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Global dollar credit: links to US monetary policy and leverage

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Abstract

Since the global financial crisis, banks and bond investors have increased the outstanding US dollar credit to non-bank borrowers outside the United States from $6 trillion to $9 trillion. This increase has implications for understanding global liquidity and monetary policy transmission. We analyse the links between US monetary policy, leverage and flows into bond funds, on the one hand, and dollar credit extended to non-US borrowers, on the other. Prior to the crisis, global banks drew on low US dollar funding rates and easy leveraging to extend dollar credit to non-US borrowers. After the Federal Reserve announced its large-scale bond purchases in 2008, however, investors responded to compressed long-term US Treasury rates by buying higher yielding dollar bonds from non-US issuers. Thus, US unconventional monetary policy contributed to shifting the balance of dollar credit transmission from global banks to global bond investors.

Keywords: US dollar, offshore credit, interest rate differentials, leverage, bond fund flows, policy rates, term premium, unconventional monetary policy

JEL classification: E43, E51, F34, G21, G23

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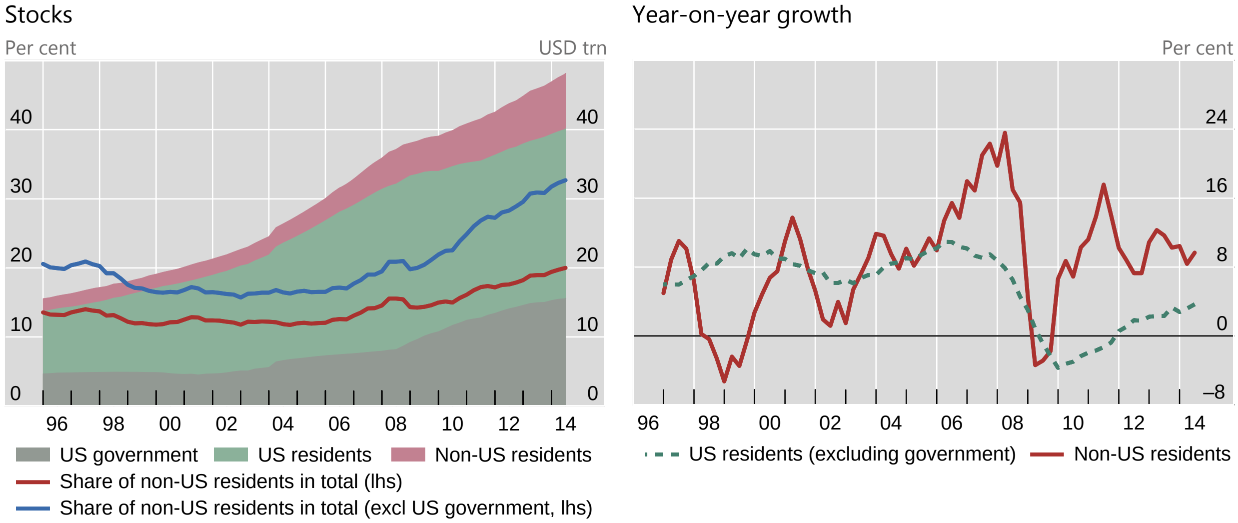
Contents

1. Introduction

Credit denominated in major currencies extended to borrowers outside those currencies' home jurisdictions has implications for monetary and financial stability. Regarding monetary stability, a substantial stock of dollar- or euro-denominated loans implies that the monetary policy of the Federal Reserve or the ECB is transmitted directly to other economies. Moreover, borrowers can choose to borrow dollars or euros instead of domestic currency at the margin, and so side-step their own central bank's monetary policy. Foreign currency credit also has implications for financial stability (CGFS (2011), Domanski et al (2011), Chen et al (2012) and Hills and Hoggarth (2013)). This is because foreign currency and cross-border credit can enable credit booms that lead to crises (Avdjiev, McCauley and McGuire (2012)).[5] Recurring G20 discussion of global liquidity focuses on global credit aggregates.[6]

Dollar credit to non-financial borrowers outside the United States (US), in particular, is large in absolute and relative terms. At approximately $8 trillion in mid-2014, it has reached 13% of non-US GDP (Graph 1, left-hand panel).[7] Such offshore dollar credit well exceeds its euro and yen counterparts, at $2.5 trillion and $0.6 trillion respectively. Moreover, euro credit is quite concentrated in the euro area's neighbours (Brown and Stix (2015)).

US dollar credit to non-financial firms, households and governments — Graph 1



Notes: Credit to non-financial residents in the United States from Federal Reserve flow of funds data, excluding identified credit to these borrowers in non-domestic currencies (ie cross-border and locally-extended loans and outstanding international bonds in currencies other than the US dollar). Dashed line plots credit to the government. US dollar credit to non-resident non-financial sector borrowers is the sum of outstanding dollar bonds issued by non-financial borrowers and cross-border and locally extended dollar loans to non-banks outside the United States.

Sources: Board of Governors of the Federal Reserve System; IMF, International Financial Statistics; BIS international debt statistics and locational banking statistics by residence.

[5] Even if small relative to the total stock of credit outstanding, swings in foreign currency credit can dominate flows of credit, amplify domestic trends, and thus figure importantly in financial booms and busts (see Borio et al (2011) and Domanski et al (2011)). Lane and McQuade (2014) find that domestic credit growth exhibits a close relationship with net international debt flows in the European context of the 2000s in which the debt flows were denominated in domestic currency in euro area countries like Ireland, Portugal and Spain.

[6] See http://www.bis.org/statistics/gli.htm. See Borio et al (2014) on the relationship to standard flow of funds concepts.

[7] If non-bank financial borrowers outside the US are included, the total is about $9 trillion; see below.

Dollar credit to borrowers outside the US behaves differently from the larger stock of credit to those resident in the US. Since the global financial crisis, credit to the US private sector only resumed growing in 2010 while dollar credit to those outside the US has grown since 2009 at often double-digit rates (Graph 1, right-hand panel).

Despite the policy attention to foreign currency credit (ie credit denominated in a currency different from the home currency of the borrower), its drivers remain poorly understood. Existing studies often focus on the generally smaller economies whose banks show high proportions of foreign currency deposits and credit (Levy Yeyati (2006)). Here, we show that most dollar credit to non-US borrowers is in economies that would not generally be considered dollarised.

That said, there has been important recent work on foreign currency bank credit. Brzoza-Brzezina et al (2010) find that when central banks in central and eastern Europe raise their policy rates, borrowers shift from domestic to foreign currency loans. Bruno and Shin (2014c) find that changes in external *interbank* claims (mostly dollar) on 46 countries track broker-dealer leverage and the capital of non-US banks.[8] In an aggregate study, Bruno and Shin (2014b) find that a lower policy rate in the US works through bank leverage to increase interbank lending in the rest of the world.[9]

Country studies have focused on developments in China. Tang and Ng (2012) show that dollar borrowing costs in the mainland affect the growth of dollar bank credit in Hong Kong SAR, mostly extended to affiliates of mainland Chinese companies. He and McCauley (2013) find that the growth of foreign currency (mostly dollar) loans extended by banks in mainland China rises in response to a lower dollar Libor or a lower onshore dollar rate. Shin and Zhao (2013) analyse Chinese and other Asian firms and find a grossing up of their assets and liabilities, suggesting that access to offshore credit is associated with financial investment, possibly including dollar-funded investment in domestic currency.

Other studies have focused on the role of bond markets in international credit. Cohen (2005) models the choice of currency in international bond issuance, including dollar bonds. Shin (2013) emphasises that the remarkable rise in bond market financing in recent years means that bank debt alone cannot be the focus of study in what he calls the second phase of global liquidity. The high share of the US dollar in international bonds is recorded annually by the ECB (2014) and is highlighted by Goldberg (2013). Lo Duca et al (2014) measure the response of corporate bond issuance in *all* currencies to Federal Reserve bond buying.[10]

In this paper, we first describe dollar credit extended to the non-financial sector outside the US. This is based on comprehensive estimates constructed from the BIS banking statistics, the BIS international debt statistics and national statistics (eg Chinese data).[11] We then measure how such credit responds to its *price*. We take a long-term perspective, focusing on the relationship between monetary policy and dollar credit growth to non-residents at the quarterly frequency from 1995 onwards, allowing us to capture several cycles in dollar credit.

8 Using the net claims of foreign banks' US branches on their foreign affiliates as a driver, Bruno and Shin (2014a) argue that a 2011 tax on the foreign currency liabilities of banks in Korea reduced their sensitivity to global factors. See also Kim (2013).

9 Judson (2012) analyses US currency in circulation outside the US. However, the drivers of demand for US banknotes differ from those of dollar-denominated bank liabilities or credit offshore, which are an order of magnitude larger.

10 The less than one-to-one pass-through of US bond yield changes to bond yields in other currencies (Obstfeld (2013)) implies that regressing issuance of bonds denominated in currencies other than the dollar on the US term premium introduces an errors in variable bias. Lo Duca et al (2014), like Fratzscher et al (2013), use individual Federal reserve bond purchases as regressors, while we consider their effect to be captured in the term premium.

11 In contrast, many focus on more traditional measures of money: Chen et al (2012), Forbes and Warnock (2012), Hahm et al (2013) and Chung et al (2015) use a multi-country monetary aggregate. Since Forbes and Warnock (2012) seek to explain all capital flows, their price measure is an average of G5 bond yields, while our price measures are strictly dollar-based.

We distinguish between bank credit and bond market credit and relate them to short-term and long-term interest rates. We relate growth of bank lending to the spread of a given economy's policy rate over the federal funds rate, or to the federal funds rate's deviation from a Taylor rule. Similarly, we relate the growth of dollar bonds to the spread of a given economy's 10-year government bond yields over US Treasury bond yields or to the term premium on 10-year US Treasuries. The latter is a gauge of US (unconventional) monetary policy since a lower term premium is the stated goal of the Federal Reserve's large-scale bond purchases (aka "quantitative easing").[12]

We have three main empirical findings. The first relates to the relationship between dollar credit growth and yield differentials in individual countries and over time. The second and third distinguish between bank and bond credit aggregated across countries and their different drivers over time.

