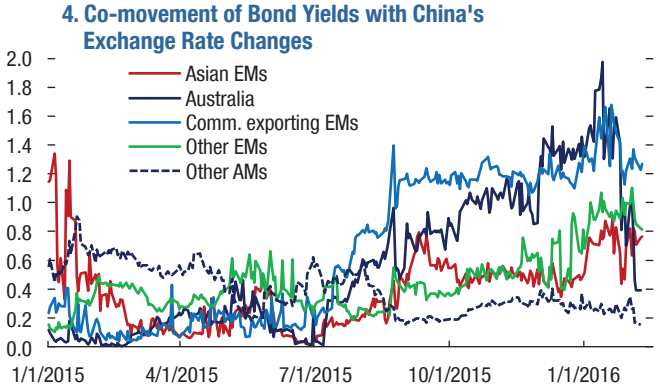


… and spikes in exchange rate volatility.

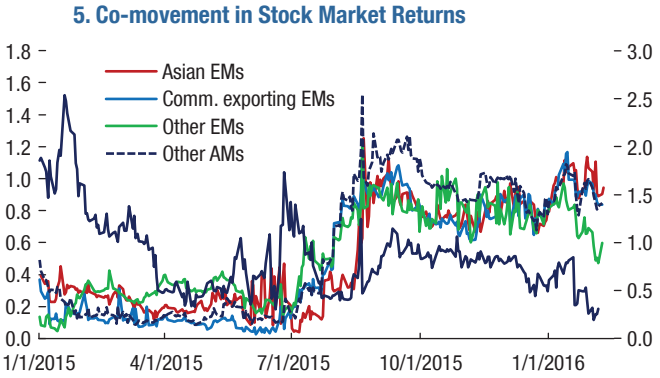


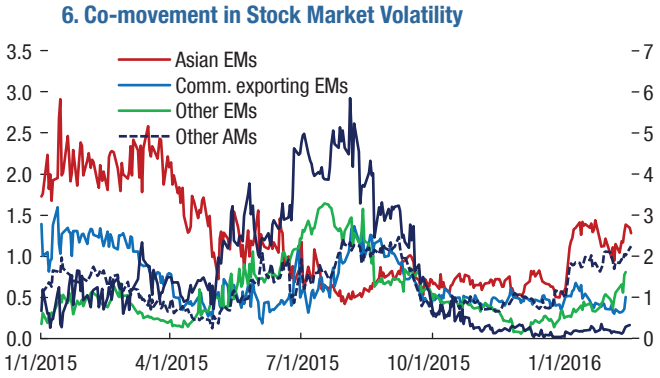
In terms of bond yields, commodity exporters were the most affected.





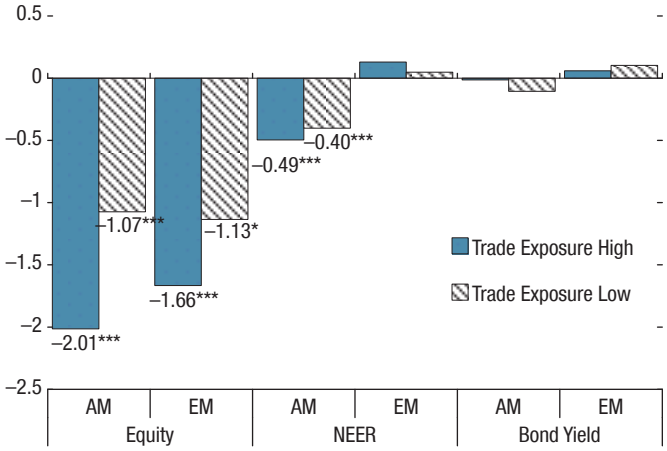
While there was less of a differentiation in stock markets.





Source: IMF staff estimates.
Note: Asian EM: India, Indonesia, Malaysia, Philippines, Thailand. Commodity-exporting EMs: Argentina, Chile, Colombia, Russia, South Africa (*World Economic Outlook* definition). Other EMs: Brazil, Mexico, Peru, Hungary, Poland, Turkey. Other advanced markets (AMs): United States, Canada, Japan, Korea, Taiwan Province of China, Singapore, Australia, United Kingdom, Germany, France, Italy, Spain.

Figure 11. Trade Exposure to China
(Percent)



Source: IMF staff estimates.
Note: NEER = nominal effective exchange rate.

China during summer 2015. Indeed, the series of financial events in China during that summer spurred concerns in global markets to an extent that has taken many by surprise. Examples of such events include the stock market correction on June 10, the move to the new exchange rate regime on August 11, a further stock market correction on August 24, and the sharp fall in the Chinese stock market on the opening day of 2016, which triggered a suspension of all trading under a new circuit breaker system.[12] Perhaps one reason why these estimates appear to be small is that the Diebold–Yilmaz (2014) technique that is used is incapable of isolating the idiosyncratic shocks that raise concern in global markets, such as during summer 2015, and conflate them with shocks from various sources and of a different nature. Thus, in what follows, we use event study techniques to assess the external effects of specific financial developments in China.

