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Shaghil Ahmed

Ricardo Correa

Daniel A. Dias

Nils Gornemann

Jasper Hoek

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Author/Creator

Shaghil Ahmed, Ricardo Correa, Daniel A. Dias, Nils Gornemann, Jasper Hoek, Anil Jane, Edith Liu, and Anna Wong

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Ahmed, Shaghil, Ricardo Correa, Daniel A. Dias, Nils Gornemann, Jasper Hoek, Anil Jain, Edith Liu, and Anna Wong

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Shaghil Ahmed, Ricardo Correa, Daniel A. Dias, Nils Gornemann, Jasper Hoek,
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Global Spillovers of a China Hard Landing[*]

Shaghil Ahmed   Ricardo Correa   Daniel A. Dias   Nils Gornemann

Jasper Hoek   Anil Jain   Edith Liu   Anna Wong

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October 2019

Abstract

This paper analyzes the potential spillovers of acute financial stress in China, accompanied by a sharp slowdown in Chinese growth, to the rest of the world. We use three methodologies: a structural VAR, an event study, and a DSGE model. We find that severe financial stress in China would have consequential spillovers to the United States and the global economy through both real trade links and financial channels. Other EMEs, particularly commodity exporters, would be hit the hardest. The U.S. economy would be affected to a lesser degree than both EMEs and other advanced economies, and the primary channel of transmission to the U.S. could well be adverse financial spillovers through increased global risk aversion and negative equity market spillovers.

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1. Introduction

China's prominence in the global economy has grown rapidly over the past 20 years. Since the country's entry into the World Trade Organization (WTO) in 2001, China's economy has become much more interconnected with the rest of the world and its aggregate and per capita GDP have more than quadrupled. No doubt, this remarkable economic rise has yielded many benefits to Chinese citizens through increased standards of living and poverty reduction. And it also has benefited many people around the globe, as China's low-cost labor has more efficiently made available a larger variety of goods to consumers all over the world.

Increasingly, though, China's growth has been credit-fueled and investment-focused, which has led to the development of notable financial vulnerabilities. In particular, there is now a large stock of nonfinancial corporate debt, the housing market appears overheated, and there is likely significant overcapacity in certain sectors. Non-traditional financial intermediation activities ("shadow-banking") have also proliferated involving opaque products, with traditional banks having deep connections to the shadow-banking activities and institutions. These developments leave the financial system heavily exposed to risky corporate and local government debt. Chinese authorities still have sizable resources to deal with potential problems, but policy space and buffers have diminished in recent years. All told, the increased financial vulnerabilities have raised concerns about a hard landing in China and the potential global spillovers from such an event in an increasingly trade- and financially-integrated world.

This paper first summarizes China's financial vulnerabilities (section 2) and the evolution of China's economic and financial linkages with the rest of the world (section 3). It then examines in section 4 the historical spillovers of Chinese equity markets to global (including U.S.) financial markets and undertakes an event study of the impact of Chinese events in recent years (such as the 2015-16 "China scare") that seemed to roil global financial markets. Without attempting to offer the likelihood of a hard landing, it then quantifies the potential transmission channels of two China stress scenarios ("adverse" and "severely adverse") to the rest of the world and, particularly, to the United States. We examine these spillover effects using two methodologies: The first is an estimated structural vector autoregression (SVAR) that identifies domestically-originated shocks to Chinese GDP after taking into account the effects of various global factors on Chinese GDP (section 5); the second is a dynamic stochastic general equilibrium (DSGE) model that combines

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information from the VAR and extra financial spillovers motivated by our event study to compute the "all-in" effects of Chinese stress scenarios (section 6). Section 7 of the paper concludes.

Our main findings can be summarized as follows. First, the VAR estimates suggests that the China adverse scenarios would have sizable effects on global variables in the expected direction. In particular, the dollar would appreciate, U.S. long-term yields would fall, global Emerging Market Bond Index (EMBI) spreads would rise, and world trade would fall (consistent with significant increases in EME risk premiums and safe haven flows to the United States, as well as China's importance in global trade flows). In addition, there would be a substantial fall in global oil and metals prices (consistent with China being a major source of global demand for commodities).

Second, the VAR estimates also suggest that the hit to economic activity in different countries and regions would generally be significant (consistent with China's strong trade links with other economies). More specifically, the output hit to EME commodity exporters would be about ¾ as large as the hit to China itself; to other EMEs would be about half; to advanced economies excluding the United States slightly more than a third; and only a relatively modest hit to the United States. The smaller U.S. effect reflects the U.S. economy being more closed, limited direct U.S. financial linkages to China, and greater capacity at the moment (than other advanced economies, say) to ease monetary policy to cushion the blow.

Third, our event study of the China 2015-16 episode suggests that despite the limited *direct* financial linkages of the United States with China, adverse scenarios in China, including a hard landing, could roil U.S. markets (and other markets around the world, for that matter) much more than the historical linkages embedded in the VAR suggest. Sustained depreciation of the Chinese currency and capital outflows from China during this episode had unusual reverberations for global markets, with significant declines in equities around the world, a retrenchment of global risk appetite, and fall in long-term advanced-economy yields.

Finally, once we amp up the financial spillovers in light of the China 2015-16 episode, our DSGE model simulations suggest that the hit to output abroad from adverse China events would be magnified, especially in the advanced economies. For example, output losses in the United States would triple from being modest to become about one-third of the hit to Chinese GDP. Thus, in the event of a China hard landing, the main effect on the U.S. economy could well be through asset price movements and changes in global risk sentiment.

Our paper adds to the literature on the spillover effects of a sharp slowdown in Chinese growth (See, for example, Ahmed (2017), Dieppe et al. (2018), Gilhooly et al. (2018), and Ma, Roberts, and Kelly (2017)). Our approach is most similar to Dieppe et al. (2018) and Gilhooly et al. (2018). Those papers use similar empirical methodologies to estimate the global spillovers from a slowdown in China, obtaining results quite consistent with ours. However, our paper is relatively more focused on economic and, especially, financial spillovers to the United States. A distinguishing contribution of our paper, is that we provide evidence of the growing importance of China's economic and financial linkages with the global economy.

This paper also supplements the literature on understanding the vulnerabilities of the unique Chinese financial system. (See Hsieh and Klenow (2009), Song et al. (2011), Manu et al. (2018), Li et al. (2014), Perry and Weltewitz (2015), Li (2016), and Ehlers et al. (2018)). This includes a focus, in particular, on developments in recent years during which policy space and the international reserves buffer have diminished in China, and developments in China have increasingly affected world financial markets.

2. Financial Vulnerabilities in China

China has developed notable financial vulnerabilities since the global financial crisis (GFC). The financial system has grown rapidly and become very large in both absolute size and in relative terms for China's level of economic development. These facts, by themselves, do not necessarily signal vulnerabilities but, on many fronts, developments in the Chinese financial system over the past several years are concerning. China's nonfinancial private credit has doubled since the GFC to more than 200 percent of GDP, a threshold that has often been followed by adverse consequences (Figure 1).[1] The country's stock of nonfinancial private debt is now second only to the United States in the world. Besides businesses being highly leveraged, household indebtedness is also rising. The banking system, which is now the largest in the world in terms of total assets (Figure 2), reports adequate buffers, but banks are heavily exposed to risky corporate and local government debt. Additionally, the large nonbank financial sector could be susceptible to liquidity

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[1] Almost half of the eleven countries that have sustained this level of debt experienced a financial crisis within five years of crossing this threshold.

problems and runs. It bears noting, though, that the Chinese government also has substantial resources to support any troubled financial and nonfinancial institutions.

Turning to an assessment of individual sectors, some vulnerabilities in the financial sector have increased since just before 2015-2016, when Chinese financial markets were shaken by the discrete devaluation of the renminbi, capital outflows, and the subsequent large movements in Chinese equity prices. Delinquencies are rising amid a slowing economy. Although banks' capital levels appear adequate, they may prove insufficient in the event of a more pronounced slowdown in economic activity, especially taking into account the banks' deep connections to shadow-banking activities and institutions. The Chinese shadow-banking sector is focused on credit intermediation through non-traditional products, such as wealth management products (WMPs).[2] These products compete with bank deposits for corporate and household savings, typically offering closed-ended instruments with short maturities (mostly under 3 months). An important portion of these products are guaranteed and marketed by banks. The proceeds of this funding are invested in longer-term assets such as corporate loans or bonds. The opaqueness of these products and the expectation that guaranteeing banks or the government will bail them out in periods of stress, may lead investors to underestimate their risks. Aware of these risks, Chinese regulators have recently focused on curtailing the growth of the riskiest activities with some success.

The nonfinancial corporate sector may have sizeable vulnerabilities. The corporate debt-to-GDP ratio has increased nearly 15 percentage points since the end of 2014 and stood in end-2017 at over 160 percent (Figure 3). Similarly, household debt has risen briskly due to the sharp increase in mortgage borrowing that has accompanied the rapid rise in house prices, especially in the largest cities. The household debt-to-GDP ratio has jumped almost 14 percentage points since the end of 2014 and has reached a level (more than 50 percent of GDP) that is high for an EME.

Balancing these vulnerabilities are strong positions in the external and sovereign sectors. China has more than $3 trillion in foreign exchange reserves and a current account surplus. Reserves have fallen in recent years, but their level remains high.

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[2] The main products in the Chinese shadow-banking sector are trust company loans, entrusted loans, and wealth management products (WMPs). Trust companies manage assets for high-net individuals and institutions and invest in a range of products including bank loans and corporate bonds and loans. Entrusted loans are loans made by one nonfinancial firm to another nonfinancial firm with a bank serving as an intermediary. WMPs are short-term investment products, often marketed by banks that invest in both equity and fixed income products.

The ultimate backstop for a financial stability event is intervention by the sovereign. In China, such intervention is easier because the government has significant resources, the financial system is closed—with little dependence on borrowing from abroad—and largely state-controlled. However, China's fiscal space has decreased in the past five years. To be sure, it still has a relatively low ratio of official fiscal debt of about 40 percent of GDP that has not changed substantially since 2014 (Figure 3). But this debt stock does not include off-budget fiscal items such as the liabilities of local government financing vehicles (LGFVs).[3] After adding these off-balance sheet items, the augmented sovereign debt level is an estimated 68 percent of GDP, which is on the high end for other emerging market economies, albeit low compared to advanced economies.

The sizeable vulnerabilities in the Chinese financial system could be fertile ground for an event that threatens financial stability.[4] We do not analyze the possible triggers for such an event, because they are difficult to predict. Under the current circumstances, some potential examples of triggers include a series of local government and corporate bond defaults that dent consumer and investor confidence, a large property sector bust hurting consumer investment and spending, and a further escalation of trade tensions hurting corporate profits and spending. Any of these triggers could precipitate the sharp and stressful slowdowns in the economy that are analyzed in our scenarios.

3. China's Linkages with the Rest of the World

3.1. Evolution of China's economic and financial importance

China's global importance has grown rapidly over the past 20 years. Since becoming a member of the WTO in 2001, China has increased its footprint on the global economy through both trade and financial channels. To quantify the evolution of the relative importance of China across many dimensions, we construct a time-series of rankings of countries based on financial and macroeconomic indicators. The ranking is composed of indicators grouped into three categories:

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[3] LGFVs are entities founded by local governments to finance projects on their behalf. They enjoy implicit debt repayment support, but are legally separate from the government. The use of these off-budget vehicles has greatly expanded after the GFC. In recent years, the central government has attempted to clamp down on this off-budget borrowing by prohibiting local governments from providing support to LGFVs, while at the same time allowing local governments greater leeway to borrow on-budget. Nonetheless, LGFV borrowing has continued to grow.

[4] A financial stability event encompasses financial crises and other periods of financial stress, not officially classified as crises, that create notable financial disruptions.

size, interconnectedness, and U.S. interconnectedness. The first component measures how big a country is on various metrics. The second component measures the overall linkages of a country to other economies based on the indicators used. And, the third component focuses more specifically on a country's linkages with the United States. Our motivation for distinguishing between the second and third components is that it helps to identify to what extent the United States may be directly exposed to a particular country, such as China, versus how it might be indirectly affected by a country through that country's links to other countries that are also linked to the United States.