First, evidence from 22 countries over the past 15 years shows that offshore dollar credit grows faster where local interest rates are higher than dollar yields, and this relationship has tightened since the global financial crisis. And the wider the gap between local 10-year yields and those on US Treasury bonds, the faster the next quarter growth in outstanding US dollar bonds issued by non-US resident borrowers. This finding is consistent with the observation that, since 2009, dollar credit has flowed to an unusual extent to emerging markets and to advanced economies that were not hit by the crisis, while it has grown at a slower pace in the euro area and the United Kingdom (UK). In sum, dollar credit has grown fastest outside the US where it has been relatively cheap.

Second, before the global financial crisis, banks extended the bulk of dollar credit to borrowers outside the US. Low volatility and easy wholesale financing enabled banks to leverage up to funnel dollar credit offshore. These findings are consistent with Bruno and Shin (2014b) and Rey (2013).

Third, since the crisis, non-bank investors have extended an unusual share of dollar credit to borrowers outside the US. Firms and governments outside the US have issued dollar bonds, and banks have stepped back as holders of such bonds. The compression of bond term premia associated with the Federal Reserve's bond buying has induced investors to bid for bonds of borrowers outside the US, many rated BBB and thus offering a welcome spread over low-yielding US Treasury bonds. We also find that inflows into bond mutual funds offering a spread over US Treasuries played a significant role in spurring offshore dollar bond issuance. We interpret this as evidence of the portfolio rebalancing channel of the Federal Reserve's large-scale asset purchases.

A key observation is that, following a brief spike in spreads in Q4 2008, spreads declined in the subsequent quarters even as the stock of offshore dollar bonds grew rapidly. Thus, while we cannot reject the "spare tire" argument of Erel et al (2012) and Adrian et al (2013) at the height of the crisis (ie firms substituting from supply-constrained bank financing to bonds, despite widening spreads), any such effect seems to have been short-lived. Instead, heavy bond issuance amid falling yields and narrowing spreads points to the importance of a largely policy-induced favourable supply of funds from bond investors beginning in early 2009.

We end with a discussion of the implications for policy. First, dollar debt outside the US serves to transmit US monetary easing into immediately easier financial conditions for borrowers around the world. Second, while policy in economies outside the US can raise the cost of dollar debt at home, the effect of such policy is limited by multinational firms' ability to borrow dollars abroad through offshore affiliates. Third, the recent prominence of bond markets in supplying dollar credit introduces new risks to financial stability, and thus changes the way that we need to think about the policy challenges posed by offshore dollar credit growth.

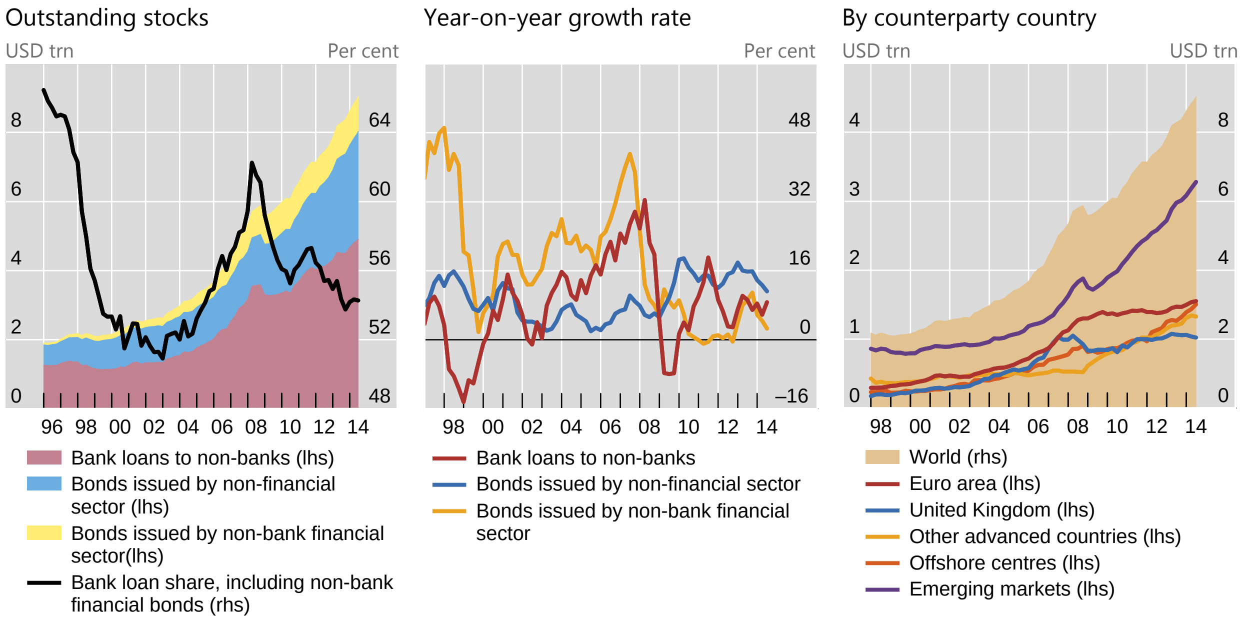
[12] Gagnon et al (2011) attribute most of the reduction in long-term Treasury yields in response to Federal Reserve asset purchase announcements to a reduction in the term premium, and Bernanke (2013) shows the premium to have been negative following bond purchases by the Federal Reserve; see Turner (2013a) for a discussion of broader international and policy repercussions.

2. Global dollar credit: evolution and composition

The baseline aggregate of dollar credit to non-financial borrowers outside the US is comprised of outstanding bank loans and bonds. For bank loans, we sum dollar loans to *non-banks* (including non-bank financial firms) booked both locally (within the respective economy) and cross-border.[13] For bonds, we sum outstanding dollar obligations of *non-financial* sector borrowers resident outside the US. In classifying bond issuers, we look through the immediate borrower (eg Petrobras International Finance Company, Cayman Islands) to the ultimate borrower's sector (eg oil, that is, non-financial).[14]

US dollar credit to non-banks outside the United States

Broken down by instrument and counterparty country — Graph 2



Notes: Bank loans include cross-border and locally extended loans to non-banks outside the United States. For China and Hong Kong SAR, locally extended loans are derived from national data on total local lending in foreign currencies on the assumption that 80% are denominated in US dollars. For other non-BIS reporting countries, local US dollar loans to non-banks are proxied by all BIS reporting banks' gross cross-border US dollar loans to banks in the country. Bonds issued by US national non-bank financial sector entities resident in the Cayman Islands have been excluded.

Sources: IMF, *International Financial Statistics*; Datastream; BIS international debt statistics and locational banking statistics by residence; authors' calculations.

13 Most of the data are from the 40+ jurisdictions that report to the BIS international banking statistics. For non-reporting countries (other than China), we proxy locally-booked dollar loans to non-banks in these countries with cross-border loans to *banks* in these countries. This proxy amounts to $331 billion. The proxy applied to China hugely understates dollar loans booked at banks in China, since most foreign currency loans there are locally funded. Hence, for China we estimate dollar loans from national data as 80% of total foreign currency loans of banks in China, or $682 billion at end-June 2014.

14 This look-through to the ultimate issuer's sector makes our bond aggregate broader than that in Borio et al (2011), on which we build. To be precise, we construct our benchmark bond aggregate as the total of outstanding dollar-denominated bonds issued by any ultimate issuer that is a non-financial corporate, government or international organisation resident outside the US. This includes bonds issued by these ultimate issuers' financing arms, which are typically classified as a non-bank financial on an immediate issuer basis. Our broadest measure of dollar bonds outstanding adds bonds issued by ultimate issuers classified as non-bank financials. In all cases, we exclude bonds issued by banks, either as the ultimate issuer or as an immediate issuer with a non-bank parent (eg GE Credit Bank).

The resulting $8 trillion aggregate for June 2014 includes bank loans to all *non-banks* but includes dollar bonds issued only by *non-financial* issuers. Our econometric analysis mainly focuses on this narrower aggregate. It maximises the comparability to non-financial debt in the US flow of funds statistics by excluding bonds issued ultimately by non-bank financials. Alternatively, a more comprehensive (and internally consistent) aggregate includes bonds issued by non-bank financials (eg the German state agency KfW with $100 billion in US dollar debt). This takes the aggregate up to $9 trillion (Graph 2, left-hand panel). For this to measure the debt of non-financial borrowers, however, KfW's dollar loans to non-financial borrowers outside the US would have to match its dollar bond debt. The share of bank loans has fallen since the global financial crisis to 55% of the broader aggregate.

The next subsections describe the small connection of dollar credit outside the US to US balance sheets and profile its trends and geography. The final subsection reports a panel analysis showing that higher foreign yields lead to more rapid offshore dollar credit growth.

2.1 The US connection

US financial institutions or US-sourced funds do not play a dominant role in dollar credit extended to borrowers outside the US. Shifting to data for the end of 2013, only $2.3 trillion ($2.1 trillion) out of the $8.6 ($7.6 trillion) in dollar claims on non-banks (non-financials) outside the US were held in the US (Graph 3, middle two arrows). In other words, offshore holdings represent almost three-quarters of the dollar credit extended to non-financial borrowers outside the US. This is possible because non-US banks operating outside the US have trillions of dollars of deposits (He and McCauley (2012)), and can swap other currencies into dollars.[15] Similarly, asset managers located outside the US have large dollar assets under management. Thus, depositors and investors outside the US can and do provide most of the dollar credit to non-US borrowers.