External Transmission of Economic and Financial Shocks

Size of Spillovers Using Event Analysis

The external impact of financial shocks in China varies depending on a country's level of development (EMs vs. advanced economies, or AEs), safe haven status, strength of trade linkages with China, and dependence on commodities.[13] Adjustments in China's equity prices and exchange rate spill over to commodity producers and trading partners, in part because they signal that growth could be weaker than previously assumed. Country fundamentals and direct financial linkage with China seem to play little, if any, role. More specifically:

- *AEs versus EMs.* An adverse financial shock in China leads to a flight of investors away from EMs toward AEs, and away from risky assets toward safe assets. On average, equity prices fall in both EMs and AEs, with larger declines in EMs; EM currencies depreciate while AE currencies appreciate, mainly for safe-haven countries; and bond yields rise in EMs and fall in AEs, primarily for safe-haven AEs.
- *Trade linkages.* An adverse financial shock in China reduces equity prices by more in countries with higher trade exposure to China (Figure 11), such as those in the Asian supply chain.[14] Currencies of EMs with stronger trade linkages with China depreciate by more, while those of AEs with larger trade exposure appreciate by less. Bond yields rise in EMs by similar magnitudes and remain broadly unchanged in AEs.
- *Commodities.* EM commodity exporters face larger falls in equity prices, more currency depreciation, and a stronger rise in bond yields (Figure 12). AE markets' response to a financial shock in China differs somewhat from that of EMs with a fall in equity prices, an appreciation of their currencies, and no significant change in bond yields.
- *Fundamentals.* EMs with higher vulnerabilities experience a sharper fall in equity prices, but there is no clear indication of differentiation in the impact on the exchange rate and bond yields (Figure 13). There also does not seem to be differentiation based on fundamentals across AEs. One possible reason for this result may be that AEs with weaker fundamentals[15] have typically little trade and financial linkages with China.

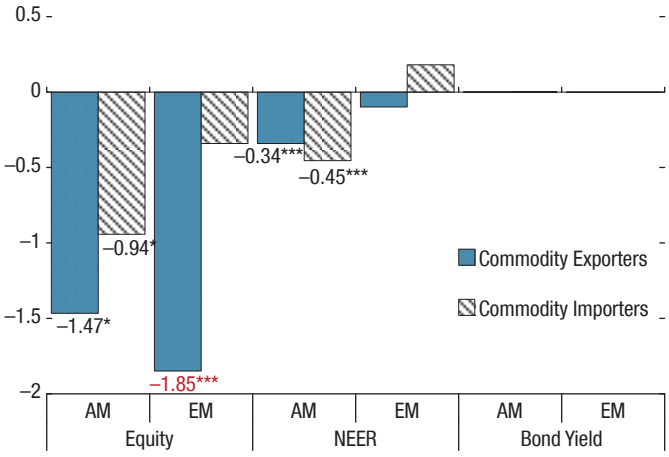
[12]Annex 3 presents the full list of events considered and describes the methodology.

[13]See Annex 3 for a description of the methodology.

[14]Arslanalp and others (2016) find that financial spillovers from China to Asian countries have increased since the global financial crisis and are higher for economies with stronger trade links with China.

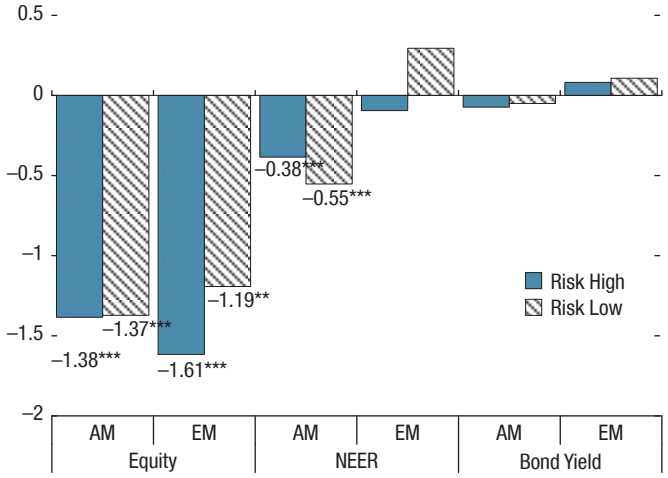
[15]Refers to level of fundamentals below which there is increased likelihood of a sudden stop in capital flows.

Figure 12. Commodity Dependence
(Percent)



Source: IMF staff estimates.
Note: NEER = nominal effective exchange rate.

Figure 13. Country Risk
(Percent)



Source: IMF staff estimates.
Note: NEER = nominal effective exchange rate.

- *Financial integration.* There is no clear indication that for EMs the external impact of financial shocks in China depends on countries' direct financial exposure. But there seems to be some semblance of a relationship for AEs, with larger equity price falls and exchange rate appreciation in countries with stronger direct financial ties with China.