To construct the rankings we use information from the Bank for International Settlements (BIS), Bloomberg, Haver Analytics, and the International Monetary Fund (IMF). The size category is comprised of a measure of real GDP, equity and bond market capitalization, and the size of the banking sector and other non-bank financial institutions. For interconnectedness we use measures of trade, foreign direct investment, and cross-border portfolio investments and bank loans.

The methodology to rank countries follows a multistep approach. First, countries are ranked based on each individual data series for every year. Second, rankings are averaged across these series within each category (and year) and countries are ranked again based on these averages. Last, the average ranking across the three categories is calculated and this average is used to construct the overall ranking.[5]

Figure 4 presents the index for China between 2000 and 2016. China starts in the early 2000s ranked in the 15th place amongst our sample of 176 countries, but by 2016 it ranked sixth. The largest gains were in size and overall interconnectedness. Although, China has become more connected the United States, it still lags compared to the linkages that United States has with other advanced economies. This property suggests that indirect linkages of China with the United States through countries that both the United States and China are connected with maybe quite important. The evidence, thus, highlights not just the growing importance of China in the global financial

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[5] If at least two of the series in the size category have observed values (i.e., are not missing) for a country in a given year, then we calculate the size ranking for that country; otherwise we set that ranking to missing. For the interconnectedness and U.S. interconnectedness series, we require a minimum of 4 observed values to calculate the ranking for the country in a specific year. To calculate the overall ranking for a country, we require at least two categories with non-missing rankings.

system but how the stronger ties between China and the rest of the world could amplify the transmission of shocks originating in China to the United States.

3.2.   U.S. financial institutions' exposures to China

The international banking literature has noted that shocks can be propagated through the activities of global financial institutions (Buch and Goldberg, 2015; Cetorelli and Goldberg, 2012; Correa, Sapriza, and Zlate, 2012). To assess the importance of this transmission channel in the spillovers from China to the United States, we describe the direct and indirect exposures of the U.S. financial sector to Chinese residents. We use information on consolidated banking exposures from the BIS Consolidated Banking statistics. For U.S. banks, these bank exposures are collected in the Federal Financial Institutions Examination Council (FFIEC) 009 report and bank capital information is aggregated using the reporting in the FFIEC 031 and FR Y-9C forms.

As shown in Table 1, consolidated U.S. bank claims on Chinese and Hong Kong residents totaled $170 billion, or 10 percent of the reporting banks' Tier 1 capital, at end-June 2018.[6] Individual exposures of U.S. global systemically important banks (G-SIBs) range between 1 and 26 percent of Tier 1 capital. These direct exposures of U.S. financial institutions to Chinese residents seem rather modest.

However, stress in China could also spill over to the United States indirectly through the exposure of other financial systems to China, to which in turn the United States may have significant exposure. Banks in the United Kingdom and Singapore have the largest exposures to China and Hong Kong (Table 2), with claims representing 95 percent and 277 percent of these banking sectors' Tier 1 capital, respectively.[7] However, U.S. banks, in turn, do not have very large direct exposures to banking sectors of these economies (Table 3), with claims on U.K. banks, for example, representing 2 percent of U.S banks' Tier 1 capital.

Beyond banks, other U.S. financial institutions are also exposed to China through holdings of Chinese financial assets. These exposures, totaling about $114 billion, are mostly of equity securities and most of those securities are held by mutual funds. The total exposure of all U.S.

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[6] Note that the FFIEC 009 report provides a conservative measure of exposures. Claims are only adjusted for explicit third-party guarantees, near-perfect hedges, and certain liquid collateral held outside the country of the borrower.
[7] To calculate the claims as a percentage of a banking sector's tier 1 capital, we use data on capital from the IMF financial soundness indicators.

financial institutions only represents 3 percent of their foreign securities portfolio and 0.2 percent of their total portfolio. So, adding in indirect exposures does not seem to significantly make the United States more at risk in the event of Chinese financial institutions getting into trouble.

U.S. banks can also be indirectly exposed to China through claims on commodity exporters, which benefit by a notable demand from Chinese residents. U.S. bank exposures to EME commodity exporters totaled almost $300 billion at the end of June, 2018 (Table 4), and the U.S. financial sector holds about $522 billion in securities issued by those countries. These amounts, although large in absolute terms, represent a modest fraction of banks' Tier 1 capital or of their overall portfolio. Of note, this analysis does not take into account the effect of changes in commodity prices on the creditworthiness of U.S. energy exploration and production companies, agricultural businesses, and other commodity producers. Importantly, this channel may have a larger impact on U.S. banks.

Another potential transmission channel from China is through activities of Chinese banks in U.S. short-term funding markets. U.S. branches of Chinese foreign banking organizations (FBOs) in the United States have grown quickly in recent years (Figure 5), but remain relatively small (Figure 6).[8] Some of their funding is sourced from U.S. money market mutual funds (MMFs). MMFs exposure to Chinese financial institutions was $5.6 billion at the end of May 2018 (Table 5), mostly in unsecured instruments (such, as time deposits).

3.3 Financial market spillovers

Given limited exposure of U.S. financial institutions to China, to the extent that problems in China could lead to a hit to the U.S. economy and financial system, they would likely come through direct trade links and any disruptions to global (including U.S.) financial markets that a China distress scenario may engender. Such disruptions in U.S. financial markets from troubles in China are not implausible, given the "China scare" episode of 2015-16 when concerns about China seemed to trigger movements in asset prices globally. Therefore, part of the new analysis in this paper is to examine the linkages between Chinese and U.S. equity markets, both historically and in the volatile period of 2015-16, which we undertake in the next section.

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[8] Data on the balance sheets of U.S. branches of foreign banks are collected in the FFIEC 002 report. This information is made public through the National Information Center website.

4. Spillovers through Equity Markets

4.1. Methodology and results

We analyze the significance of equity market using a variance decomposition approach proposed by Diebold and Yilmaz (2009, 2012). As a simple example of the method, assume that the returns of the headline equity indexes for China and the United States follow this first-order VAR process:

$$r_t = \varphi r_{t-1} + \epsilon_t \qquad (1)$$

where $r_t = (r_{US,t}, r_{CN,t})$, φ is a 2x2 matrix of coefficients, and $\varepsilon \sim (0, \Sigma)$, with $\Sigma = \{\sigma_{i,j}, i, j = 1,2\}$, are independently and identically distributed disturbances.

The goal of the variance decomposition method is to assess the impact of orthogonal shocks to each country on other countries' forecast errors. To do so, we rewrite Eq. (1) as a moving average, as follows:[9]

$$r_t = A(L)u_t \qquad (2)$$

where $u_t = Q_t \varepsilon_t$ are orthogonal shocks. As in Diebold and Yilmaz (2012), we use the generalized approach of Koop, Pesaran, and Potter (1996) and Pesaran and Shin (1998) to recover Q_t.[10]

Using the structural parameters retrieved from the matrices $A(L)$ in Eq. (2), we can construct the forecast error variance of U.S. stock returns as:

$$Var(e_{US,t+1,t}) = a_{US,CN}^2 + a_{US,US}^2.$$

This expression shows that a fraction of the U.S. forecast error variance is explained by domestic shocks, as in $d_{US,US} = \frac{a_{US,US}^2}{a_{US,CN}^2 + a_{US,US}^2}$, while another fraction is explained by shocks in China's stock returns, as in $d_{US,CN} = \frac{a_{US,CN}^2}{a_{US,CN}^2 + a_{US,US}^2}$.

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[9] The moving average representation is obtained under the assumption that r_t is a covariance stationary process.

[10] This approach shocks one variable at a time and integrates out the effects of other shocks using the historically observed distribution of the errors. This method has two desirable characteristics. First, the orthogonalization (and, therefore, the impulse-response functions) does not depend on the ordering of countries in vector r_t, which is a typical way in which structural shocks are identified in a structural VAR. Second, the orthogonalization obtained with this method is unique, in the sense that there is no other matrix Q_t that satisfies the identification conditions.

We use weekly local-currency-denominated headline indexes for 22 countries. The sample is composed of 13 advanced economies (AFEs), 6 emerging markets (EMEs), plus China and the United States. We estimate the VAR using 52-week (backward looking) rolling windows between January 1996 and October 2018. The share of the one-week ahead forward variance explained by shocks originating in China ($d_{X,CN}$) are plotted in Figure 7. We report the share of the forecast error variance grouped for AFEs and EMEs, and separately for the United States.

The main takeaway from the this exercise is that, as with direct exposures of financial institutions, the impact of shocks to Chinese equity markets on equity markets elsewhere does not appear to be outsized according to the historical experience. For the three groups of countries analyzed, emerging markets, the United States, and other advanced economies, the share of the forecast error variance explained by China has increased in recent years but still remains very small, ranging from 2-5 percent.

4.2. Event study analysis

The historical experience notwithstanding, we know that some Chinese events in recent years (for example, in 2015-16 as noted earlier, but others too) have created substantial volatility in global financial markets. Therefore, we proceed to conduct a more detailed event study analysis to quantify the impact of specific recent shocks originating in China on global asset prices and exactly how outsized they are compared to historical experience. We identify five recent events in China that precipitated dramatic reactions in global financial markets:

(1) Sudden credit crunch affecting China's commercial banks on June 20, 2013, as indicated by the Shanghai interbank overnight lending rate shooting as high as 30 percent from the usual rate of less than 3 percent.

(2) Following substantial losses in Chinese equity markets, an acceleration of capital outflows, and amid global concerns about Chinese growth, Chinese authorities implemented a sudden, discrete 2 percent devaluation of the Chinese renminbi against the dollar on August 11, 2015.

(3) A few weeks later, on August 24, a precipitous drop in the stock market that became known as "China's Black Monday" occurred, where the Shanghai stock index declined by almost 8.5 percent of its value.

(4) and (5) Two large and sudden declines in the Chinese stock market of above 7 percent between January 4 and January 7, 2016 that led to the trigger of automatic circuit breakers that halted trading.[11] Capital outflows continued during these episodes.

Table 6 reports the changes and percent returns for select global financial assets and indicators before and after the Chinese events previously described.[12] We find that during these events the broad dollar index appreciated about ¾ percent, with larger appreciations against EME currencies than AFE currencies. In addition, world equity markets fell between 3 percent and 4½ percent, and investor risk appetite as measured by the VIX and VDAX decreased. Along with the significant declines in global equities and a retrenchment of global risk appetite, we find that flight to safety flows lowered long-term AFE yields, as negative market shocks from China spilled over to assets abroad.

To put the above numbers into perspective, the spillovers from the China market turbulence roughly corresponds to the 1 percent tail of the distribution for each financial asset, computed from the overall historical experience discussed in the previous subsection. Given these extreme outcomes relative to the overall historical experience, in some of our simulations later, we use the estimates from these tail events to calibrate the impact of financial stress in China on financial variables in the rest of the world to examine the spillovers of tail events in China.

5. Aggregate Channels of Transmission and Their Importance

In this section, we take a holistic approach to assess the potential spillovers of a Chinese growth slowdown precipitated by financial stress in the country on the rest of the world. To get a detailed picture, we need to estimate the effect of such an event on a large set of global and country-specific macroeconomic and financial variables. This poses a methodological challenge because most

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[11] The automatic circuit breakers led to a halting of trading for brief periods and also led early in the day on July 7, after a quick 7 percent decline, to suspension of trading for the remainder of the day. The circuit breakers were later abandoned because, outside of the period when trading stood suspended, they appeared to increase volatility.

[12] Using price quotes from Bloomberg, we compute the market return and level changes from the previous day's Close (4pm, Eastern Standard Time) to the event day's Open (9am, Eastern Standard Time). This uniform time horizon allows us to capture the pre-market open in China (4am, China Standard Time) and post-market close (9pm, China Standard Time), even though the European markets and US markets continue trading after the end of our event window. This timing convention is used for all assets in Table 6 except for U.S. corporate spreads which is previous day close (4pm, Eastern Standard Time) to the event day close (4pm, Eastern Standard Time).

empirical methodologies can only simultaneously handle a limited number of variables.[13] We overcome this challenge by using a two-stage approach—specifically a two-stage SVAR—that allows us to estimate the effect of a China GDP growth slowdown on a large number of macroeconomic and financial variables.[14]

5.1.   Methodology

5.1.1. First stage

In the first stage, we use an SVAR model to decompose Chinese GDP into foreign- and domestically-originated shocks and then analyze the effects of exogenous shocks to Chinese economic growth on a set of global variables. U.S. monetary policy shocks, autonomous changes in global risk sentiment, commodity price changes originating in the rest of the world, and foreign fiscal policy shocks are examples of foreign shocks to China's GDP. Exogenous changes in China's aggregate productivity or in credit conditions are examples of domestic shocks to China's GDP.