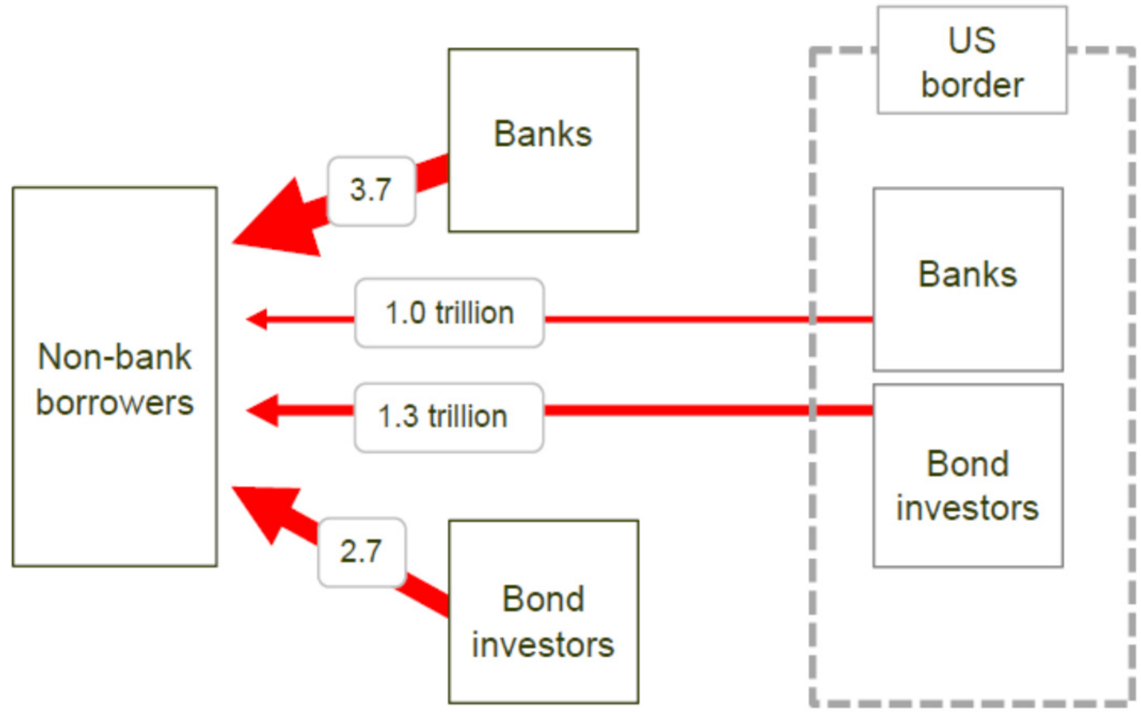
The small US role holds particularly in banking, where the loans booked in the US, loans booked by US-headquartered banks or funding from the US all play bit parts. In particular, in December 2013, $1 trillion out of $4.7 trillion of dollar bank loans to non-US residents were booked in the US (Graph 3, top two arrows):[16] in other words, about 80% of the dollar bank loans to borrowers resident outside the US are booked at banks outside the US.[17] Moreover, these US dollar loans are not funded by borrowing from banks in the US. This contrasts with a popular metaphor that the Federal Reserve's large-scale asset purchases inject liquidity into banks in the US that spills over the border to offshore banks, which then lend out the dollars. Contrary to this image, banks headquartered outside the US shifted after the global financial crisis from a "net due to" position vis-à-vis their branches in the US to a "net due from" these branches. In other words, dollar funding flowed *into* the US through non-US headquartered banks' balance sheets. Far from funding offshore dollar loans, interbank flows competed with such loans for

15 That said, non-US banks do depend more on wholesale dollar funding; its disruption (McGuire and von Peter (2012)), or a decline in their creditworthiness (Ivashina et al (2012); Avdjiev, Kuti and Takáts (2012)) may lead them to cut dollar credit.

16 Data from BIS international banking statistics, Table 5B (http://www.bis.org/statistics/r_qa1403_hanx5b.pdf); and *Global liquidity: selected indicators*, 17 March 2014 (http://www.bis.org/statistics/gli/gli.xlsx).

17 Looking at bank loans by the nationality of consolidated banks rather than by location as in the main text, the global operations of US-headquartered banks play only a relatively small role in the extension of dollar credit to non-US residents. In particular, in March 2014, US-headquartered banks had only 16% of international dollar claims of BIS-reporting banks (and 11% of all international claims). Table A2 in the December 2014 *BIS Quarterly Review* shows US banks with $2.4 trillion out of $15.1 trillion of US dollar international claims and $3.9 trillion out of $34.4 trillion in total international claims at end-June 2014. US-headquartered banks hold only 7% of the $1.1 trillion in local dollar claims on non-banks booked outside the US.

US dollar-denominated credit to non-bank borrowers outside the US, end-2013 Graph 3



Sources: US Department of the Treasury (2014); BIS; authors' estimates.

dollar funding.[18] In sum, dollar bank loans extended to borrowers outside the US do not depend much on the US banking system.

US residents play a larger role in holding US dollar bonds issued by borrowers outside the US (Graph 3, bottom two arrows). Of the $4.0 trillion ($3.0 trillion) outstanding dollar bonds issued at end-2013 by non-US resident non-banks (non-financials), US residents held $1.3 trillion ($1.1 trillion).[19] If US-based investors hold a third of dollar bonds issued by non-US residents, the ease of financing in the international bond market could well be affected by the common element in US ("spread product") bond flows identified by Feroli et al (2014). We return below to the significance of the observation that US bond investors play a larger role in dollar bond credit than US banks play in dollar bank credit.

18 In 2011-13, banks headquartered outside the US shifted $600 billion to their affiliates in the US even as BIS data showed a $300 billion increase in their dollar claims on non-US resident non-banks. See McCauley and McGuire (2014).

19 Total holdings of dollar bonds issued by non-US non-banks start with the dollar bond holdings on Table 10 of US Department of the Treasury et al (2014) of $1.98 trillion. Then Cayman Islands-issued private bonds ($218 billion, Table A11) are subtracted, leaving $1.77 trillion. Then 75% (the overall dollar share) of the bank and thrift issued bonds ($668 billion, Table A15) are subtracted, leaving $1.265 trillion. For non-financial, 75% of non-bank financial sector bonds ($1.12 trillion less Cayman Islands total), or $679 billion, is subtracted from the non-bank total, leaving $1.09 trillion. Since the Treasury/Federal Reserve survey takes market value, while our measure aggregates book values, the 2013 survey share is a bit overstated. However, these US resident holdings do not include the holdings of US-controlled investment funds that are legally domiciled in the Cayman Islands, and so probably underestimate the share of holdings of de facto US investors.

2.2 Growth profile of offshore US dollar credit

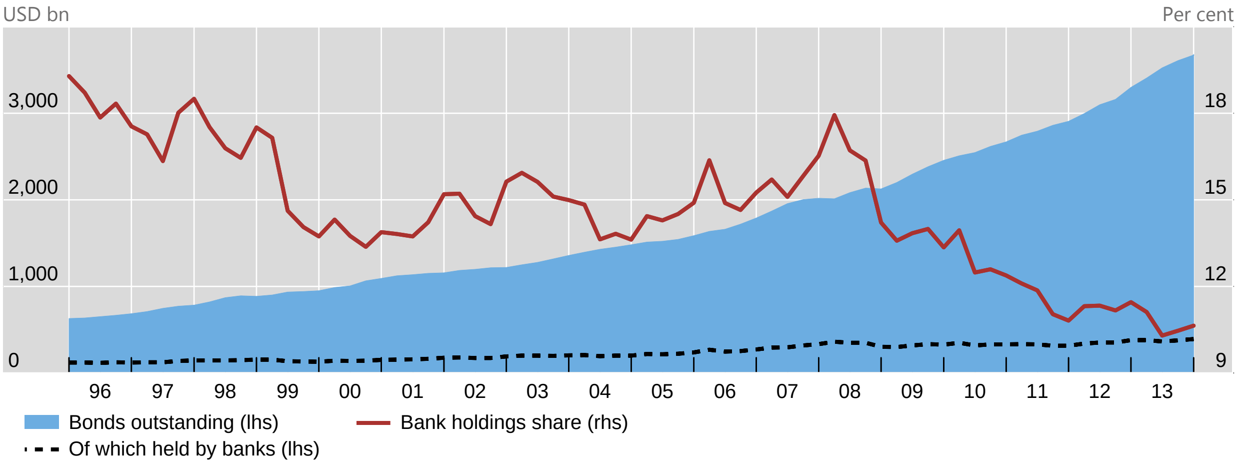
There is only one federal funds rate and only one dollar Libor, but there are two stocks of dollar debt responding in very different fashion to these interest rates. From a time series perspective, the offshore aggregate has behaved quite differently from its larger US aggregate, not least since the global financial crisis (Graph 1). Coming out of the Asian financial crisis of 1997-98, dollar credit to non-US residents only briefly grew faster than US debt before the dot.com crash and subsequent recession. Then, in the later boom years of the 2000s, offshore dollar credit grew more rapidly than its larger US counterpart, only to drop more sharply during the 2008-09 financial crisis.

Since 2009, dollar credit to non-financial borrowers outside the US has consistently grown faster than that extended to US residents. In particular, its growth rate hovered near 10% and rose to as high as 15% before the worst of the European sovereign and bank strains. In contrast, dollar credit to private US non-financial borrowers only started growing again in 2010.

Looking back over the cycle of the 2000s, much of the procyclicality of the growth of dollar credit extended to borrowers outside the US arose from bank loans (Graph 2, centre panel). Bond market credit showed more stable growth. Indeed, despite the practical closure of the bond market to all but the best issuers in late 2008, the year-over-year growth of bonds outstanding issued by non-US non-financial firms never turned negative. And, since 2009, it has grown at about a 15% rate, faster than the growth of bank credit to non-US non-banks, which decelerated into 2012 in response to the worsening of the European sovereign strains. (An even larger divergence in the growth of US dollar bank loans and bonds outstanding was also observed during the Asian financial crisis (Graph 2, centre panel)).

The resulting falling share of dollar loans relative to dollar bonds (Graph 2, left-hand panel) is reinforced by banks' diminished role as bond market investors: both point to a smaller role of banks in global dollar credit. In particular, banks' holdings of US dollar bonds issued by non-US residents hit a nine-year high just before the crisis, reflecting banks' easy access to funding and the market's acceptance of high bank leverage (Graph 4). Since Q4 2007, banks have reduced their holdings from $672 billion to $570 billion in Q4 2013, that is from a sixth to a tenth of all non-US non-banks' US dollar bonds (red line, right-hand scale). Thus, non-bank investors have not only taken up the large increase in outstanding dollar bonds, but have also absorbed the bonds released by deleveraging banks. In particular, they increased their holdings from $1.3 trillion to $3.1 trillion between Q4 2007 and Q4 2013.