While the external effects of financial shocks in China are statistically significant, they remain smaller than those of economic news, consistent with China's greater importance in global trade than on financial markets. The difference in the impact is particularly pronounced when one compares European to Asian countries, which are more integrated on trade.

The analysis so far indicated that both daily financial and economic developments in China affect global markets. The section that follows uses data with a longer time span and lower frequency, to gauge whether the economic and financial developments in China have a material, long-lasting impact on global markets.

Size of Spillovers Using Longer Time Span Data

Empirical analysis using VAR techniques (Annex 4) shows that Chinese financial market developments and economic data releases have a statistically significant impact on global markets.[16] In particular, a decline in equity prices, a depreciation of the renminbi, and disappointing industrial production data lead to higher global risk aversion, lower U.S. stock valuations, weaker oil and metals prices,[17] and lower EM equity and FX values (Figure 14).

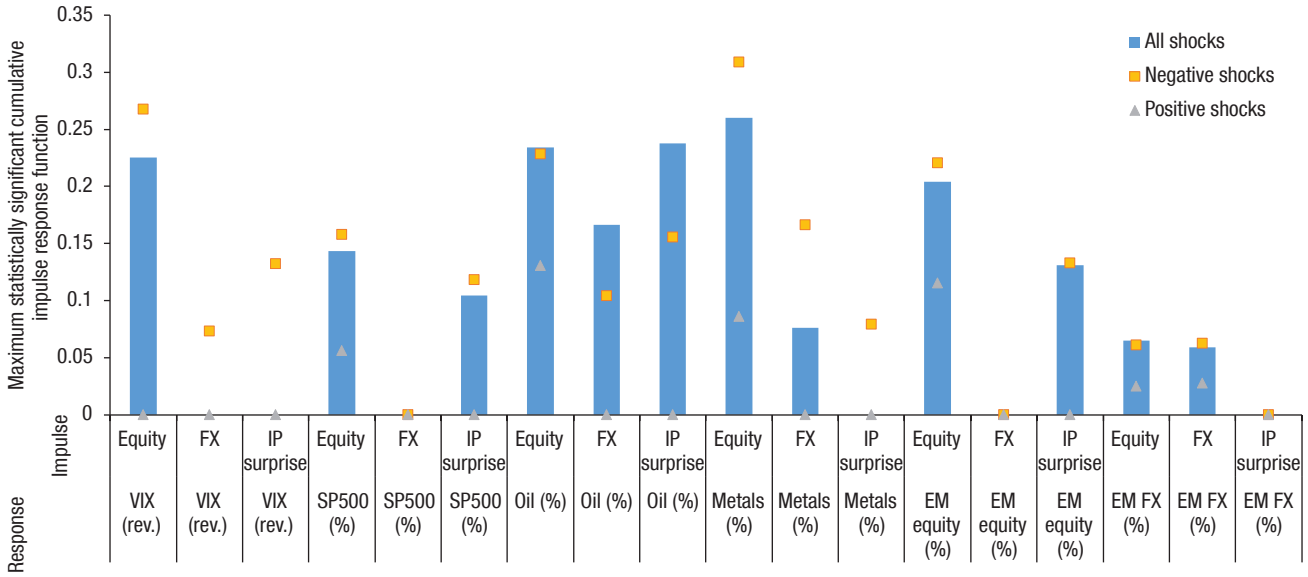
In terms of relative impact, Chinese equity values have the largest impact on global and EM markets, the renminbi exchange rate has a large impact on oil prices, and Chinese economic data surprises affect both oil prices and EM equity valuations. The larger external impact of equity price shocks could be driven by the less restricted movements in the Chinese equity market over the estimation period relative to the exchange rate market, which until recently has been heavily supervised. There was no evidence of an external impact of shocks to China's bond yields.

Despite being statistically significant, the effects of financial developments in China on the rest of the world seem economically modest. Figure 14 shows the results of the VAR estimation in terms of the largest statistically significant cumulative impulse response function value for each global and EM response variable and for

[16]See also Cashin, Mohaddes, and Raissi (2016), and Guimarães-Filho and Hong (2016).

[17]This is consistent with the findings of Kolerus, N'Diaye, and Saborowski (forthcoming).

Figure 14. Impact on EMs of China Economic and Financial Shocks



Source: IMF staff estimates.
Note: IP = industrial production.

each Chinese variable. It shows that, for instance, a one standard deviation (about 2 percent) decline in Chinese equities results in a ¼ percentage point rise in the Chicago Board Options Exchange Volatility Index (VIX) (compared with 1½ percentage points for one standard deviation in the VIX). The estimates suggest that the late August 2015 episode of volatility in global markets, when the Chinese equity market lost over 20 percent in the span of a few days, explains about 2 points of the 27-point increase in the VIX.