Specifically, we estimate a nine-variable VAR model, using quarterly data.[15] Of these nine variables, eight represent global financial and macroeconomic conditions—U.S. long-term yields, broad nominal dollar, VIX, EMBI spreads, oil price, metals prices, GDP growth for the G7 economies, and growth of global imports excluding Asian EMEs—and the remaining variable is Chinese GDP growth. In order to have greater confidence that we have identified exogenous domestically-originated shocks to Chinese GDP, we assume that Chinese GDP growth is affected contemporaneously (within the quarter) by all other variables, but that Chinese GDP growth can affect the other variables only with a lag.[16] That is, Chinese GDP growth comes last in a recursive contemporaneous causal ordering. Any change in China's GDP growth that cannot be accounted for by developments in these global indicators is taken to originate from domestic factors. After

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[13] A methodology that allows using a very large number of variables is the factor augmented VAR (FAVAR) of Bernanke et al. (2005). We opted for not using this methodology, because the interpretation of the factors in the model is unclear and this would make it difficult to interpret the structural shocks in the model.

[14] One limitation of our approach is that we do not take into account the correlations between all the variables that we are interested in analyzing. An alternative methodology that would account for such correlations is the GVAR (Global Vector Autoregressive) model. The reason why we opted for not using GVAR model, is that this methodology limits the number of variables per country/economic block that can be studied. However, Ericsson et al. (2014) use both a VAR and GVAR model to study the effects on global growth of a China GDP growth slowdown and find that the results based on the two models are broadly comparable (especially in the short- to medium-term).

[15] Appendix A provides a more detailed description of the VAR model and how the shocks are identified.

[16] The eight global variables are ordered as follows: U.S. long-term yields, broad nominal dollar, VIX, EMBI spreads, oil price, metals prices, G7 economies GDP growth, and growth of global imports excluding Asian EMEs.

identifying exogenous Chinese GDP shocks, the effects of these shocks on the global variables included in the model are traced out.

5.1.2. Second stage

In the second stage, we estimate numerous other two-variable SVAR models, with one variable always being the identified domestic shock to China's GDP growth from the first stage model and the second variable being different outcome variables, in turn. These second outcome variables could be other global variables of interest that are not included in the first-stage model or country-specific variables (most notably GDP growth of different countries). The second-stage models are then used to trace out the effects of a Chinese GDP growth shock on these other outcome variables of interest. Since we have already identified exogenous Chinese GDP growth shocks from the first stage, we feel comfortable in putting them first in the causal ordering in the second-stage SVARs.

5.2. Results

First, note that, in both stages we include a constant term, a linear trend, and a dummy variable for the years 2008 and 2009 to account for the GFC. We include the linear trend to account for possible trends in the data (e.g., China's GDP growth rate has been on a downward trend), and we include the GFC dummy variable because we see the GFC as an extreme event and we do not want the analysis to be overly influenced by this period/event.[17]

5.2.1. First-stage results

Figure 8 shows the response of all the variables included in the VAR model to a negative unit China GDP shock (equivalent to 1 percentage point decrease in quarter-on-quarter Chinese GDP growth). Starting with the financial variables, our results show that, in response to a surprise decrease in China's GDP, U.S. long term yields decrease, the dollar appreciates, and the VIX and EMBI spreads both increase, as would be expected. Our results also show that both oil and metals prices decrease substantially following the adverse China output shock, a result that is also not surprising given the importance of China for global demand for commodities. We also find that a

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[17] During the GFC, the correlation between some of the variables and China's GDP was very strong, which translates into larger estimated effects of internally-originated shocks to China's GDP on some of the other variables (both variables analyzed in the first-stage and variables analyzed in the second stage) when the GFC dummy variable is not included in the model. We discuss these differences in Appendix B.

negative China GDP surprise pushes both aggregate G7 GDP growth and world trade excluding EME Asia lower.

These results suggest that an adverse China GDP shock is akin to a negative global demand shock, pushing U.S. long-term yields, commodity prices and economic activity indicators lower. Moreover, the responses of the dollar, the VIX, and the EMBI spread are consistent with a negative China GDP surprise leading to a retrenchment of global risk appetite. The fall of U.S. long-term yields is also consistent with a decrease in global risk appetite, as safe-haven capital flows from risky to safe assets push these yields lower).

How much of the fluctuation in global variables and in China's own GDP growth be explained by domestic Chinese growth shocks? To address this question, we compute the forecast error variance decompositions (FEVD) of the variables in the VAR model.

The results, presented in Table 7, show that, overall, fluctuations in China's GDP growth account for a significant proportion of fluctuations in several of the global variables included in the model, especially considering that China's GDP is just one source among all other possible sources of fluctuation for these global variables. Of the variables included in the first-stage VAR, fluctuations in China's GDP growth are most important for fluctuations in the dollar and the EMBI spreads, as well as for commodity prices and world trade.

For the decomposition of China's own GDP growth, it is interesting that about a quarter (over the short run) to half (over the longer run) of the fluctuations are accounted for by external shocks. This is consistent with China being a conduit of global demand because of its importance in global supply chains.

5.2.2. Second-stage results

Our second-stage results, presented in Figure 9, focus on the effects of Chinese growth on growth elsewhere in the world.[18] A negative Chinese GDP shock brings down substantially growth of EMEs elsewhere, especially those of commodity exporters. Growth in advanced foreign

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[18] The confidence intervals shown in Figure 9 (and also in Figure A1 in the Appendix) should be seen as a lower bound for the real size of the 90% confidence intervals around the estimated impulse response functions because we did not account for the fact that the China GDP socks were estimated in the first stage. Ultimately, what these confidence intervals tell us is that the effects of a China GDP slowdown are quite uncertain, and therefore any policy response to such an event should take this high degree of uncertainty into consideration.

economies other than the United States is also affected significantly, while the effect on U.S. growth, although still negative, is more modest.

Similar to what we did in the first stage, we also compute variance decompositions for the second-stage outcome variables. The results are presented in Tables 8. As can be seen from this table, China's GDP growth shocks account for a significant proportion of growth fluctuations in other EMEs (especially commodity exporters) but much less so for advanced economies (especially the United States).

The results in Figure 9 and Table 8 are consistent with growth in EMEs being highly connected to China's economic growth, especially through commodity trade linkages, and with AFEs economies being on average more open than the United States, and therefore more exposed to shocks from China affecting global trade. Therefore, not only EMEs' GDP responds more to developments in China's economy than that of AFEs and the United States, volatility in EMEs' GDP is more linked to volatility in China's GDP that that of AFEs and the United States.

5.2.3. Spillovers of a China GDP growth slowdown

To analyze the global spillovers from a financial distress scenario in China, we first need to identify concretely the impact of the distress scenario on China's own GDP growth. Specifically, we consider two different hypothetical scenarios with varying levels of distress that are calibrated to different points of the historical distribution of growth slowdowns following financial distress. In the "adverse" financial distress scenario, we assume a 4 percent decline in output relative to baseline, which corresponds to the 50th percentile of growth slowdowns in the distribution of historical financial crises.[19] Whereas, in the "severely adverse" financial distress scenario, we assume an 8½ percent decline in output relative to baseline, which corresponds to the 80th percentile of historical growth slowdowns during financial crises.

We use these two scenarios to quantify the potential effects of extreme events in China on the global economy, based on the VAR models described in the previous sub-sections. Specifically, to estimate the spillover effects of the two adverse scenarios for China's GDP, we simulate a sequence of shocks to China's GDP growth rate that generate a response of China's GDP equal to

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[19] We estimate the historical impact on growth of financial crises by computing the difference between the average annualized real GDP growth in the two years prior to a financial crisis with the average real GDP growth in the two years after a financial crisis. The financial crisis episodes are taken from the database compiled by Reinhart and Rogoff (2011) and Laeven and Valencia (2013).

that assumed in each scenario and shown in Figure 10. We then feed the two sequences of shocks (one for each scenario) into the estimated SVAR models to obtain an estimate of the response of the variables of interest to these shocks. Figure 11 shows the response of GDP for various regions/countries and Figure 12 shows the response of several financial variables.

The results shown in Figure 11 show that the hit to economic activity around the world can be quite substantial. The effects on U.S. GDP are relatively modest, while those on AFE GDP are more than twice larger than that on the U.S. In the severe scenario and relative to the baseline, U.S. output declines by slightly more than 1¼ percent and AFEs output declines by more than 3¼ percent (just over a third of the hit to Chinese GDP itself). GDP in other EMEs falls close to 6 percent below baseline, over two-thirds of the decline in Chinese GDP. Among EMEs, EME commodity exporters are hit much harder than EME commodity importers.

Turning to the effects on financial variables (Figure 12). U.S. long-term yields fall substantially, which suggests that the negative effects on yields of increased flows into safe-haven assets dominates the positive effects of any Chinese sell-off of reserves. Global EMBI spreads rise, with a peak increase of over 350 basis points in the severe scenario, and risk aversion (as measured by the VIX) increases substantially. The broad nominal dollar appreciates (about 7 and 15 percent in the mild and in the severe scenarios over roughly two years, respectively). Finally, with China a key driver of world commodity demand, oil and metals prices tumble in both scenarios.

6. DSGE Model Simulations

The event study analysis we discussed earlier, particularly the China 2015-16 episode, suggests strong spillovers from China to global financial markets. Thus the VAR could be underestimating the effects on U.S. real GDP in the event of a China crisis occurring in the current global financial environment. Therefore, we use the Federal Reserve Board's open economy SIGMA model to simulate the spillover effects on real GDP to the rest of the world of a Chinese crisis incorporating the interactions found in the VAR in combination with the stronger financial spillovers suggested by our event study analysis of the 2015-16 Chinese scare.[20]

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[20] SIGMA is a medium scale open-economy dynamic stochastic general equilibrium model in the tradition of Christiano, Eichenbaum, and Evans (2005). The version we use consists of three blocks, which are structurally identically, but calibrated differently to capture the U.S. economy, the advanced foreign economies (or AFEs), and

Different scenarios in SIGMA can be generated through shocks to, for example, exchange rate risk premiums, household confidence, and corporate spreads. As the current version of SIGMA has only an aggregate EME block, we use the results from our SVAR to construct an overall EME GDP response to a financial stability event in China. In each simulation, we feed in a series of shocks to the EMEs in our SIGMA model to mimic the response in each of our two Chinese adverse scenarios.[21] Therefore, the GDP responses of the EMEs, shown in Figure 13, Panels A and B, are by construction identical to the ones embedded in the SVAR analysis.

We start by simulating SIGMA under the assumption that no additional shocks occur. In this case the United States and the AFEs are only affected by standard trade channels built into our SIGMA model and the small endogenous response of financial variables that is embedded in SIGMA. We then re-run the simulations with additional shocks to the corporate and currency risk premiums in the U.S. and AFE blocks, calibrated to capture both flight-to-safety flows and other spillovers to global financial markets motivated by the China 2015-16 episode. Panels C and D of Figure 13 show the effects of AFE and U.S. GDP under both assumptions. Starting in the scenario without the additional financial effects, in the Chinese "medium adverse" scenario, U.S. real GDP (panel D) would fall a maximum of about 3/4 percent below baseline and in the "severely adverse" scenario by about 1 percent. The U.S. responses without financial spillovers are significant but not large.[22] AFE output falls by about ¼ percentage point more than that of the United States in the two scenarios with standard spillovers.

The adverse effects on advanced economies from a financial stability event in China are notably bigger if turmoil in China causes reverberations in other financial markets around as those implied by the event-study we presented earlier of the 2015-16 episode. The solid lines of panels C and D

the EMEs. In addition to many other features the model contains a financial sector that assigns an explicit role to financial shocks in driving the economy. Monetary policy in each block follows a Taylor rule and can be simulated subject to an effective-lower-bound (ELB) constraint. For a more detailed discussion of the elements of the model please see Erceg, Guerrieri, and Gust (2006), which describes the basis for the current model. The extensions most relevant for the current simulations are contained in Erceg, Guerrieri, and Gust (2008), Gust, Leduc, and Sheets (2009), Erceg and Lindé (2010), Bodenstein, Erceg, and Guerrieri (2011).