Banks' share in holdings of dollar bonds issued by non-banks outside the US — Graph 4



Note: Excludes bonds issued by residents of Cayman Islands.

Sources: BIS locational banking statistics by residency; BIS international debt securities statistics; authors' calculations.

These observations of more rapid growth in dollar bonds compared to dollar loans, along with increased specialisation on the buy side, suggest that the drivers of bank and bond components of dollar credit to non-US borrowers may well differ. Moreover, compression of long-term bond yields through unconventional monetary policy by the Federal Reserve in recent years has introduced a new policy influence on both investors' demand for bonds and borrowers' choice between bank borrowing and bond issuance. We thus investigate the separate drivers of bank loans and bonds in Section 3 below.

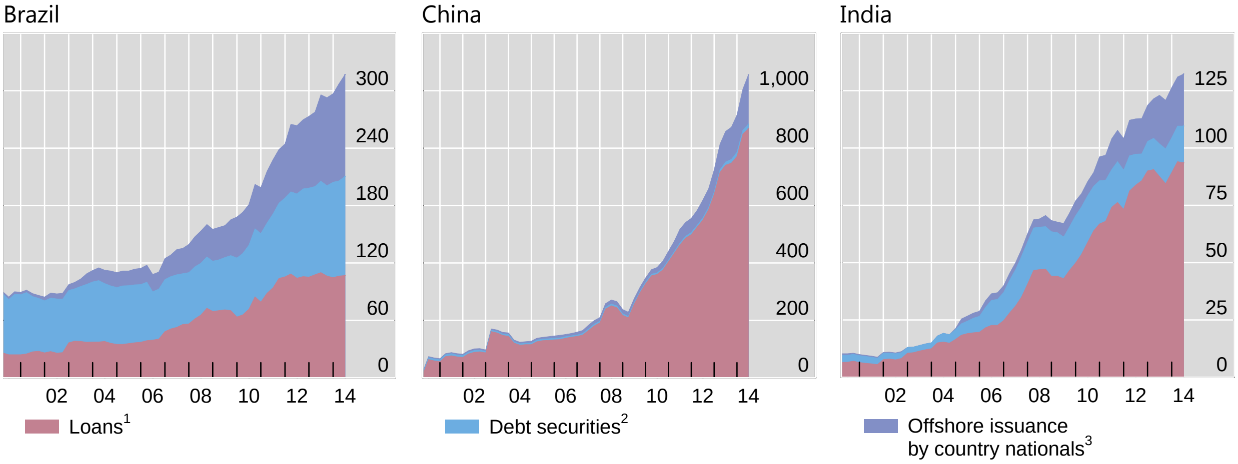
2.3 The geography of US dollar credit outside the US

What is the residence of borrowers of dollars outside the US? Before the global financial crisis, much of it is extended to borrowers in advanced economies: the euro area, the UK, Japan, Canada and the Nordic countries (Graph 2, right-hand panel). In fact, the share of dollar credit to emerging market borrowers fell from around half to about a third on the eve of the global financial crisis. Yet, since 2009, it has since recovered to almost half.[20]

An immediate implication is that not all that much of the dollar credit outside the US is extended to borrowers in dollarised economies. While studies of such economies at their broadest would focus on economies in which a tenth or more of bank loans are dollar-denominated, offshore dollar credit is mostly found in economies where it represents a single-digit percentage of credit. Thus, the top three stocks of dollar credit are in jurisdictions that are not usually thought of as dollarised: the euro area, China and the UK. The euro area and China have single-digit dollarisation rates, while the UK is higher, in the mid-teens (Borio et al (2011, p 46)).

US dollar credit to non-financial borrowers from Brazil, China and India

In billions of US dollars — Graph 5



[1] US dollar-denominated loans to non-bank residents of the country listed in the panel titles. For China, locally extended US dollar loans are estimated from national data on total foreign currency loans, assuming 80% are dollar-denominated. [2] Outstanding US dollar debt securities issued by non-financial residents of the country listed in the panel title. [3] Outstanding US dollar-denominated bonds issued offshore (ie outside the country listed in the panel title) by non-financials with the nationality listed in the panel title.

Sources: BIS locational banking statistics by residency; BIS International Debt Securities Statistics; national sources; authors' calculations.

[20] The share is over half if locally-booked bank loans to non-banks in non-reporting countries (almost entirely emerging markets), proxied by loans to banks in these countries, are included.

Other larger emerging market economies, like Brazil, India and Korea, have rates around 10%.[21] Dollar credit reaches a fifth to a third in places with closer ties to the US like Mexico and the Philippines and high fractions in Bolivia, Peru and Cambodia. But these do not contribute very much to overall dollar credit to borrowers outside the US.

Dollar credit to Brazilian, Chinese and Indian borrowers has grown rapidly since the global financial crisis (Graph 5). On this measure, which includes offshore bond issuance by non-banks' financial subsidiaries outside the country (dark blue area), dollar borrowing has reached more than $300 billion in Brazil, $1.1 trillion in China, and $125 billion in India. The rapid growth of bonds relative to loans is more evident in Brazil and India than in China. Indeed, in China and India, dollar credit continues to be extended mostly through bank loans.

The extent and rate of growth of dollar credit would be understated if one were to neglect the area at the top in the panels of Graph 5 showing the bonds issued by affiliates of Brazilian or Chinese firms incorporated outside Brazil or China (McCauley et al (2013)). The balance sheets of emerging market multinational firms span the national border, so balance of payments data do not capture their consolidated accounts. Interpreting the flows of funds through the consolidated balance sheets of multinational firms (eg Chinese real estate developers selling high-yielding dollar bonds in Hong Kong) represents a big analytical challenge (Avdjiev et al (2014)).

2.4 Foreign interest rates and US dollar credit to non-residents

As highlighted in the previous section, the largest recipient economies of US dollar credit tend to be emerging market economies with relatively high domestic interest rates. In order to check whether interest rate differentials relative to the US are systematically associated with US dollar credit, we run panel regressions on a sample of 22 major economies over Q1 2000 to Q2 2014.[22]

Panel regressions of US dollar credit on yield differentials, full sample — Table 1

Dependent variable	(1) Δ(Credit/GDP)	(2) Δ(Credit/GDP)	(3) Δ(Loan/GDP)	(4) Δ(Loan/GDP)	(5) Δ(Bond/GDP)	(6) Δ(Bond/GDP)
ΔPolicy rate gap	0.095*	0.013	0.032**	0.022		-0.009
	(0.050)	(0.022)	(0.015)	(0.014)		(0.013)
Δ10-year yield gap		0.078		0.023	0.052*	0.056**
		(0.056)		(0.043)	(0.028)	(0.028)
Country dummies	yes	yes	yes	yes	yes	yes
Time dummies	yes	yes	yes	yes	yes	yes
Observations	1,195	1,106	1,231	1,136	1,106	1,106
R-squared	0.124	0.155	0.106	0.108	0.180	0.183

Notes: The table reports regressions of quarterly changes in US dollar credit to non-financials in country *i* scaled by country *i*'s GDP on the lagged change in the policy rate and 10-year yield differential relative to US, including full country and quarterly dummies; unbalanced panel of 22 countries from Q1 2000 to Q2 2014; robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

[21] He and McCauley (2013) argue for a broader measure in Korea , including won debt hedged with currency forward sales into dollars. This produces a dollar bank debt percentage between 10% and 15% in recent years. See also Bruno and Shin (2014a).

[22] The panel is unbalanced due to late starts for 10-year government bond yield data for some emerging market economies. Economies included are Argentina, Australia, Brazil, Canada, Switzerland, Colombia, China, Czech Republic, UK, Hungary, Indonesia, India, Japan, Korea, Mexico, Malaysia, Poland, Russia, Thailand, Turkey, euro area and South Africa.

We regress the quarterly change in the US dollar credit to GDP ratio in country *i*, $(CRED_{i,t}^{j}/GDP_{i,t} - CRED_{i,t-1}^{j}/GDP_{i,t-1})$, on the spread in policy rates between country i and the US and the corresponding spread in 10-year bond yields, both lagged by one quarter. For US dollar credit, we consider three alternative aggregates, designated as *Loan*, *Bond* and *Credit* (= *Loan* + *Bond*) in Tables 1 and 2 below. Country and time dummies control for other factors.

We find that wider policy rate differentials are associated with a bigger change in US dollar credit relative to GDP (Table 1, column (1)). Decomposing aggregate US dollar credit, bank loans in particular seem to grow faster relative to GDP following a widening of the policy rate gap in the previous quarter. The coefficient on the policy rate gap (column (3)) indicates that a 1 percentage point widening in a country's policy rate relative to the federal funds rate is, on average, associated with 0.03% more dollar bank loans relative to GDP in the following quarter. For their part, dollar bonds outstanding grow faster relative to GDP following a widening of the *long-term* yield gap (column (6)); a 1 percentage point increase in the 10-year yield gap is associated with 0.06% more in non-banks' dollar bonds relative to GDP in the following quarter.