Digging deeper, the analysis shows that the impact of economic and financial developments in China is stronger during episodes of bad (negative) news.[18] In particular, Figure 15 shows, in addition to results based on the baseline specification, the separate impact of negative and positive China shocks on global and EM variables.[19] These suggest that the impact of negative shocks is more substantial than that of positive shocks for all combinations of impact and response variables. For instance, while the impact of negative shocks in Chinese equities on the VIX is comparable to the overall baseline estimate of the effect, this separate estimation detects no impact of positive Chinese equity shocks on risk aversion. In the case of the impact of Chinese FX and economic data surprises on risk aversion, both the baseline and positive shock estimates reveal no effects, while negative developments in both raise global risk aversion.

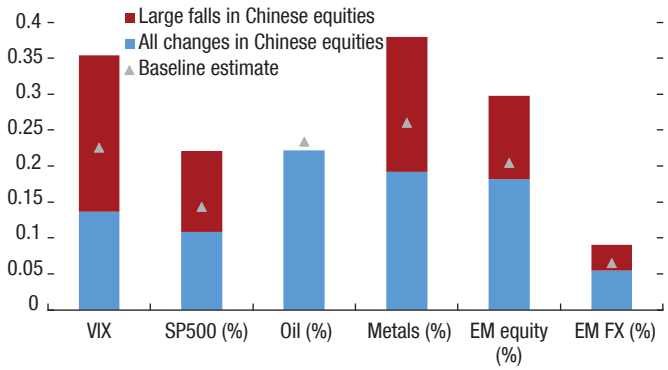
Digging even deeper, the analysis shows that large drops in Chinese equity markets have particularly pronounced effects on global and EM markets. The results shown in Figure 15 suggest that separately considering large falls in equities in the model estimation produces substantially larger effects.[20] This, together with the evidence of asymmetry above,

[18]See also IMF (2016a).

[19]These are obtained by replacing each of the three Chinese variables in the VAR model by two separate variables. The negative and positive variables take the values of their underlying variables when those are negative and positive, respectively, and take zero otherwise. The separate estimates of the impact of the negative and positive Chinese variables then allow differentiating between the effect of negative and positive developments in the Chinese markets and economy. See Mork (1989) and Hamilton (2003) for a similar econometric approach.

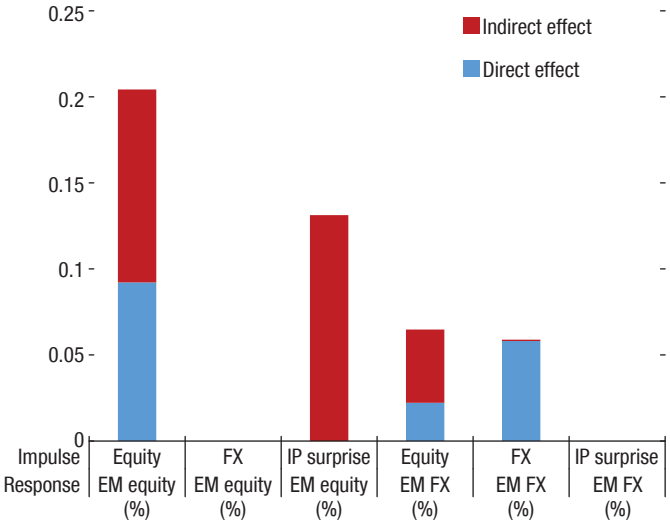
[20]Figure 15 depicts the results of an alternative specification that, in addition to the baseline version of the model, includes an additional variable for each of the three Chinese variables that equals the underlying variable when the latter is more than two standard deviations below its mean and zero otherwise. The figure stacks the impact of any change in Chinese equities and the "large falls" in Chinese equities and compares them to the baseline estimates of the effect of Chinese equities on global and EM markets.

Figure 15. Asymmetric Spillover Effects



Source: IMF staff estimates.

Figure 16. Role of Global Factors



Source: IMF staff estimates.

indicates that the impact of Chinese equities is not only asymmetric—it is especially pronounced during episodes of large equity falls.

A large share of the impact of Chinese financial market variables on EM asset prices occurs via their effect on the global markets. Figure 16 shows that about half of the impact of Chinese equities on EM asset prices and all of the impact of Chinese data surprises on EM equities occurs via their impact on global variables rather than directly.[21] Treating global variables as exogenous is thus not appropriate when investigating the role of an economy the size of China in global and EM financial markets.

There are indications of some differentiation in the external impact of economic and financial developments in China (Figure 17), consistent with the evidence using higher-frequency data. In particular, the VAR analysis indicates that the FX markets' reaction to Chinese developments is stronger the more dependent countries are on commodities. This is consistent with the finding above on the role of global variables, with a chunk of the estimated spillover effects from China going through global variables (VIX and commodity prices, especially metals) with differentiation through trade linkages.