[21] We also used a set of shocks hitting the economy 2 years before the crisis begins to place the model into an initial condition similar to the world economy in mid-2018. This matters for the possibility of a binding zero lower bound in the simulations. All simulation results are reported as deviations from the paths implied by those initial shocks. We used data from Haver Analytics and the World Economic Outlook to construct that baseline.

[22] The GDP losses occur despite an accommodative U.S. monetary policy response, which follows the model's policy reaction function.

depict this for both a medium and hard landing scenarios in China. U.S. GDP falls a bit more than 1 percent in the medium scenario and shy of 3 percent in the hard scenario; these effects are about a third of the hit to the Chinese economy. In AFEs, output falls by about 1½ and 3¾ percentage points in the two scenarios, respectively.

According to these results, the spillovers to advanced economies as a whole from a China crisis and associated problems in other EMEs would be significantly bigger than we have observed in previous EME crises. One obvious reason for the bigger response is the rising share of China and other EMEs in global GDP and trade. Another important reason for stronger spillovers could be the limited scope for monetary policy to respond appropriately to negative shocks in several advanced economies. While the U.S. policy rate is now sufficiently away from the ELB, the constraint on monetary policy in the AFEs becomes binding in the simulation for the hard landing scenario with financial spillovers.

In Panels E and F of Figure 13, we show the response of AFE real GDP (Panel E) and U.S. real GDP (Panel F) under three assumptions. The red line represents the effect in the hard landing in the presence of the ELB.[23] The green line shows the response of GDP if the effective lower bound was not binding, but the calibrated shocks stay the same. Finally, the black line illustrates the effect on GDP if we would rescale the shocks to match the same targets as in the main simulation. There are two takeaways from the figure. First, the ELB, if not accompanied by QE, forward guidance, or fiscal policy changes, results in far worse outcomes for the advanced economies as GDP falls by an additional percentage point. Even fixing the size of the crisis in the emerging markets, GDP in the advanced foreign economies falls by ¾ percentage points more. Second, while the ELB scenario might provide an upper bound on the effects of constraint policy (abstracting from an debt-sustainability issues that might arise in some advanced economies), the re-scaled simulation in the absence of the ELB might give us a good sense of 'best' case scenario in which unconventional policy effectively offsets the constraint as some recent work has suggested was the case for the global financial crisis. The most realistic scenario probably lies somewhere in between.

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[23] In the simulation the ELB binds for 7 quarters.

18

7. Conclusions

China's economic heft and its linkages with the world economy have increased over the past two decades. The surprise RMB depreciation in 2015, and the subsequent reverberations felt around world financial markets, demonstrated how deeply integrated into the global economy China has become. The event also showed that financial channels have increased in importance in recent years in addition to the trade channel, which has traditionally been the dominant transmission mechanism for spillovers from emerging market economies. This paper formally documents the evolving macroeconomic and financial linkages between China and the rest of the world, and assesses the impact of various adverse scenarios in China on the United States and the rest of the world using three approaches–a VAR, an event study analysis, and a DSGE model.

We find that a hard landing in China would have consequential spillovers to the global economy, including the U.S. economy, both through real and financial channels. In particular, there would be substantial output hits in both emerging market economies and advanced economies. The United States would also experience significant output losses under the adverse China growth scenarios posited in this paper, but less so than in emerging market economies and in other advanced economies due to the relatively closed U.S. economy and greater U.S. capacity to ease monetary policy to cushion the blow. However, although there is weak direct financial linkages between the United States and China, a China shock would have a non-trivial impact on U.S. financial markets through the risk sentiment channel.

All in all, a Chinese hard landing would be a big global event and lead to serious negative spillovers to economic growth around the world, especially if it roiled global financial markets.

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Appendix A

Let Y_t denote a K-dimensional time series, t=1,…,T, which we assume to be well approximated by an SVAR model of order p

$$B_0 Y_t = C_0 X_t + B_1 Y_{t-1} + \cdots + B_p Y_{t-p} + \omega_t, \qquad (1)$$

In equation (1), B_i, i=1,..,p, and C_0 are KxK matrices of coefficients, ω_t is a vector of structural white noise shocks, and X_t is an Lx1 vector of exogenous variables (such as a linear trend or the constant of the model). Multiplying each side of equation (1) by B_0^{-1}, yields the reduced-form representation of the model

$$Y_t = A_0 X_t + A_1 Y_{t-1} + \cdots + A_p Y_{t-p} + u_t. \qquad (2)$$

Where $u_t = B_0^{-1}\omega_t$ represents the vector of reduced form shocks, $A_0 = B_0^{-1}C_0$, and $A_i = B_0^{-1}B_i$, i=1,..,p. While we estimate (2), we are ultimately interested in using (1) to analyze the effects of changes in ω_t on Y_t. The problem is that there is not a unique mapping between (1) and (2), and, in order to go from (2) to (1), it is necessary to make some identifying assumptions. In our application, we assume that B_0 is lower triangular and that its main diagonal elements are all equal to 1. This, in practice, means that we assume that each variable y_{jt}, j=1,…,K, included in Y_t is only contemporaneously affected by the variables y_{bt} for which b<j. That is, we assume a recursive relationship between the elements of Y_t. Another implication from our assumption for B_0, is that we can identify the variance of the structural shocks, and therefore the structural shocks are in the same unit as the corresponding variable.[26]

Appendix B

Figure A1 replicate the results shown in Figure 9 and addx the results based on VAR models in which we do not control for the GFC (by excluding the dummy variable for the years 2008 and 2009).
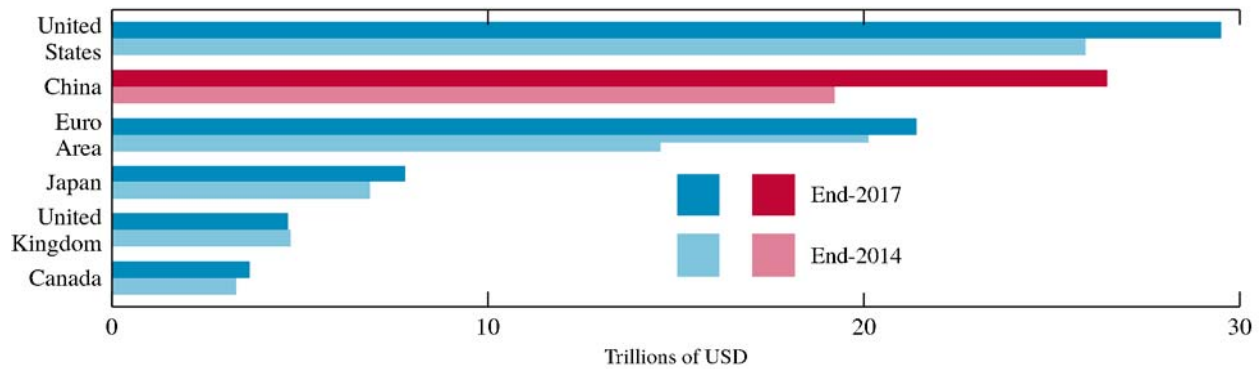
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[26] Assuming that the main diagonal elements B_0 are all equal to 1 and that the structural shocks do not have a unit variance has no implications for our results. We make this assumption so that we do not need to adjust the shocks in the second-stage VAR to mimic the shocks in the first-stage VAR.

As shown in Figure A1, controlling for the GFC matters the most for the estimated effects of a China GDP shock on the U.S. and AFEs GDP. In particular, when we do not control for the GFC, the long run effect of a China GDP shock on U.S. GDP is more than three times larger than when we control for the GFC. For AFEs, the effect of a China GDP shock it twice as large when we do not control for the GFC than when we do. In the case of EMEs, we also find that the effects of a China GDP shock are larger when we do not control for the GFC, but the relative magnitudes are smaller than in the cases of the U.S. and AFEs GDP.

The results excluding the GFC dummy suggest that, during the GFC, China's GDP and that of the rest of the world commoved substantially and that China may be more integrated in the global economy than our baseline results, those including the GFC dummy, suggest. The relative difference between the two sets of results, excluding and including the GFC dummy, based on the SVAR analysis indicate that there could be a non-linear transmission of shocks between China and the rest of the world. This higher level of integration or interconnectedness is something we do not consider in the baseline SVAR, and only allow for the higher level of integration when we use the SIGMA model. Alternatively, it can be argued that the GFC is a rare event and that we should control for it in our statistical analysis because the statistical models, such as the SVAR model, are not adequate tools to study the effects of rare events.
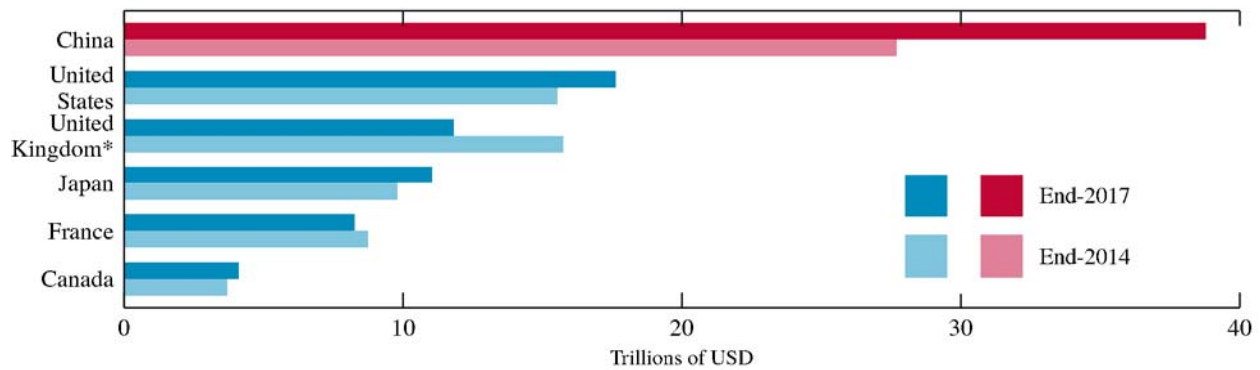
The results discussed in this appendix are important because they show that, if a China GDP slowdown could lead to a crisis similar to the GFC, then the estimates of a China GDP slowdown shown in section 5 should be seen as a lower bound of the true effects of a China GDP slowdown on the global economy.

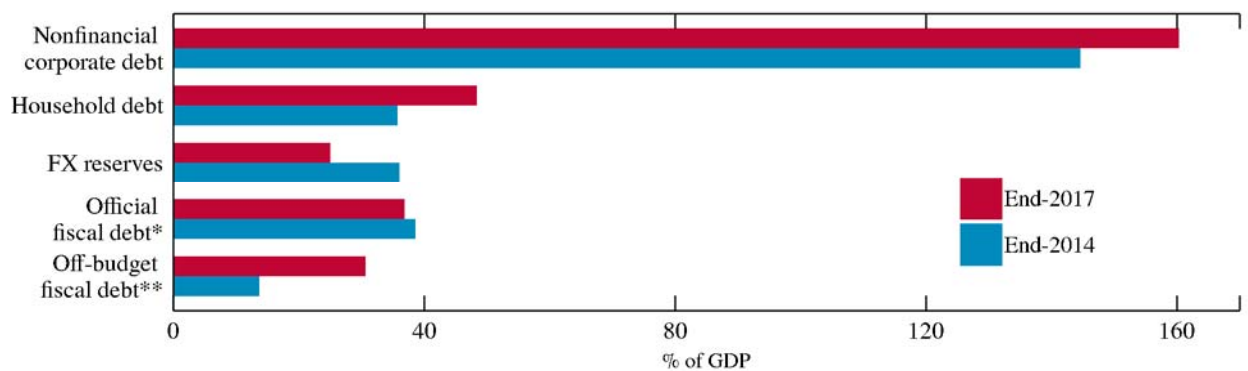## Figure 1: Total Credit to the Private Nonfinancial Sector

United States
China
Euro Area
Japan
United Kingdom
Canada

End-2017
End-2014

Trillions of USD
0 10 20 30

Figure 2: Total Bank Assets

China
United States
United Kingdom*
Japan
France
Canada

End-2017
End-2014

Trillions of USD
0 10 20 30 40

*U.K. Sterling has fallen significantly relative to the U.S. Dollar, causing a decline in total bank assets measured in Dollars.