Thus, US dollar bank lending responds to policy rates, which set benchmark rates in money markets (eg US dollar Libor), which in turn form the basis of banks' US dollar funding costs and customer lending rates. For its part, US dollar bond market credit shows a tighter relation with benchmark long-term bond yields, as these could determine relative funding costs for non-bank US dollar bond issuers relative to their own currency.[23]

Next, we re-analyse dollar bank loans and bonds separately for pre- and post-crisis periods, excluding 2008 from both. While a wider gap in policy rates is associated with faster US dollar bank loan growth relative to GDP in both periods, a wider long-term yield gap is associated with faster US dollar bond growth relative to GDP in the post-crisis period only (Table 2, columns (1) and (3) versus (2) and (4)). In addition, notwithstanding the unchanging federal funds target in the post-crisis period, the association of US dollar bank loan growth with policy rate gap strengthens, driven by changes in policy rates by other central banks. The coefficient of 0.18 on the policy rate gap in the post-crisis period in

Panel regressions of US dollar credit on yield differentials, pre- and post-crisis — Table 2

	Pre-2008		Post-2008	
	(1)	(2)	(3)	(4)
Dependent variable	Δ(Loan/GDP)	Δ(Bond/GDP)	Δ(Loan/GDP)	Δ(Bond/GDP)
ΔPolicy rate gap	0.029*		0.181***	
	(0.015)		(0.058)	
Δ10-year yield gap		0.045		0.086***
		(0.037)		(0.032)
Country dummies	yes	yes	yes	yes
Time dummies	yes	yes	yes	yes
Observations	659	572	484	454
R-squared	0.115	0.131	0.159	0.259

Notes: The table reports regressions of quarterly changes in US dollar credit to non-financials in country *i* scaled by country *i*'s GDP on the lagged change in the policy rate and 10-year yield differential relative to US, including full country and quarterly dummies; unbalanced panel of 22 countries from Q1 2000 to Q2 2014; robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

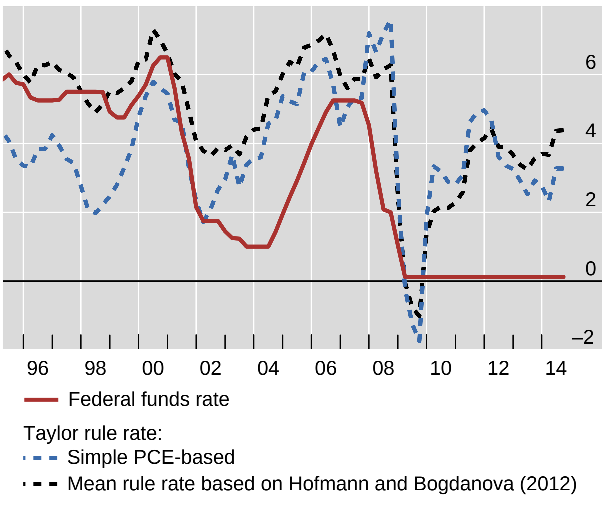
[23] The response of offshore US dollar bonds to long-term yields has been strengthened by the lengthening maturity in global international debt issuance, particularly by emerging market corporates. See Chui et al (2014) and Gruić et al (2014).

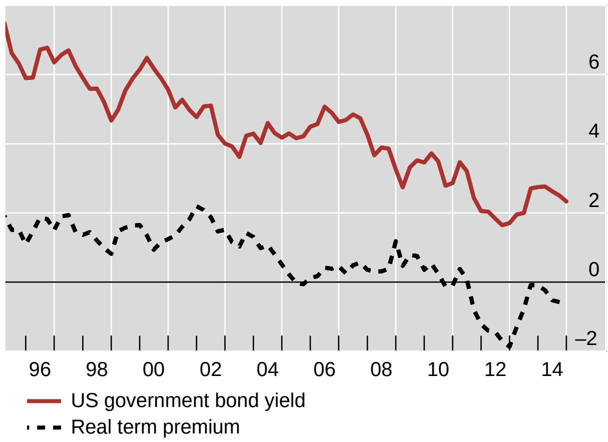
column (3) of Table 2 implies that a 1 percentage point wider gap in policy rates is associated with 0.18% more US dollar bank loans relative to GDP in the following quarter. Given that the average ratio of US dollar bank loans to GDP in our sample is 5.3%, holding GDP constant, this means a boost of approximately 4% (eg 0.18/5.3) to the stock of US dollar bank loans from a 1 percentage point foreign policy rate hike (or 1% more US dollar bank lending for every 25 basis points). This finding is consistent with that of Bruno and Shin (2014c), who find a statistically significant association between cross-border bank flows and the interest rate spread between local lending rates and the US federal funds rate.

3. US drivers of US dollar credit to non-residents

This section examines the association between the growth of US dollar credit to non-residents and measures of the US monetary policy stance as well as financial market volatility and cost of leverage. In contrast to section 2.4, which used panel regressions at the country level and non-US interest rates, this section focuses only the time series of aggregate US dollar credit to non-US, non-financial borrowers. We also abstract from non-US interest rates in recognition that much of US dollar borrowing takes place through offshore subsidiaries of global firms whose spreads relative to US interest rates are determined by a complex mix of different yields on different currencies, which cannot be inferred from their location. We focus on financing conditions in US dollar funding markets as a generally relevant common factor regardless of the borrower's location.[24]

Short-term and long-term financing conditions in US dollars — Graph 6





Notes: Taylor rule specification of Hofmann and Bogdanova (2012) is the mean of Taylor rule rates for combinations of various inflation and output gap measures for $i=r^*+\pi+1.5(\pi-\pi^*)+0.5y$. An alternative simple Taylor rule takes the form $i=r^*+\pi+0.5(\pi-\pi^*)+0.5y$, where π is the inflation rate of the personal consumption expenditure (PCE) index and y denotes the output gap from the Hodrick-Prescott (HP) filtered trend. r^* and π^* are set to 2% as the assumed equilibrium real interest rate and target inflation rate. The ten-year real term premium is estimated using a term structure model of Hördahl and Tristani (2014).

Sources: Bloomberg; Consensus Economics; Hofmann and Bogdanova (2012); BIS calculations; authors' calculations.

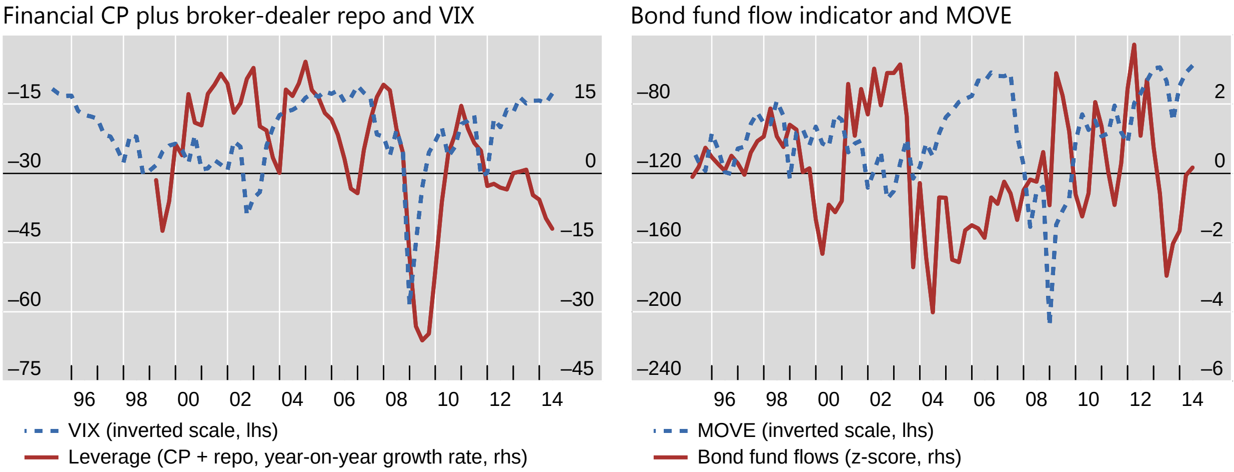
[24] For example, a Brazilian firms' UK or Dutch financing subsidiary will not necessarily consider sterling or euro bank lending rates despite its location.

Monetary policy stance: For monetary policy, we consider both indicators of conventional short-term policy rate setting and indicators of long-term rates, which are related to unconventional bond buying (Graph 6).[25] First, we regress the aggregate of US dollar bank loans to non-US residents on various US dollar interest rates and proxies for financial sector leverage. Then we do a similar analysis of aggregate outstanding dollar bonds. The ordinary least squares time-series regressions are conducted with stationary explanatory variables.[26]

Leverage: Our indicators of financial system leverage include the VIX and financial commercial paper plus primary dealer repo outstanding. Graph 7 (left-hand panel) shows that the quantity measures of leverage are closely associated with the VIX, which may be capturing risk-on/sell-out spirals to the extent that it proxies for the value-at-risk constraint of leveraged investors.[27] Hence, one way to interpret the VIX (which, after all, is just a measure of implied volatilities of S&P500 index options) is that it captures swings in the shadow cost of leverage by financial institutions managing risk against a value-at-risk constraint or the like. Thus, one may expect that the VIX, along with other measures of leverage, would have a closer association with the behaviour of global banks than with that of bond investors, which would include not only leveraged investors but also real money accounts (eg pension funds).

Quantity and price indicators of financial intermediary leverage

Graph 7



Notes: VIX is the Chicago Board of Exchange S&P500 index option implied volatility (annualised volatility in per cent). MOVE is the Merrill Option Volatility Expectations Index of US Treasury bond yields. The bond fund flow indicator is constructed following the methodology of Feroli et al (2014), where we take the first principal component of emerging markets, high-yield, investment grade, and MBS bond fund net inflows adjusted by asset under management.

Sources: Bloomberg; EPFR; Lipper; Federal Reserve Bank of New York; Feroli et al (2014); authors' calculations.

[25] For evidence that Federal Reserve large-scale asset purchases resulted in the compression of long-term yields, see Gagnon et al (2011), Krishnamurthy and Vissing-Jorgensen (2011) and D'Amico and King (2013).

[26] All the credit series are also log-differenced and tested for unit roots (see Appendix Table A1). Unlike all other variables, for which a unit root cannot be rejected in levels but can be strongly rejected in first differences, the VIX and MOVE appear (borderline) stationary even in levels.

[27] McGuire and von Kleist (2008) related the growth of international bank claims to crisis events. CGFS (2011) summarised the crisis events with the VIX. Bruno and Shin (2014b) and Rey (2013) relate the VIX to credit flows through international banks, Forbes and Warnock (2012) discuss its impact on gross flows. The commercial paper and repo measures draw on Adrian and Shin (2010). In fact, it is straightforward to show that first order conditions derived with investors with CARA preferences (eg mean-variance optimising investors) are equivalent to those derived with risk neutral banks, which instead face a value-at-risk constraint. In the latter case, the degree to which the leverage constraint is binding is captured by a term that plays the same role as the risk premium on the variance of expected returns in the CARA setup.