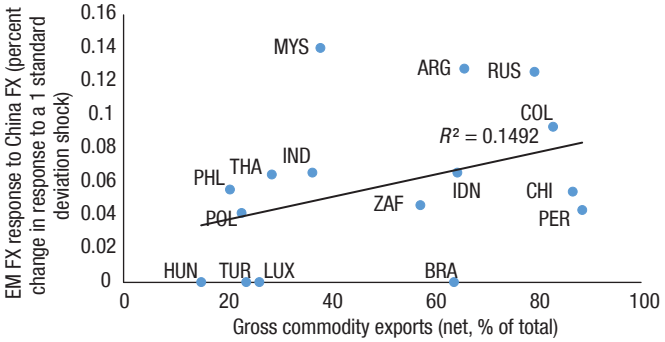
[21]Figure 16 shows the results of the baseline model combined with a model where all of the global variables are treated as exogenous. It attributes the impact of the Chinese variables in the latter model to direct effects, whereas the difference between the baseline model (where global variables are endogenous) and the exogenous model is attributed to indirect effects via the global variables.

Conclusion

Putting it all together, the empirical analysis above shows that economic and financial developments in China have an impact on global financial markets. These effects reflect primarily the central role China plays in goods trade and commodity markets, rather than China's financial integration in global markets and the direct financial linkages it has with other countries.

We found that the external impact of economic and financial developments in China on global financial markets is more pronounced for bad news than for good news, increases with the size of the shock, and

Figure 17. Role of Commodity Dependence



Source: IMF staff estimates.
Note: Data labels in the figure use International Organization for Standardization (ISO) country codes.

Figure 18. Financial Spillovers from China: Summary[1]

To the rest of the world	From China	Impact: Equity	Impact: FX	Impact: Bonds
Bonds	Domestic			
	Global			
Equity	Domestic			
	Global			
FX	Domestic			
	Global			
Differentiation				
Commodity Dependence		✓	✓	✗
Trade Exposure		✓	✓	✗
Financial Integration		✗	✗	✗
Fundamentals		✓	✗	✗

[1]The heat map summarizes the strength of financial spillovers from China. Global channels include VIX, oil prices, metal prices, U.S. S&P 500, and the U.S. 10-year yield. Color coding indicates relative strength of impact, with red highest, yellow medium, and green smallest. Gray color indicates results that are not statistically significant.

works largely through risk aversion and global commodity prices. While no asset market is immune to economic and financial developments in China, effects are felt most acutely in FX and equity markets. Countries most affected are those with deeper trade ties with China, especially Asian countries integrated in the global supply chain, commodity exporters, and EMs with weaker fundamentals (Figure 18).

This differentiation in the external effects of developments in Chinese financial markets seems to suggest that the estimated financial spillovers from China reflect primarily concerns about China's growth prospects rather than specific news about Chinese markets that would trigger a substitution of Chinese for foreign assets. Thus, improved communication of policy direction by the People's Bank of China since the beginning of 2016 may have dampened both the magnitude and frequency of these financial spillovers—as suggested by limited global market reaction to renminbi (RMB) depreciation during the second quarter of 2016.

Annex 1. Stress Test

System-Wide Analysis

The stress test envisages the following two scenarios:

- The first scenario assumes a15 percent loss rate on foreign banks' exposure to China, including total claims (ultimate risk basis), derivatives, guarantees, and credit commitments. This loss rate is similar to the one assumed in the April 2016 *Global Financial Stability Report* (GFSR) (IMF 2016a). The hurdle rate—the capital adequacy ratio (CAR) below which a banking system is considered in distress—is set at 6 percent of the Tier 1 capital ratio, consistent with the Basel III minimum capital requirements.[22]
- The second scenario considers a combined shock to foreign banks' exposure to China and Hong Kong SAR (dubbed "greater China"), given the strong economic and financial linkage between the two. Under this scenario, a 15 percent loss rate on these foreign holdings would not lower the Tier 1 CAR of BIS reporting banks below the minimum Basel III requirement of 6 percent.
- Quantifying spillovers. The global spillover effects of the two credit events above are derived using the approach developed by Espinoza-Vega and Sole (2010).
- Data. Banking systems' cross-border exposures are constructed on an ultimate risk basis using BIS data as of September 2015. The countries covered in the analysis are Australia, Austria, Belgium, Canada, Chile, France, Germany, Greece, Italy, Japan, Korea, the Netherlands, Spain, Sweden, Switzerland, Taiwan POC, the United Kingdom, and the United States. This list is not exhaustive because of limits in the number of BIS reporting banking systems, and thus there could be additional spillover effects through other banking system (such as Singapore and other Asian EMs).
- Channels. In addition to the direct credit loss from exposure to China, there are two indirect spillover channels: 1) through country A's banking system's credit exposure to another country B's banking system, which has substantial links to China's banking system, and 2, through country A's reliance on funding from country B's banking system.
- Assumptions. For loss rates between 30 and 70 percent on exposures to greater China, only the Taiwanese banking system would see its CAR fall below 6 percent. The impact on Taiwan POC's banking system would, however, be unlikely to spill over to other countries' banking systems even if they were to lose 100 percent of their holdings in and funding from Taiwanese banks, and those funding needs would be met through fire sales of assets with a 90 percent haircut on asset values.

[22]While it is ideal to use the common equity Tier 1 capital ratio (CET1 ratio), it is hard to obtain the cross-country aggregate data. Therefore, we use Tier 1 capital data at country levels as reported in the IMF's Financial Soundness Indicators database.