Figure 3: Financial Vulnerabilities

Nonfinancial corporate debt
Household debt
FX reserves
Official fiscal debt*
Off-budget fiscal debt**

End-2017
End-2014

% of GDP
0 40 80 120 160

*This narrow definition of government debt includes central government debt and explicit local government debt recognized in the national audit in 2015, but does not include off-budget borrowing after 2015.
** Off-budget fiscal debt includes local government financing vehicles and other off-budget activity. The sum of this item and recognized fiscal debt equals IMF's definition of augmented fiscal debt.
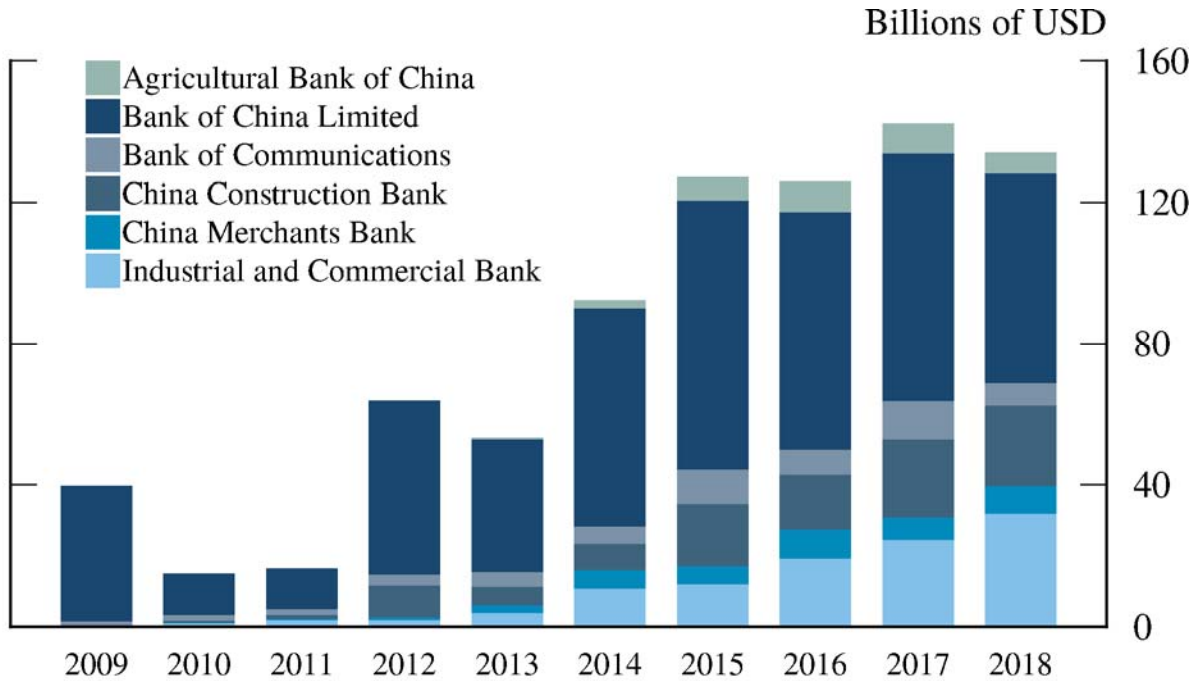
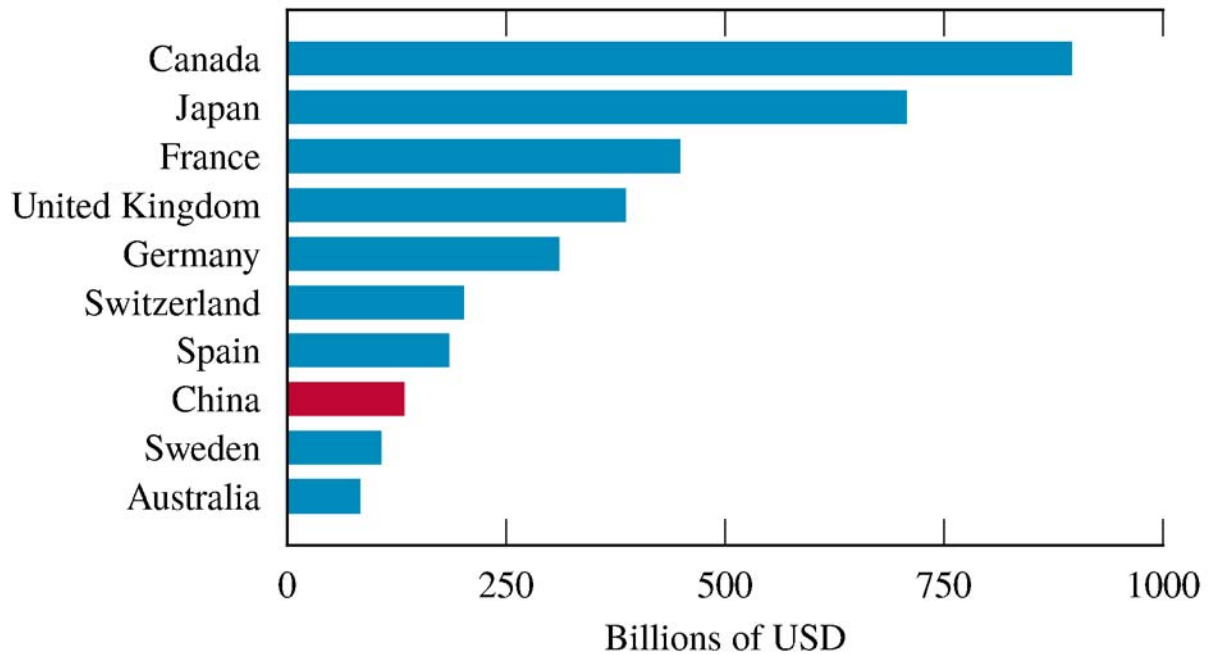**Figure 4: China's Systemic Importance Ranking**
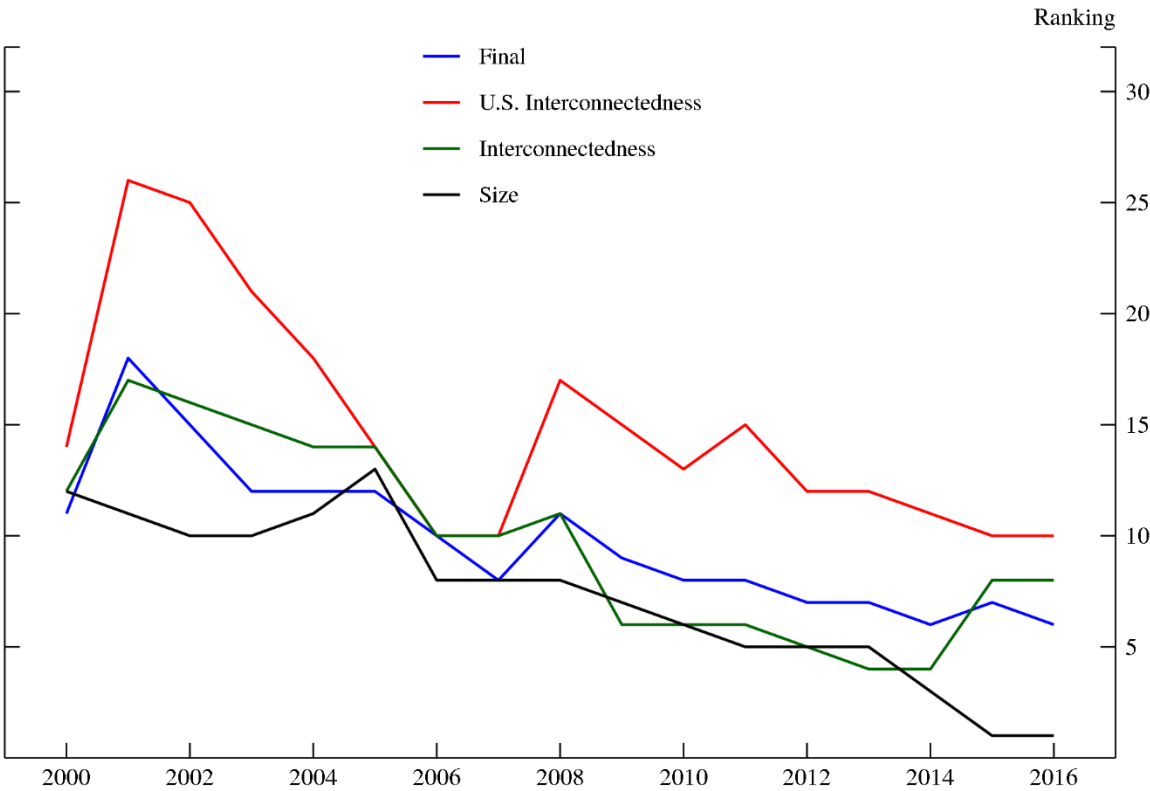
Sources: Authors' calculations based on information from the Bank for International Settlements, the IMF, and the World Bank.

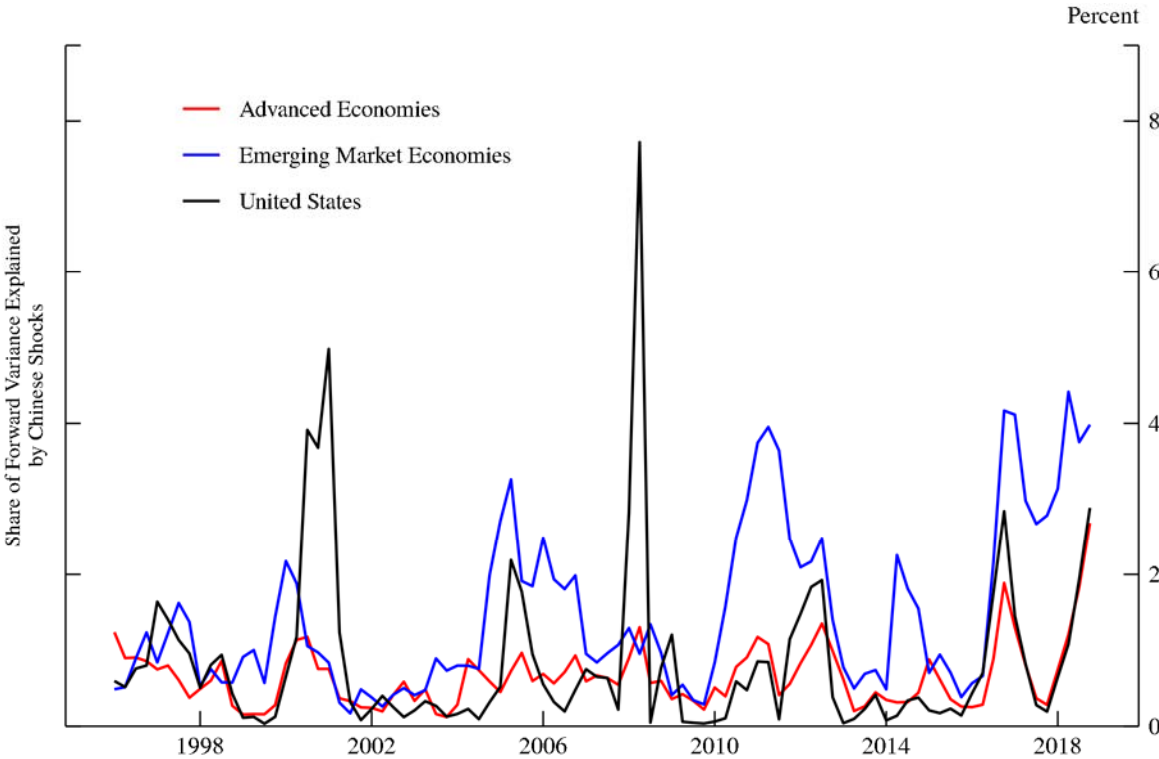**Figure 5: U.S. Branch Assets of Chinese Banks**

Source: U.S. Federal Reserve Board. Data reported for Q1 of each year.