For analogous price and quantity measures for bond markets, we rely on the MOVE index of bond market volatility and an indicator of US flows into fixed income credit. In particular, we follow Feroli et al (2014) and construct an indicator of flows into bond mutual funds. Specifically, we use the first principal component of net flows into investment grade, emerging markets, and mortgage-backed security bond funds, adjusted for assets under management (Graph 7, right-hand panel).[28]

3.1. Dollar bank credit to borrowers outside the US

A scatter plot makes evident the negative association between a federal funds rate set below that prescribed by a Taylor rule and the growth in US dollar bank loans to borrowers outside the US (Graph 8, centre and right-hand panels). A low level of the federal funds rate in relation to US inflation and the output gap is associated with higher growth of dollar loans to borrowers outside the US. The association is statistically significant at a 1% level. In fact, when the effective federal funds rate is below that prescribed by the Taylor rule, hardly any instances of year-on-year shrinkage in offshore US dollar bank lending are observed (particularly for the simple PCE-based Taylor rule). Rather, most of the observations are in the upper left-hand quadrant of the graph, indicating positive offshore US dollar loan growth, with abundant observations of double-digit growth.

Next, we look at the association between the federal funds rate, volatility and the cost of leverage and US dollar bank credit to non-US residents while also controlling for global factors. Unit roots in year-on-year growth rates in the US dollar credit series as well as in the Taylor rule-adjusted federal funds rates in levels prevent us from running time-series regression on the same series as shown in the scatter plot (see Appendix Table A1). Therefore, in these regressions we enter log differences for the quantity variables to make them stationary, and first differences for prices and interest rates.

Table 3 shows the results for the growth in the bank loan component of US dollar credit to non-US residents as the dependent variable. The time-series regression is specified as follows:

$$\Delta logLOAN_t = \alpha + \beta_R^L \Delta STRATES_{t-1} + \beta_V^L VOLA/LEVERAGE_{t-1} + \beta_X^L \mathbf{X}_t + \epsilon_t, \qquad (1)$$

where $LOAN_t$ denotes US dollar credit extended through bank loans in quarter t, $\mathrm{STRATES}_{t-1}$ is the federal funds rate less the Taylor rule rate in quarter t-1, $\mathrm{VOLA/LEVERAGE}_{t-1}$ refers to either one-quarter lag level of the VIX or log-difference of financial CP plus primary dealer repo, and X_t is a vector of global controls. As noted, these include credit growth outside the US, the growth in the volume of world trade, and the Federal Reserve's broad nominal US dollar index. These controls can be seen as a reduced-form representation of supply and demand factors of US dollar credit extended via a global bank intermediation chain modelled in Bruno and Shin (2014c). On the supply side, banks' ability to leverage up and to raise wholesale funding in US dollars plays a key role. These factors are proxied by the VIX and the sum of US financial CP and primary dealer repo plus reverse repo. On the demand side, the incentive and capacity to borrow in US dollars increases with US dollar depreciation (appreciation of local currency). As in Bruno and Shin (2014b), a low federal funds rate can spur bank cross-border lending indirectly through either higher leverage or US dollar depreciation. The addition of world trade captures other factors affecting aggregate demand and supply of international credit, as well as proxying for global business cycle more broadly.

[28] Since EPFR bond fund flow data does not go back to Q1 1995, we backdate each series using data from Lipper (by applying changes from the latter to the levels of the former), prior to using the series as inputs in the principal component analysis. Appendix Graph A1 shows the raw net inflows by fund type adjusted by assets under management.

The coefficients on federal funds rate deviations from the Taylor rule are not significant, which runs contrary to our expectations.[29] This result arises because the growth in bank loans to non-US residents continued to rise even when the Federal Reserve raised the federal funds rate towards the Taylor benchmark in 2004-06, then fell in tandem with the federal funds rate in late 2008, as the Federal Reserve rapidly lowered its target to zero by Q4 2008 in the face of a rapid pullback of banks from international lending (Graph 8, left-hand panel). In 2004-06, banks took comfort from the Federal Reserve's "measured pace" of very gradual tightening after a long period of exceptionally low rates. This induced low volatility and allowed banks to leverage up despite steady increases in the federal funds target. The weaker results concerning the federal funds rate in the regression that also includes leverage and US dollar exchange rate variables are in line with the results of Bruno and Shin (2014c).

Moving to the effects of leverage and wholesale funding, leverage, however measured, drives the pace of offshore dollar bank lending. The coefficient in Table 3, column (1) indicates that a one per cent higher wholesale market leverage growth is associated with 0.13 per cent higher growth rate of aggregate dollar credit in the following quarter. Similarly, the coefficients on the VIX in columns (2) and (3) indicate that a one per cent increase in annualised financial market implied volatility is associated with a 0.12 to 0.15 per cent lower growth rate of US dollar credit to non-US residents the following quarter. These results are robust to the inclusion of global factors: the US dollar exchange rate or world

Drivers of offshore US dollar bank loan growth

Table 3

Dependent variable: $\Delta logLOAN_t$	(1)	(2)	(3)
ΔFed funds deviation from Taylor rule[1]	0.295	0.169	0.519
	(0.487)	(0.505)	(0.513)
Δlog(leverage (CP + repo))[2]	0.134*		
	(0.071)		
VIX[3]		-0.148***	-0.116**
		(0.045)	(0.053)
Δlog(US dollar NEER)			-0.391*
			(0.227)
Δlog(World trade)			-0.003
			(0.095)
Constant	2.026***	5.171***	4.531***
	(0.416)	(1.001)	(1.214)
Observations	64	73	73
R-squared	0.042	0.116	0.173

Notes: Dependent variable is the quarterly growth in US dollar bank loans to non-US resident non-financial sector borrowers, in per cent. All explanatory variables lagged by one quarter. Sample period from Q1 1996 to Q2 2014; robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

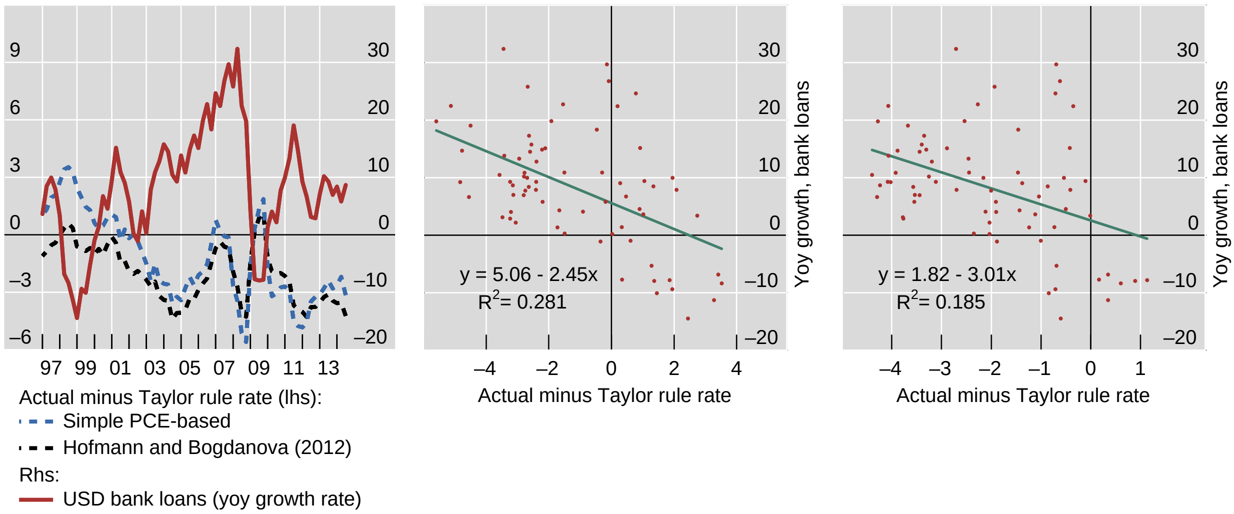
[1] Federal funds target rate and the rate implied by the Taylor rule using the output gap and PCE inflation: i = r* + p + 0.5 (p-p*) + 0.5 (y-y*); in first differences, per cent. [2] Sum of US financial CP and broker-dealer repo and reverse repo outstanding. [3] Chicago Board of Exchange S&P500 index option implied volatility (annualised volatility in per cent).

[29] The somewhat puzzling result of the 1-lag OLS time series regressions of dollar bank credit on our measure of monetary policy contrasts not only with the simpler scatter plot analysis above but also with a less restrictive VAR (results available upon request). Accounting for past shocks to both dollar credit growth and US short-term rates in a VAR system, the impulse responses show a negative and significant contemporaneous association between dollar Libor and US dollar bank lending.

Offshore dollar bank loan growth and federal funds deviations from Taylor rules

In per cent | Graph 8

Federal funds rate, Taylor rules deviations and US dollar bank loans | Simple PCE Taylor rule | Hofmann-Bogdanova Taylor rule



Notes: Left-hand panel uses the Taylor rule using the output gap and PCE inflation: i = r* + p + 0.5 (p-p*) + 0.5 (y-y*). Right-hand panel uses the Taylor rule specification taken from Hofmann and Bogdanova (2012), that is the mean of Taylor rates for different combinations of varying inflation and output gap measures for i=r*+π+1.5(π-π*)+0.5y

Sources: Hofmann and Bogdanova (2012); Bloomberg, Consensus Economics; BIS locational banking statistics by residence; authors' calculations.

trade growth.[30] Finally, in line with greater incentives to borrow offshore US dollars when the dollar depreciates, the coefficient on US dollar nominal effective exchange rate is negative (specification (3)).

3.2. Dollar bonds of non-financial borrowers outside the US

As noted, the stock of dollar bonds issued by borrowers outside the US has been growing faster and more steadily in recent years than that stock of their bank debt. Turner (2013b) associates the US term premium compression between 2010 and 2013 with an unprecedented $1.03 trillion of net emerging market international bond issuance, of which non-banks accounted for more than 70%. This section presents evidence that such recent compression of long-term yields is associated with faster growth of the stock of offshore dollar bonds. This is in contrast to US dollar bank lending, which responds more to short-term rates and leverage conditions. Like Table 3, Table 4 reports regression results for the US dollar bonds issued by non-US residents. The time series OLS regression is specified as follows:

$$\Delta logBOND_t = \alpha + \beta_T^B \Delta TERMPREM_{t-1} + \beta_V^B VOLA/LEVERAGE_{t-1} + \beta_X^B \mathbf{X}_t + \epsilon_t \quad (2)$$

where $BOND_t$ denotes US dollar credit extended through international debt markets in quarter t, $\mathrm{TERMPREM}_{t-1}$ is the term premium estimate on 10-year Treasury bonds in quarter t-1, VOLA/

[30] Results (available upon request) are robust to using a Taylor rule specification based on Hofmann and Bogdanova (2012).