Annex 2. Diebold-Yilmaz Connectedness Index

Method

The Diebold-Yilmaz (2014) Connectedness Index defines country *j*'s spillover to or connectedness with country *i* as the fraction of the H-day-ahead forecast error variance of country *i*'s asset price that can be accounted for by innovations in the country *j*'s asset price. Based on a daily vector autoregression (VAR) and following the most recent Diebold and Yilmaz approach, an H-step generalized variance decomposition (GVD) matrix $D^{gH} = \left[d_{ij}^{gH}\right]$ is estimated with entries such as:

$$d_{ij}^{gH} = \frac{\sigma_{jj}^{-1} \sum_{h=0}^{H-1} \left(e_i' \Theta_h \Sigma e_j\right)^2}{\sum_{h=0}^{H-1} \left(e_i' \Theta_h \Sigma \Theta_h' e_i\right)}$$

where e_j is a selection vector with *j*th element unity and zeros elsewhere, Θ_h is the coefficient matrix multiplying the *h*-lagged shock vector in the infinite moving-average representation of the non-orthogonalized VAR, Σ is the covariance matrix of the shock vector in the non-orthogonalized VAR, and σjj is the *j*th diagonal element of Σ. The entries are then normalized such that they sum to one:

$$\tilde{d}_{ij}^{gH} = \frac{d_{ij}^{gH}}{\sum_{j=1}^{N} d_{ij}^{gH}}$$

This is necessary because in the GVD setting, shocks are not necessarily orthogonal and the sums of forecast error variance contributions are not necessarily unity. The connectedness of China to a particular country is the corresponding entry of the normalized GVD matrix. The impact on a group of countries is an average of the corresponding entries.

Estimation

The model is estimated based on daily data for three asset markets (local currency stock market, bilateral exchange rate vis-à-vis the U.S. dollar, and 10-year government bond yield) of 12 advanced (Australia, Canada, France, Germany, Italy, Japan, Korea, Singapore, Spain, Taiwan POC, United Kingdom, United States) and 16 emerging markets (Argentina, Brazil, Chile, Colombia, Hungary, India, Indonesia, Malaysia, Mexico, Peru, Philippines, Poland, Russia, South Africa, Thailand, Turkey) over the period of China tensions (January 1, 2015–February 2016). Given that the co-movement is assessed through a variance decomposition, the methodology does not allow the impact of exogenous factors, such as economic news from China, to be studied.

Given that shocks can lead to both an adjustment in asset price level and a spike in the uncertainty about it, the study focuses on both the co-movements in asset returns and the co-movement in asset volatilities. Asset return is defined as the difference in the natural log of stock prices and exchange rates and the difference in the yield on government bonds. Volatility is defined as the log of the annualized daily standard deviation based on the spread between high and low prices during the day,[23] e.g., for any country *i* on day *t:*

$$volatility_{it} = ln\left(100\sqrt{365\left\{0.361\left[\ln\left(P_{it}^{max}\right) - ln\left(P_{it}^{min}\right)^2\right]\right\}}\right)$$

Given that volatilities tend to be distributed asymmetrically with positive skew, it is necessary to take logs to ensure approximate normality, which is one of the VAR assumptions. The VAR is estimated over a rolling 150-day window with three lags, and the forecast is done 10 days ahead. Given the large set of variables, the VAR is estimated using the elastic net shrinkage technique.

Robustness

The results discussed in the text are robust to an alternative identification that uses the Cholesky decomposition (Annex Figure 2.1).