Figure 6: U.S. Branch Assets of Foreign Banking Organizations as of End-March 2018
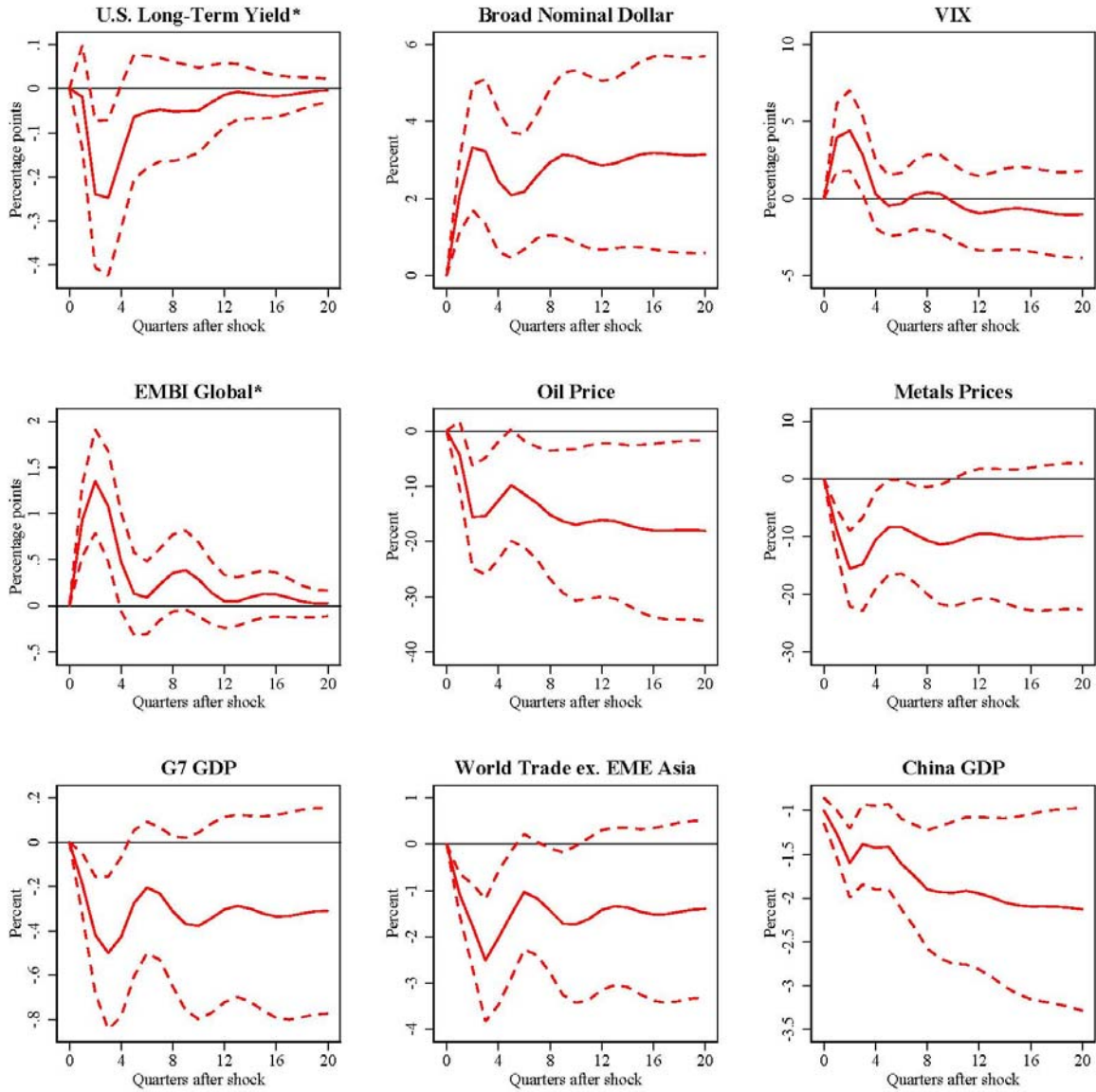

Source: FFIEC 002 Responses.

Figure 7: Forward Variance for Headline Stock Indexes

Source: Author's calculations.

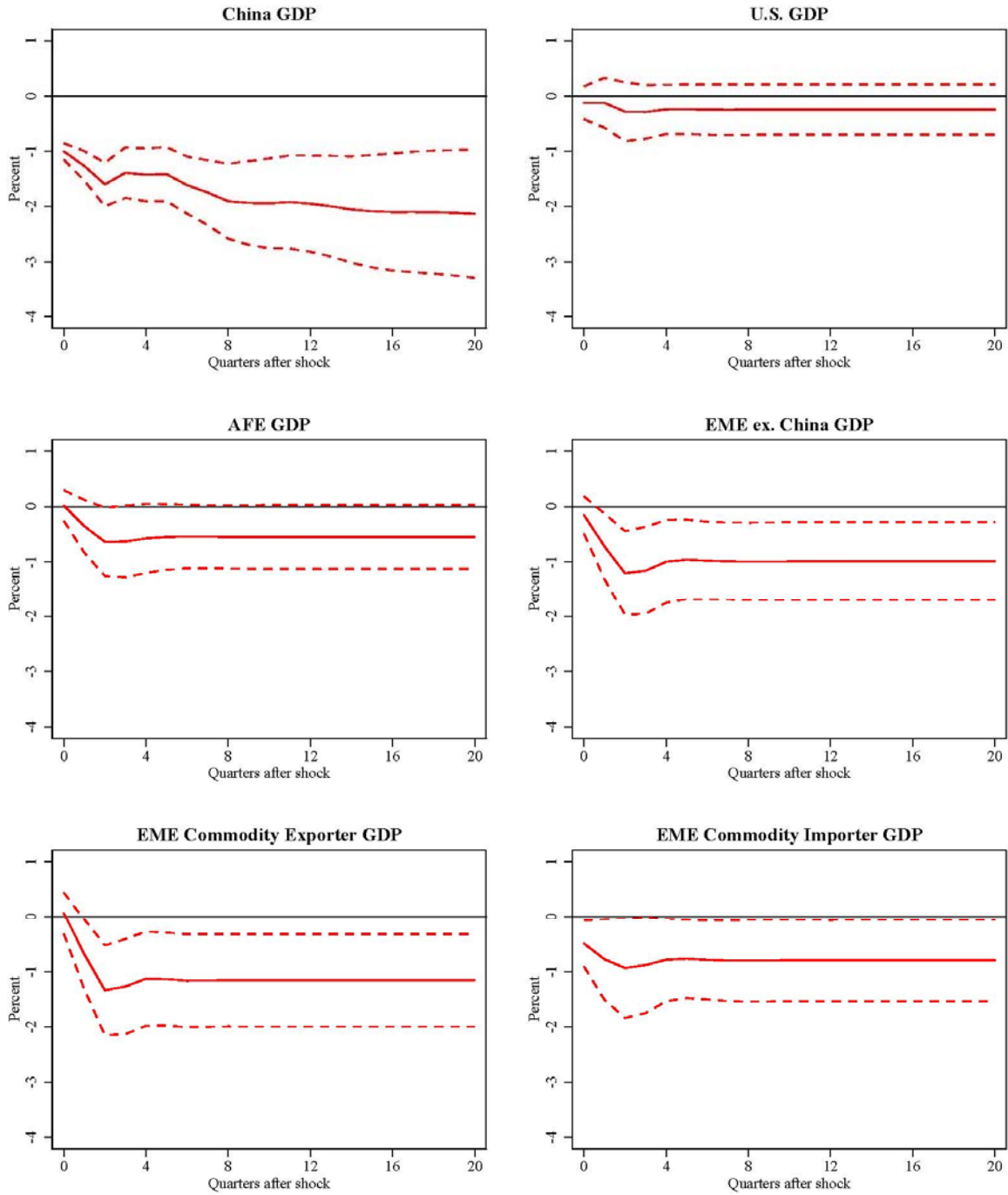**Figure 8: Responses to a Negative Unit China GDP Shock**

Figure 9: Activity Responses to a Negative Unit China GDP Shock

Note: The dashed lines represent the upper and lower bounds of the 90% confidence interval around the impulse response estimate.
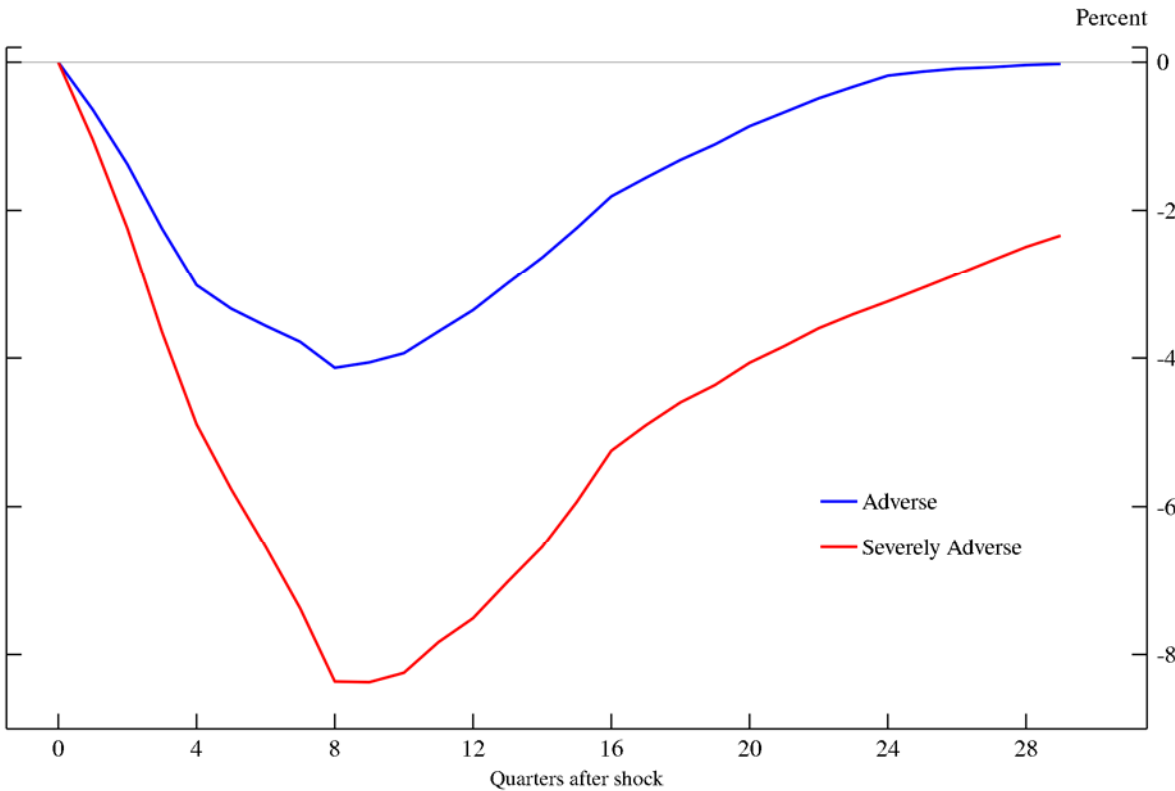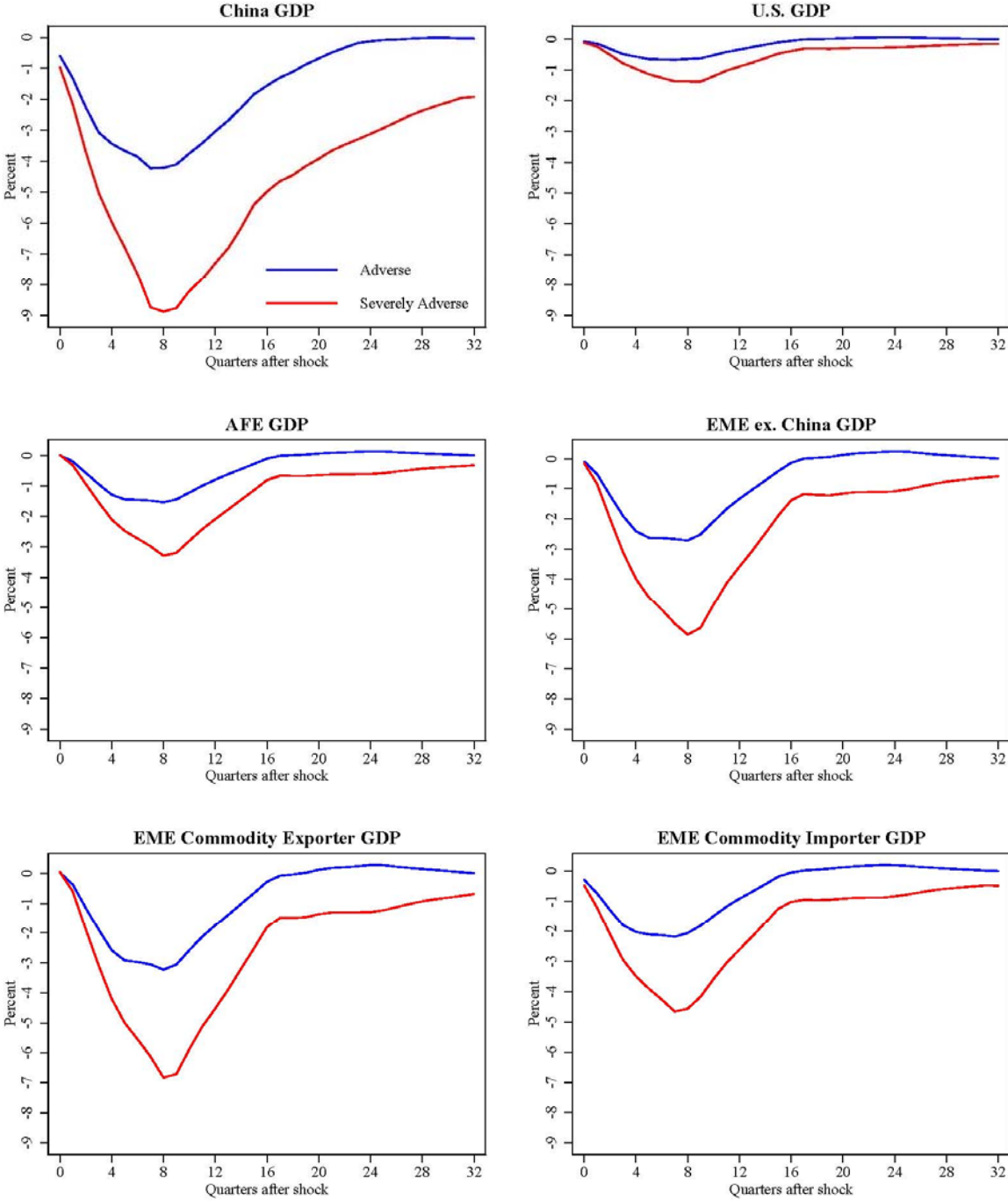Source: Authors' calculations using data from Haver Analytics and Bloomberg.