$\mathrm{LEVERAGE}_{t-1}$ refers to either the previous quarter level of the MOVE index or to the bond fund flow indicator, and X_t is the same vector of global controls used for bank credit in Equation (1).

While the coefficient on the MOVE index is not significant, the coefficient on the bond fund flow indicator is positive and significant. A one standard deviation increase in fund inflows is associated with 0.2 per cent higher growth rate in US dollar debt securities issued by non-bank borrowers outside the US. The coefficients on the 10-year term premium are not significant.

Still, as in the case of US dollar bank lending, the results for the full sample regression of quarterly growth rates on lagged independent variables mask non-linearities and time-varying effects. In particular, a statistically significant association between the term premium and growth in offshore US dollar bond issuance emerges when the *levels* of the term premium are considered (Graph 9, left-hand panel). The scatter plot shows that a lower-term premium is associated with higher quarterly growth in US dollar bonds, with all of the upper left-hand quadrant occupied by the post-2009 observations. In addition, inspection of quarterly *changes* in the term premium and offshore US dollar bond issuance growth (eg of the variable as they entered the regression based on Equation (2) above) suggests a regime change around the end of 2008, with the volatility of both series rising and a visibly negative association emerging as well (Graph 9, centre panel). In Q4 2008, there is a spike in the term premium as the financial contagion from the Lehman collapse peaked and the Federal Reserve cut its policy rate target to zero. Then, in Q1 2009, the term premium compresses sharply while offshore US dollar bond issuance soars.

To gain statistical insight into the behaviour of the series shown in Graph 9, we repeat the regression analysis of bond issuance (Equation (2)) over rolling 16-quarter samples to see how the coefficients evolve over time. Because of the reduced degrees of freedom, we drop the controls, $\mathbf{X}_t$. The relationship between the term premium and offshore US dollar bond issuance showed a sharp break when the Federal Reserve undertook its first round of large-scale bond buying, denoted by a vertical line in Graph 9. The estimated coefficients on lagged changes in the term premium, plotted in the right-hand panel of Graph 9, abruptly turn negative then.

Drivers of offshore US dollar bond growth

Table 4

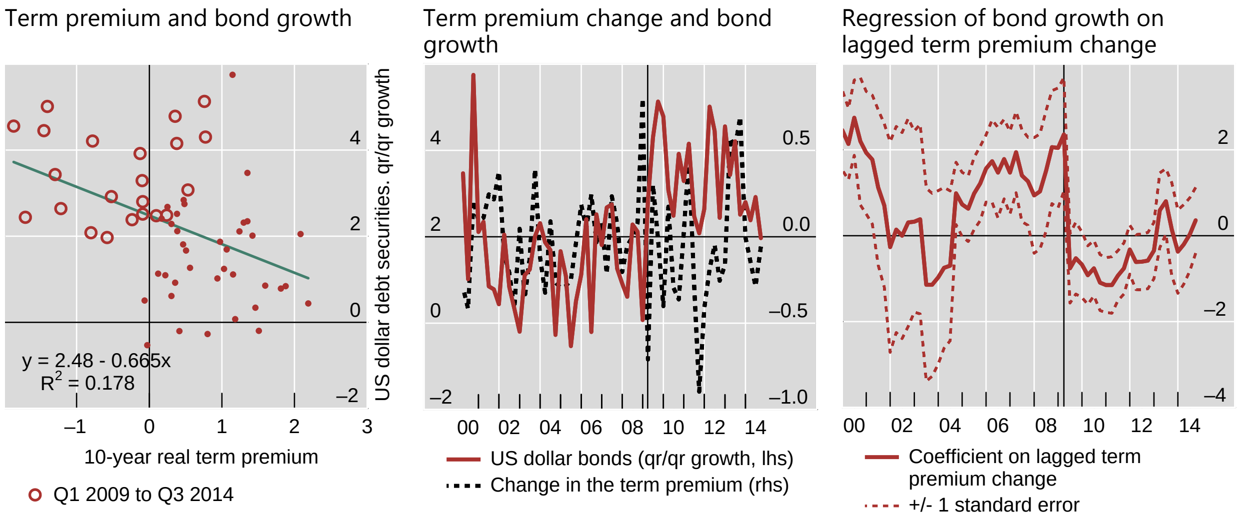
Dependent variable: $\Delta logBOND_t$	(1)	(2)	(3)
ΔReal term premium[1]	0.335	0.559	0.432
	(0.546)	(0.549)	(0.614)
MOVE[2]	-0.001		
	(0.006)		
Fund flow indicator[3]		0.223*	0.240*
		(0.120)	(0.124)
Δlog(US dollar NEER)			0.142
			(0.111)
Δlog(World trade)			0.024
			(0.043)
Constant	2.367***	2.265***	2.203***
	(0.621)	(0.171)	(0.182)
Observations	73	73	73
R-squared	0.005	0.062	0.093

Notes: Dependent variable is quarterly growth rate in US dollar-denominated international debt securities outstanding issued by private non-financial borrowers outside the US, in per cent. All explanatory variables lagged by one quarter. Sample period from Q1 1996 to Q2 2014; robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

[1] The ten-year real term premium is estimated using a term structure model of Hördahl and Tristani (2014). [2] Merrill Option Volatility Expectations Index of Treasury bond yields. [3] Bond mutual fund inflow indicator based on the first principal component of emerging markets, high-yield, investment grade, and MBS bond fund flows (adjusted by assets under management), following Feroli et al (2014).

Term premium on 10-year Treasury bonds and US dollar bonds

Relationship with offshore US dollar bonds outstanding — Graph 9



The vertical line indicates end Q1 2009. Rolling regression estimates based on 16-quarter rolling regressions of quarterly log change in US dollar bonds on lagged change in the term premium and lagged VIX (controlling for overall financial market conditions). The ten-year real term premium is estimated using a term structure model of Hördahl and Tristani (2014).

Sources: Federal Reserve Bank of New York; Bloomberg; BIS calculations; authors' calculations.

This timing coincides with the announcement and initial implementation of the first large-scale asset purchases by the Federal Reserve. The emergence of the negative association between the term premium changes and the growth in offshore US dollar bond issuance in 2009 is consistent with the portfolio rebalancing channel of the Federal Reserve's asset purchases. This channel is open when term premium compression on long-term Treasuries induces investors to seek yield in riskier securities (Gagnon et al (2011), Krishnamurthy and Vissing-Jorgensen (2011), D'Amico and King (2013) and Bernanke (2013)). US dollar bonds issued by non-resident borrowers, generally by recognisable names that are often rated BBB, fit the bill.

Following the money, the first step in the portfolio rebalancing involved a rise in US investor purchases of bonds other than Treasuries. This dynamic is indeed evident from the left-hand panel of Graph 10, which juxtaposes the bond fund flow indicator and term premium changes. The Q1 2009 term premium compression is associated with a three standard deviation spike in inflows into US bond mutual funds, which cater to US investors. The negative association between the two series persists into 2014, with mutual fund inflows picking up whenever there is a pronounced decline in the term premium on 10-year Treasuries, and contracting whenever the term-premium rebounds.

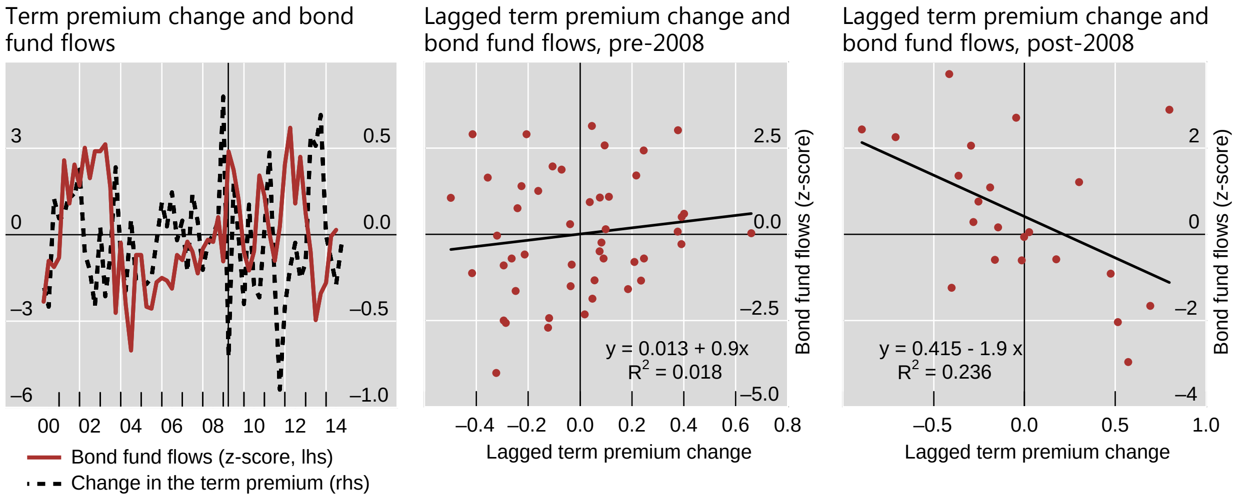
As noted, the Federal Reserve's large-scale bond buying faced bond investors with the prospect of receiving lower yields on Treasury bonds than they could foresee by rolling over Treasury bills (even at the current low yields on such bills). Under such circumstances, bond investors turned to higher yielding bonds, including those sold by emerging market firms. This dynamic is confirmed by the scatter plots in the centre- and right-hand panels of Graph 10, which show the association between bond flows and term premium changes in the preceding quarter. A negative and statistically significant association emerges in the relationship between bond fund flows and lagged change in the term premium only beginning 2009 in the right-hand panel of Graph 10. Lower yields on safe Treasury securities led investors to shift flows into riskier bond funds. From the issuer's perspective, a low or negative term premia implies that there is little or no cost in securing fixed interest payments over a given horizon rather than bearing the risk of paying the succession of floating-rate interest rates. From this point of view, term premium compression induced more bond issuance (a negative coefficient). More broadly, just when unconventional monetary policy started to push down the term premium, it began to exert a measurable effect of accelerating issuance of dollar bonds by borrowers outside the US.