Annex 3. Event Study

Description of Events

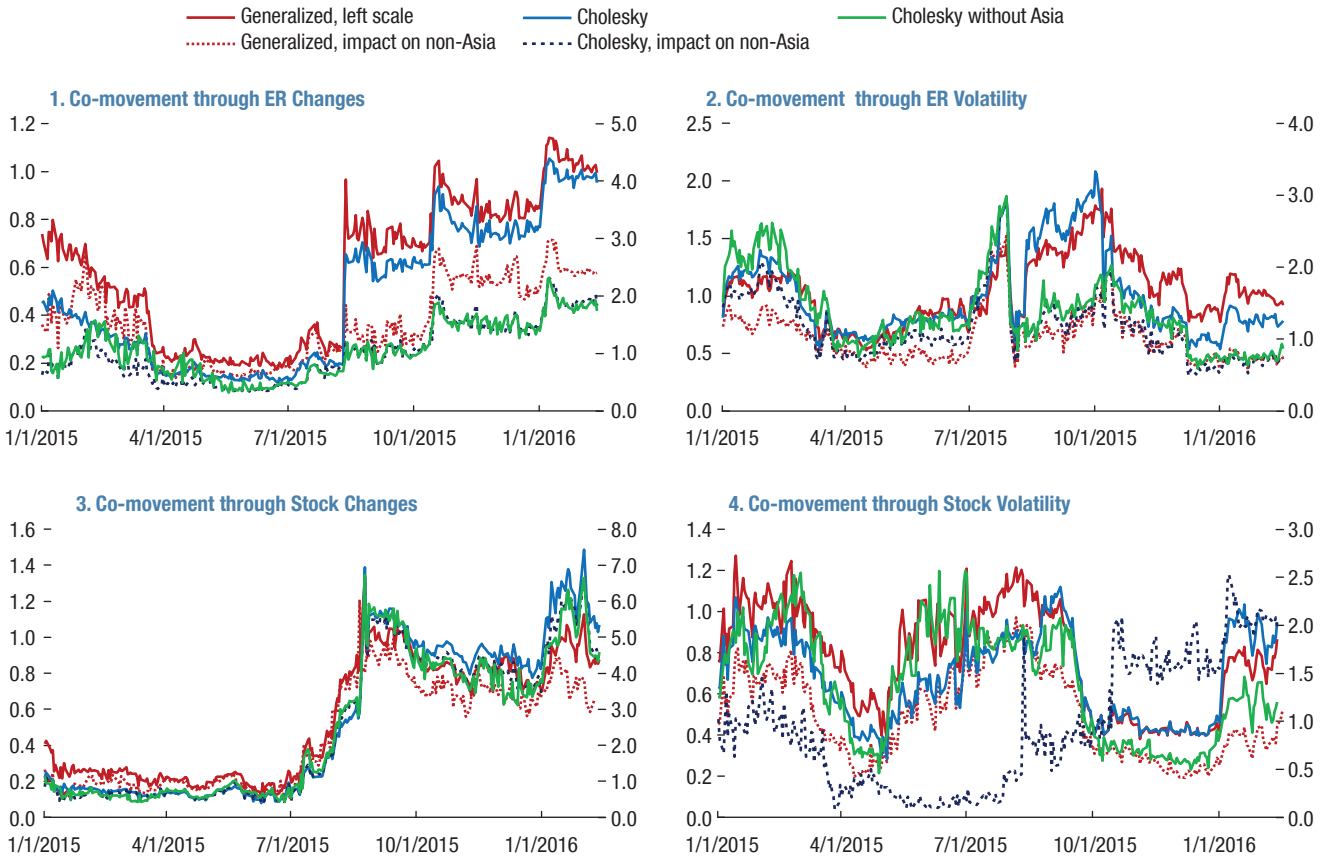
The events selected in this study contain both negative economic and financial events. These events are not necessarily related to global events, but more likely to be China specific, as shown in Annex Figure 3.1.

To identify financial shocks originating from China, we follow Arslanalp, Piao, and Seneviratne (2016) that identify exceptionally large changes in the Chinese stock market and the exchange rate related to domestic news and unrelated to global events from January 2001 to June 2016. These shocks originate from either real shocks (such as news about growth prospects) or pure financial shocks (such as news about a change in the exchange rate regime), or a mixture of both. An exceptionally large movement is defined as a daily change in the Shanghai Composite Index by more than 5 percentage points. To make sure these are unrelated to global

[23]Diebold and Yilmaz (2012), and Alizadeh, Brandt, and Diebold (2002).

Annex Figure 2.1. Robustness Checks[1]

(Share of forecast error variance due to China for an average country; within asset class co-movement)



[1]Generalized—standard specification, generalized variance decomposition Cholesky—variance decomposition with Cholesky ordering as follows: China, Asian AMs, Asian EMs, European AEs, European EMs, VIX and Western Hemisphere AEs, Western Hemisphere EMs. Choleksy on non-Asia—specification as above, but only show impact on non-Asia. Cholesky without Asia—specification excludes Asian AMs and Asian EMs in the estimation.

events, this definition excludes days when the U.S. stock market moves by more than one standard deviation just hours before the Chinese market opens (as a proxy for global events). Similarly, for the Chinese exchange rate, an exceptionally large movement is defined as a daily change in the onshore renminbi–U.S. dollar exchange rate by more than 0.5 percentage points. Similar to the approach for the stock market, to make sure these are unrelated to global events or simply movements in the U.S. dollar rather than the renminbi, days in which the U.S. Dollar Index (DXY) moves by more than one standard deviation against major Group of Ten (G10) currencies are excluded. Finally, a thorough news search is conducted to ensure that the selected China events occurred during days with major domestic news or policy announcements, as detailed in Annex 1 of Arslanalp and others (2016).

Economic news shocks are defined as the deviation of actual Purchasing Managers' Index (PMI) from consensus expectation (PMI surprise). Events are the economic news associated with a negative PMI surprise that is larger than –½ percent, which is the median of all the negative shocks in the sample. None of the events selected coincide with U.S. industrial production shocks.