Figure 10: Chinese Real GDP Deviation from Baseline

Source: Authors' calculations.

Figure 11: Activity Responses to China GDP Scenarios

Figure 12: Financial Responses to China GDP Scenarios

U.S. Long-Term Yield

EMBI Global

VIX

Broad Nominal Dollar

Oil Price

Metals Prices

Adverse
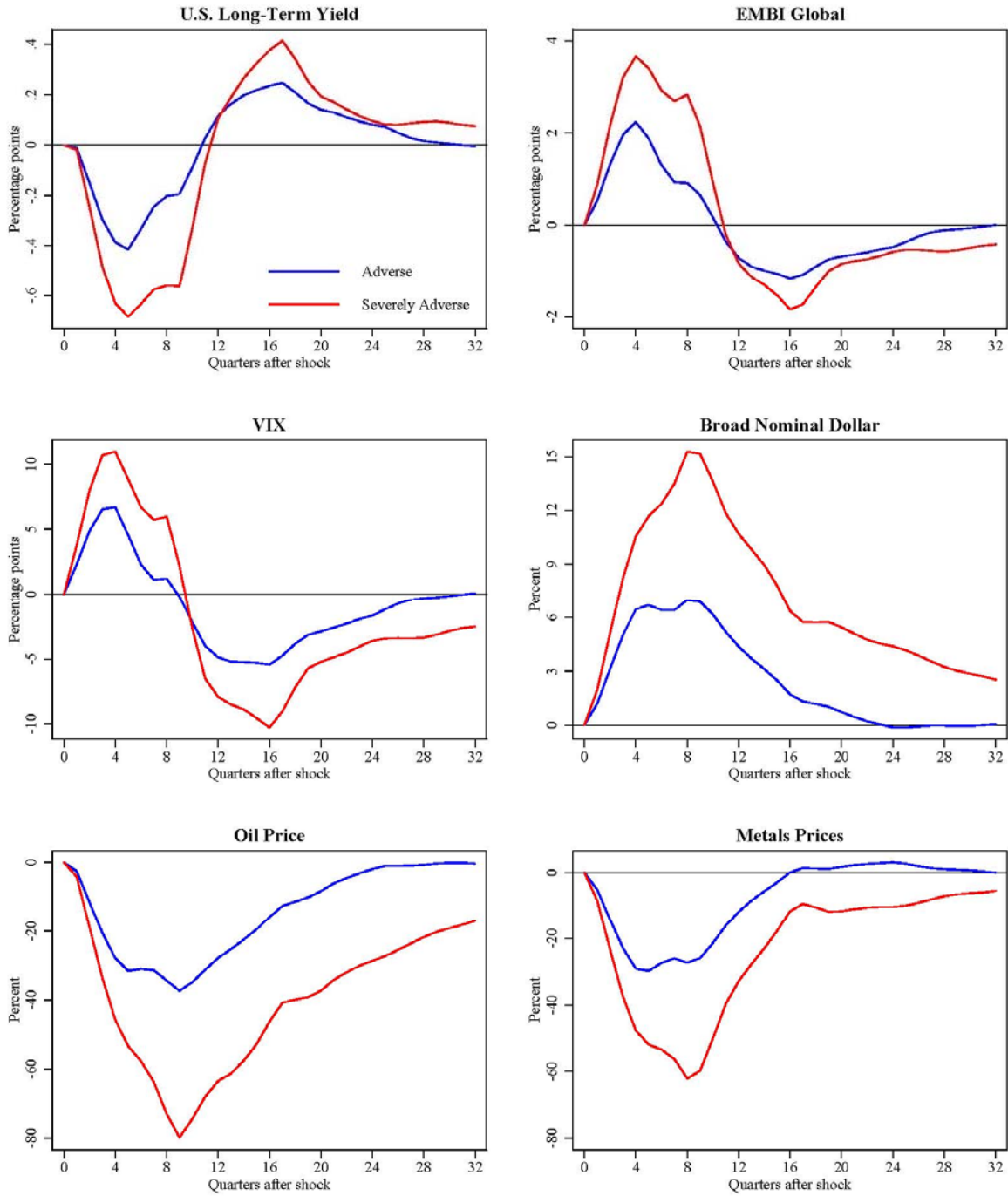
Severely Adverse

Source: Authors' calculations using data from Haver Analytics and Bloomberg.

Figure 13: GDP Simulation Results from SIGMA

A. GDP Deviations China
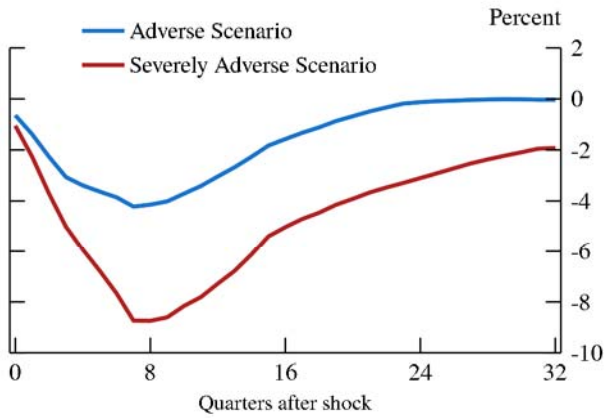
B. GDP Deviations EME Ex-China
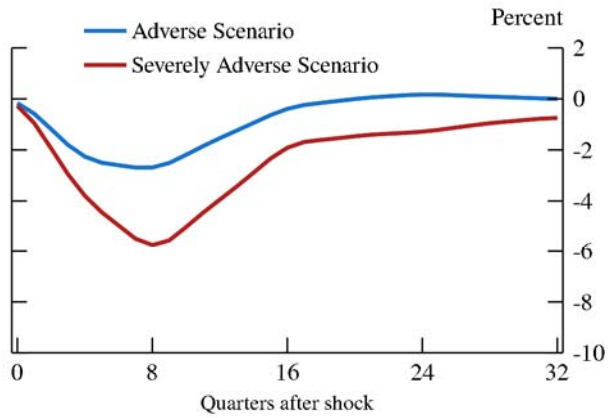
C. GDP Deviations AFE
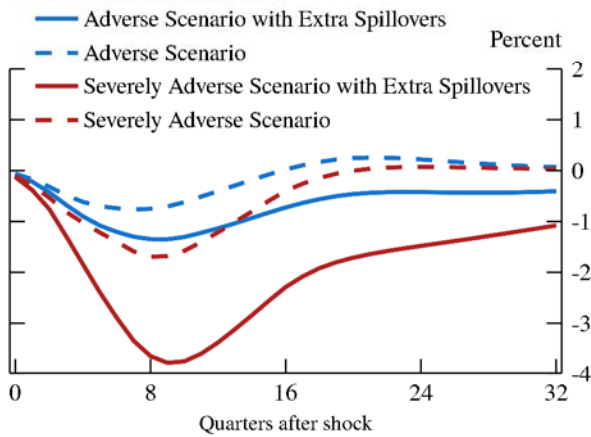
D. GDP Deviations US
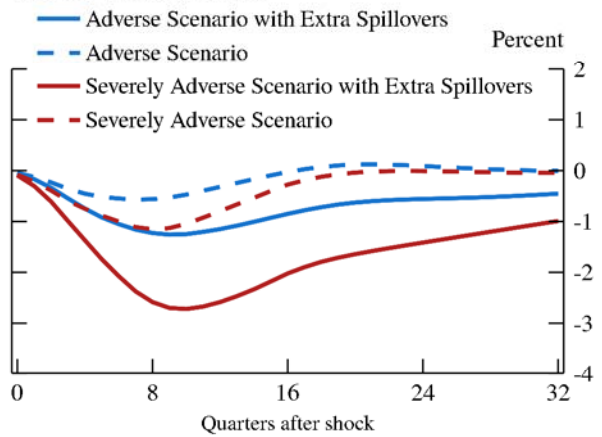
E. Severely Adverse Scenario: Different ELB Assumptions AFE
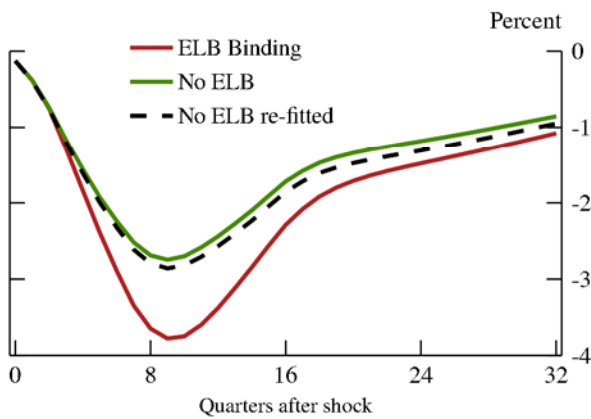
F. Severely Adverse Scenario: Different ELB Assumptions US
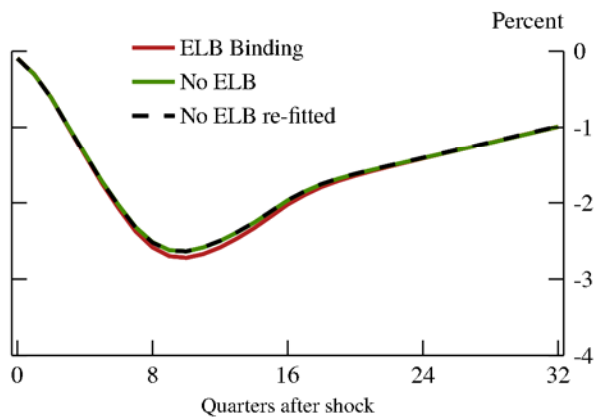
Source: Authors' calculations.

Figure A1: Activity Responses to a Negative Unit China GDP Shock
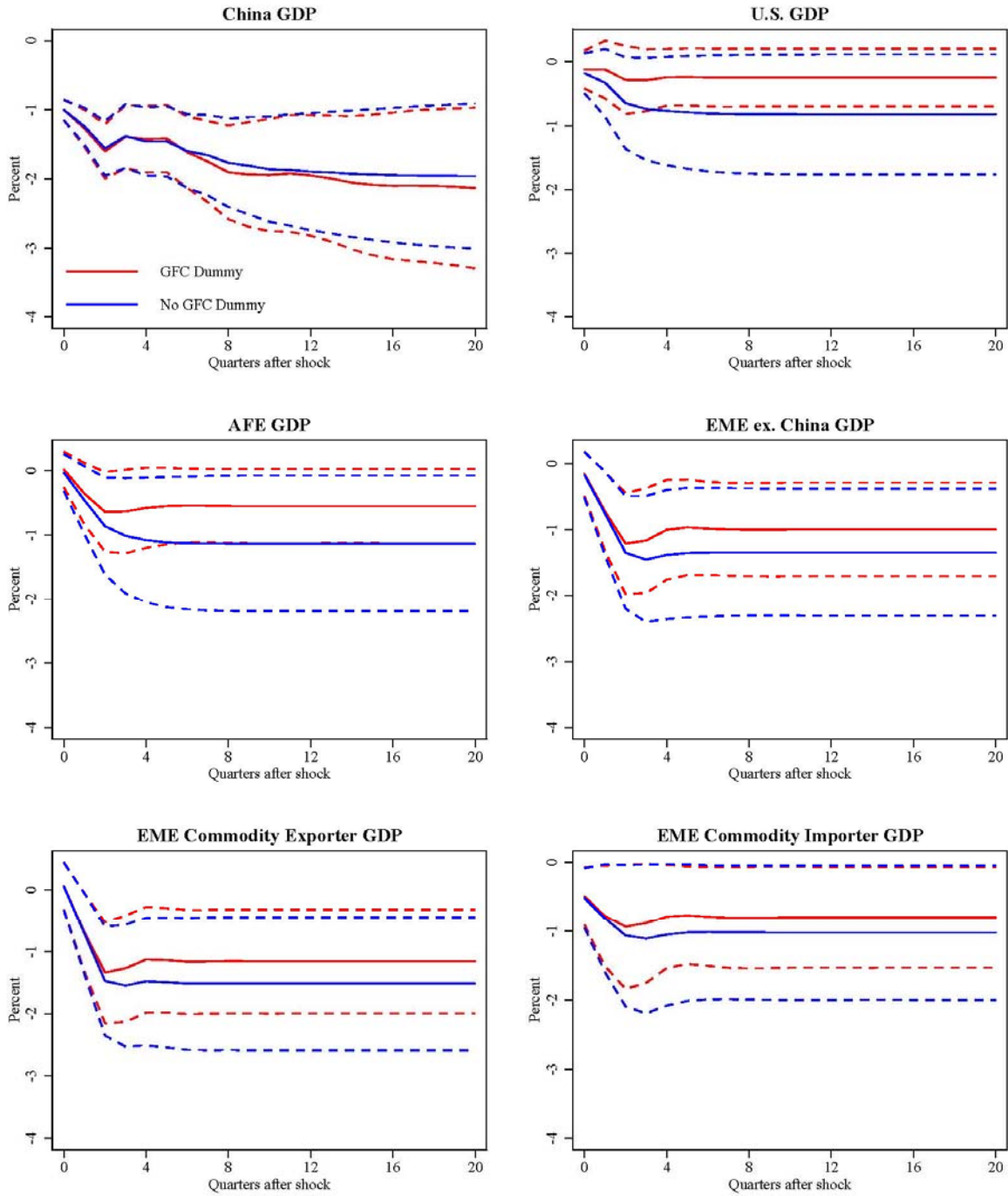
Note: The dashed lines represent the upper and lower bounds of the 90% confidence interval around the impulse response estimate.
Source: Authors' calculations using data from Haver Analytics and Bloomberg.

Table 1: U.S. Bank Claims to China and Hong Kong*

	China	Hong Kong	China and Hong Kong
In USD Billions **	97.7	72.5	170.2
As Percent of Tier 1 Capital	6	4	10

* Exposure subtracts claims guaranteed by or collateralized by claims on residents of other countries and adds claims on residents of other countries that are guaranteed by or collateralized by claims on local residents.
** Total exposure is equal to the sum of cross-border claims, foreign office claims, and derivatives.
Sources: BIS consolidated banking statistics, IMF FSI, FFIEC 031, FR Y-9C, and authors' calculations. As of 2018:Q2.

Table 2: Banks' Exposures to China and Hong Kong*

	USD Billions	Pct. Of Tier 1
United Kingdom	619.2	95
Singapore	218.4	277
United States	170.2	10
Japan	160.4	38
France	95.2	21

* Banking systems exposures are the sum of cross-border and foreign office exposures of banks headquartered in countries that compile the BIS consolidated banking statistics. Claims are adjusted for explicit third-party guarantees, near-perfect hedges, and certain liquid collateral held outside the country of the borrower.
Sources: BIS consolidated banking statistics, IMF FSI, FFIEC 031, FR Y-9C, and authors' calculations. As of 2018:Q2.

Table 3: U.S. Headquartered Banks' Exposure to Banks in*:

	USD Billions	Pct. of Tier 1
United Kingdom	36.5	2
Singapore	10.1	1
Japan	114.7	7
France	27.6	2

* Banking systems exposures are the sum of cross-border and foreign office exposures of banks headquartered in countries that compile the BIS consolidated banking statistics. Claims are adjusted for explicit third-party guarantees, near-perfect hedges, and certain liquid collateral held outside the country of the borrower.
Sources: BIS consolidated banking statistics, IMF FSI, and Authors' calculations. As of 2018:Q2.

Table 4: U.S. Banks' Exposures to EME Commodity Exporters

Commodity Exporters	USD Billions
Brazil	99.5
Mexico	97.2
Saudi Arabia	23.2
Malaysia	16.5
Indonesia	14.5
Russia	12.4
Chile	11.3
Argentina	10.9
Colombia	9.5
Total	**294.9**

Sources: FFIEC 009 and FFIEC 009a. As of 2018:Q1.

Table 5: Exposures of U.S. MMFs to China

Panel A: By Issuer Type

Issuer	Total MMF Exposure (USD Billions)	By Instrument Type (USD Billions)			By Maturity (USD Billions)				Holding WAM (Days)
		CP	CDs	Time Deposits	O/N	2-7 Days	8-30 Days	> 30 Days	
China Total	**6.4**	**2.4**	**2.0**	**2.0**	**2.5**	**0.8**	**0.9**	**2.1**	**25**
Financial Subtotal	**5.6**	**1.5**	**2.1**	**1.9**	**2.5**	**0.4**	**0.8**	**2.0**	**--**
Industrial & Commercial Bank of China	2.3	0.5	0.7	1.1	1.5	0.2	0.1	0.5	18
China Construction Bank Corporation	2.3	0.5	0.9	0.8	1.5	0.1	0.7	0.6	20
Agricultural Bank of China	0.3	0.0	0.3	0.0	0.0	0.1	0.0	0.2	56
Bank of China	0.7	0.5	0.2	0.0	0.0	0.0	0.0	0.7	62
Non-Financial Subtotal	**0.9**	**0.9**	**0.0**	**0.0**	**0.1**	**0.5**	**0.2**	**0.1**	**--**
Sinopec Ltd	0.5	0.5	0.0	0.0	0.0	0.3	0.0	0.1	21
China National Petroleum Corporation	0.4	0.4	0.0	0.0	0.1	0.2	0.2	0	13

Panel B: By U.S. Mutual Fund Complex

Direct Exposures

Complex	Total Exposure (USD Billions)	By Security Type (USD Billions)			Pct. Of Complex AUM	Pct. Of Complex Prime AUM	Maximum Pct. Of Fund AUM	Exposure WAM (Days)
		CP	CDs	Time Deposits				
JP Morgan	4.8	1.1	1.7	2.0	1.7%	11.7%	13.7%	30
UBS Global	1.2	1.2	0.0	0.0	1.2%	4.0%	11.0%	11
Wells Fargo	0.1	0.0	0.1	0.0	0.1%	1.1%	1.8%	20
SSGA	0.2	0.0	0.2	0.0	0.1%	0.6%	1.2%	15
Goldman Sachs	0.1	0.1	0.0	0.0	0.1%	1.1%	1.3%	11
Invesco	0.1	0.0	0.1	0.0	0.2%	2.3%	2.9%	20

Note: May not sum to total due to rounding.
Source: SEC Form NPF, as of May 31, 2018.

Table 6: Event Study Analysis

	Market Reaction*					Historical Percentiles		
Changes (in % of bps)	Event #1 6/20/2013	Event #2 8/11/2015	Event #3** 8/24/2015	Event #4** 1/4/2016 - 1/7/2016		1% Tail	5% Tail	Most Extreme Value
Broad	0.70%	0.70%	-0.10%	1.30%		0.65%	0.40%	1.62%
Broad AFE	0.70%	0.10%	-0.90%	0.50%		0.92%	0.56%	1.95%
Broad EME	0.60%	1.20%	0.50%	1.90%		0.59%	0.38%	2.24%
U.S. 2Y yield	2	-4.8	-5.7	-8.8		-5.7	-2.8	-15.4
U.S. 10Y	6.2	-6.4	-7.5	-10.8		-9.8	-6.2	-19.9
German 10Y	10.7	-4.2	-0.3	-10.1		-9.4	-5.8	-23.8
U.K. 10Y	16.1	-5.7	8	-16.5		-11.1	-7.1	-29.7
Japan 10Y	4	-1.4	-1	-2.4		-4.8	-2.8	-12.7
S&P 500 Futures	-2.4%	-0.6%	-3.8%	-4.5%		-1.8%	-1.0%	-3.8%
EuroSTOXX	-3.2%	-1.4%	-4.5%	-6.4%		-2.8%	-1.6%	-7.7%
FTSE 100	-3.0%	-0.8%	-4.0%	-5.4%		-2.2%	-1.3%	-5.1%
MSCI EME Index	-2.5%	-0.4%	-4.3%	-5.8%		-2.9%	-1.5%	-7.3%
VIX	1.76	1.01	4.7	3.7		2.6	1.3	6.6
VDAX	2.55	2.25	9.5	8.06		3.7	2.0	9.5
US Corp Spread	3	2.9	3.7	4.6		9.2	4.6	35.1
EMBI+ Spread	28	8	13	15		15.0	8.0	28.0

*Overnight change as of Close (4pm EST) to Open (9am EST) the next day for exchange rate indices, equity markets, VIX, VDAX, and government bond indices. 1-day change as of Close to Close for US corporate spread and EMBI+.
**Event falls on Monday, change as of previous Friday Close to Monday Open. Event 4 is the cumulative change over 4 days.
Source: Bloomberg.

Table 7: Percent of Forecast Error Attributable to China GDP by Number of Quarters

Horizon	U.S. Long-Term Yield	Broad Nominal Dollar	VIX	EMBI Global	Oil Price	Metals Prices	G7 GDP	World Trade ex. EME Asia	China GDP
1									79.9
2	0.0	11.3	7.3	8.7	1.4	13.1	3.7	7.5	65.3
3	4.3	14.0	6.7	18.6	9.2	17.4	7.8	8.9	60.4
4	7.5	13.4	7.3	22.9	9.0	16.7	7.8	10.2	56.8
8	7.6	14.5	9.3	20.8	9.4	17.7	8.9	11.5	49.1
12	7.8	14.7	9.3	21.1	9.7	17.8	9.4	11.8	48.8
∞	7.8	14.7	9.4	21.0	9.7	17.8	9.5	11.9	48.3

Source: Authors' calculations using data from Haver Analytics and Bloomberg.

Table 8: Percent of Forecast Error Attributable to China GDP by Number of Quarters

Horizon	China GDP	U.S. GDP	AFE GDP	EME ex. China GDP	EME Commodity Exporter GDP	EME Commodity Importer GDP
1	79.9	0.7	0.0	0.9	0.1	5.9
2	65.3	0.7	6.4	10.1	13.5	6.5
3	60.4	1.9	9.6	15.9	21.3	6.9
4	56.8	1.9	9.6	15.8	21.4	6.8
8	49.1	2.0	9.7	16.4	21.7	6.9
12	48.8	2.0	9.7	16.4	21.7	6.9
∞	48.3	2.0	9.7	16.4	21.7	6.9

Source: Authors' calculations using data from Haver Analytics and Bloomberg.