Empirical Setup

Baseline Specification

$$\Delta F_{it} = \partial + \beta Event_t + \sum_{j=1}^{J} \delta_j Controls + \varepsilon_{it}$$

where F_{it} is alternatively the nominal effective exchange rates, equity returns, and long-term interest rates (domestic long-term interest rates, domestic long-term

interest rates for AEs, and Emerging Markets Bond Index yields for EMs).[24]

- *Controls.* The baseline regression controls for global financial volatility (VIX), U.S. equity benchmark returns (Standard & Poor's, or S&P, 500), commodity prices, and domestic short-term interest rates. To account for the indirect impact of China shock through global financial variables, e.g., VIX, S&P 500 returns and commodity prices, these variables are regressed on dummies of China's events. Residuals of the global variables are used as control in the regressions.
- *Sample.* Daily data from January 1, 2008, to March 16, 2016. We use two-day changes to account for the time differences between countries. To test if there is any structural increase in spillovers since June 2015, the sample is divided into two sub-samples.
- *Events* are treated as dummies in the regression. There are in total 16 equity shocks, 11 FX shocks, and 20 economic news shocks in the sample.

Spillover Channels

Four key potential spillover channels are tested: trade, financial, risk, and commodity-exporting channels. Countries are divided into high/low subgroups based their trade exposure, financial exposure, risk level, and commodity-exporting status.

- *Trade exposure* is measured by exports to China divided by GDP. Countries in the 75 percentile and above are considered to have a high trade exposure to China.
- *Financial exposure* is calculated as (portfolio + FDI + banks claims on China)/GDP. Countries in the 75 percentile and above are considered to have high financial exposure to China.
- *Risk level* is determined by indicators of country vulnerability.
- *Commodity exporters* are those countries with net commodity exports higher than zero.

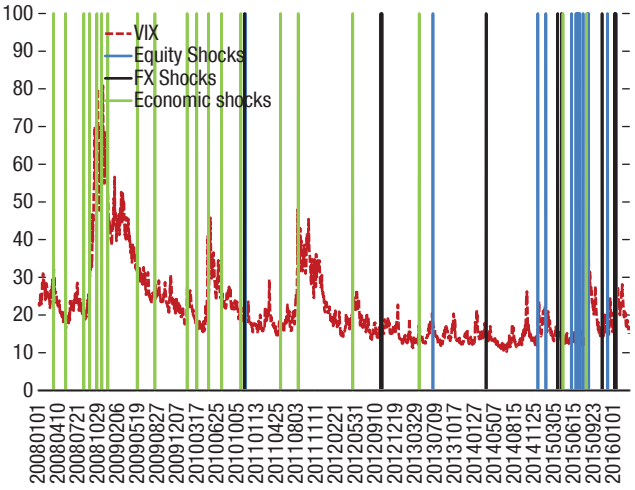
Annex 4. Vector Autoregression Model

The impact of Chinese financial market developments and economic news on global and EM markets is analyzed in a vector autoregression (VAR) framework. The baseline VAR includes three groups of endogenous variables: Chinese (equities, bilateral exchange rate against the U.S. dollar), global (VIX, S&P 500 stock index, U.S. 10-year yield, oil price and metals price index) and EM[25] (equities and bilateral exchange rate against the U.S. dollar). VIX and the U.S. 10-year yield enter the model as simple daily differences, whereas all the remaining variables are included as natural logarithm differences. The model also includes two exogenous variables: the surprise in Chinese industrial production (IP) data (calculated as the difference between the released value and the consensus forecast of the value at the time of release and zero on other days) and the Citi economic surprise index for the U.S. economy (which is an amalgamation of similar surprises in a variety of economic variables including GDP, IP, PMI, etc.).

The baseline model is run on daily data from January 1, 2005, through April 22, 2016, with five lags on both endogenous and exogenous variables. Variables are ordered chronologically for the Cholesky decomposition: Chinese variables followed by global variables and EM variables.[26]

All the results in the main text survive various robustness checks. Altering the number of lags in the model

Annex Figure 3.1. Selected China Shocks



Sources: IMF staff estimates.
Note: 16 events on major equity declines and 13 events on major FX fluctuation, and 20 large negative ceonomic news shocks.

[24]Using EMBI yields for EMs is due to the small country coverage of data on long-term interest rates among EMs.

[25]Argentina, Brazil, Chile, Colombia, Hungary, India, Indonesia, Malaysia, Mexico, Peru, Philippines, Poland, Russia, South Africa, Thailand, and Turkey.

[26]On any given day, Chinese markets generally close before U.S./most commodity/most EM markets open.

or replacing Chinese IP data surprises with the Citi economic surprise index does not materially affect the outcome. The baseline model specification includes the average daily returns on EM equities and exchange rates. The results do not differ substantially if the EM variable responses are instead calculated as averages of responses of individual EM country asset prices estimated in separate VAR models. Excluding Asian EM countries that do not follow the baseline chronological ordering of variables (since they are in the same or a similar time zone as China) from the EM average likewise produces similar results. Finally, placing the global variables ahead of the Chinese variables in the Cholesky decomposition ordering also qualitatively preserves the results regarding impact of China on EM asset prices.[27]

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[27]To preserve chronological ordering in this alternative setup, global variables are lagged one day when placed ahead of the Chinese variables. The resulting impact of the latter on the former is understandably different from that obtained in the baseline specification. Yet the impact of the Chinese variables on EM asset prices remains qualitatively similar.