The results so far suggest a link between term premium compression on US Treasuries and the rapid growth in the stock of offshore US dollar bonds, and that portfolio rebalancing by bond fund investors may be a part of the transmission mechanism. A less restrictive approach in terms of lead-lag structure is to estimate a VAR system, which allows for endogeneity between these variables. To estimate a time-varying VAR system, we adopt the methodology of Primiceri (2005) and Nakajima (2011). Endogenous variables are the change in the term premium, the MOVE index, the bond fund flow indicator, and the log change in the US dollar bonds outstanding. We sample the impulse responses of endogenous variables at different points in time using the time-varying parameter estimates.

Graph 11 displays impulse responses sampled in Q4 2006, Q1 2009, and Q1 2013.[31] The impulse response of bond fund inflows is always negative and significant, indicating that a negative one standard deviation shock to the term premium causes an increase in bond fund inflows (Graph 11, left-hand panels). The impulse response of offshore US dollar debt issuance to a positive one standard deviation shock to bond flows, in turn, also tends to be positive, at least until we begin to approach the "taper tantrums" in early 2013 (Graph 11, centre panels). Finally, the impulse response of offshore US dollar

Term premium on 10-year Treasury bonds and bond mutual fund flows

Relationship with bond mutual fund flows — Graph 10



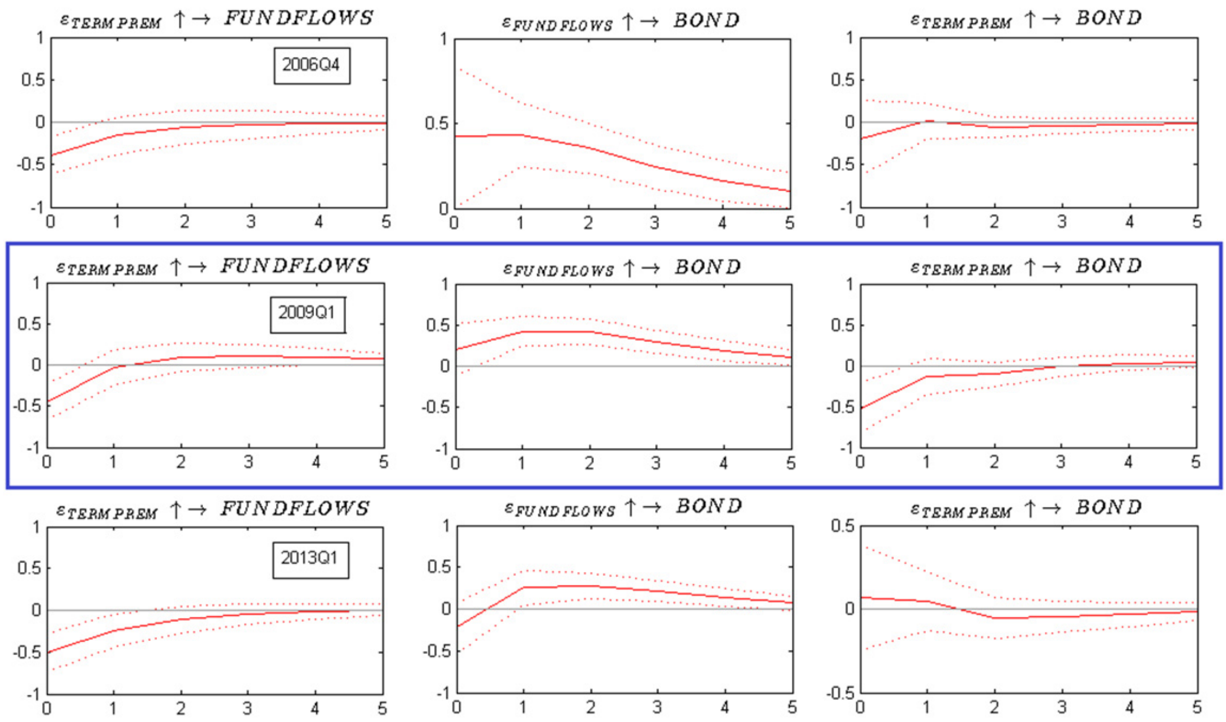
The vertical line indicates end Q1 2009. The bond fund flow indicator is constructed following Feroli et al (2014) using the first principal component of emerging markets, high-yield, investment grade, and mortgage-backed bond fund net inflows adjusted by assets under management.

Sources: Lipper; Feroli et al (2014); Federal Reserve Bank of New York; Bloomberg; EPFR; BIS calculations; authors' calculations.

[31] See Appendix 2 for methodology and technical details. Graph A2 plots the time series of endogenous variables and the estimated volatility of structural shocks. It shows a significant term premium compression during the latter part of the sample period and a rise in the estimated volatility of term premium shocks. We assume that both compression and volatility of the term premium have been largely induced by the policies of the Federal Reserve (see, for example, Gagnon et al (2011)). Graph A3 plots selected parameter diagnostics. The reported sample autocorrelations are mild (top panels), the chain is not sticky (centre panels), and posterior parameter densities are approximately normal (although with a slight skew), overall indicating stable convergence and a reasonable fit of the model.

Impulse responses of dollar bonds issued by non-US residents

Graph 11



Notes: Selected Bayesian time-varying VAR impulse responses to shocks to the 10-year term premium (left-hand column) and to the bond fund flow indicator (centre and right-hand columns), with 68% credible interval bands. Estimated system parameters sampled in Q4 2006, Q1 2009 and Q1 2013 based on 10,000 samples after discarding the first 1000 as burn-in. The graph shows impulse responses sampled from the following system: $\boldsymbol{y}_t' = (\Delta TERMPREM_t, MOVE_t, FUNDFLOWSt\ \Delta logBOND_t)$. We estimate the three-variable TVP-VAR model using quarterly data from Q2 1995 to Q2 2014.

bonds to the term premium shock becomes negative and statistically significant in Q4 2009 (Graph 11, right-hand panels).[32]

Since VAR impulse responses control for the covariances among all the endogenous variables in the system, the significant impulse response of offshore US dollar debt securities to term premium compression in Q1 2009 can be interpreted as a strengthening of the effect on top of that transmitted through an increase in (mostly US-domiciled retail investor) bond fund inflows.[33] In practice, this may reflect portfolio rebalancing by other investors who do not invest in bonds through mutual funds, such as non-US residents and large institutional fund managers, who were also probably induced into buying foreign issued US dollar bonds. Thus, similar to the dynamics in Graph 10, the impulse responses in Graph 11 point to a shift at the start of the Federal Reserve large-scale bond buying. The effect appears to have disappeared recently as the Federal Reserve began scaling back its asset purchases and the term premium has risen.

What are some of the financial stability implications of these developments? From the usual perspective of avoiding a sudden stop (Greenspan/Guidotti rule), the increasing reliance on dollar bond

32 In addition, the impulse responses of offshore US dollar debt issuance to the spike in bond yield volatilities, as measured by the MOVE index shock, are always negative and significant. The complete set of impulse responses in Q4 2006, Q1 2009 and Q1 2013, which also show responses to a positive one standard deviation MOVE index shock, are reported in Appendix 2 (Graphs A4, A5 and A6, respectively).

33 EPFR data on bond mutual funds capture some institutional investor flows but are highly skewed towards US retail investors.

funding of longer duration by non-US borrowers is a good thing, other things equal. For an investment grade issuer like the Republic of Indonesia or a lower-rated Indonesian firm, the ability to sell debt with an initial maturity of 30 years or 10 years, respectively, improves its liquidity profile and makes an episode of forced borrowing in a difficult market less likely. However, all other things are not equal: in particular, US dollar short rates will at some point rise and the term premium in the dollar bond market will revert from the negative to the positive. While some institutional investors are disciplined by benchmarks that include emerging market bonds, many holders of bond mutual funds are not. As yields rise and net asset values fall, the price of long-duration bonds can fall sharply. From a buy-side perspective, long duration could provoke destabilising market dynamics. At the same time, bonds will mature over the medium term over which yield normalisation may be expected. It is worth recalling that the market for dollar bonds for non-US residents can essentially close – this happened in late 2008.

4. Conclusions and policy implications

We examine the role of benchmark policy rates, long-term yield compression, and the cost of leverage in the growth of US dollar credit to non-US borrowers through banks and bond markets. Overall, we find that accommodative US monetary policy and cheap leverage promote growth in this credit, but the relative importance of these factors is sensitive to the sample period and estimation method.

We draw four conclusions. First, dollar credit has flowed since the global financial crisis to an unusual extent to emerging markets and to advanced economies that were not hit by it. Dollar credit has grown slowly in two economies where dollar credit was large and growing rapidly before the crisis, namely the euro area and the UK. In other words, since the crisis, dollar credit has grown fastest in the economies with relatively high domestic interest rates. These observations are corroborated by panel regression results. These wider policy rate differentials relative to the federal funds rate spur subsequent quarter US dollar bank loan growth across 22 countries over the past 15-year period. At the same time, wider 10-year yield differentials spur subsequent quarter growth in US dollar bonds outstanding. In addition, these associations appear to have strengthened post-crisis.

Second, non-bank investors have extended an unusual share of dollar credit to non-US residents since the crisis. Such credit flowed through the international bond market to an unprecedented extent, while banks have stepped back as holders (and issuers) of bonds. Non-bank investors have not only bought all the net increase in bonds outstanding but taken up the bonds that have come out of bank portfolios.

Third, prior to the crisis, the familiar drivers of international bank credit played a predominant role in offshore US dollar credit growth. Bank leverage (as measured by financial CP and broker-dealer repo), or low-cost leverage (as measured by the VIX) set the pace for offshore dollar lending, as measured by quarterly growth rates. For the longer run (eg year on year rather than quarterly growth rates), we document that the *level* of the federal funds rate matters. When the effective federal funds rate is below that prescribed by the Taylor rule, offshore dollar lending generally grows and often at double-digit rates.

Fourth, since the crisis, the Federal Reserve's compression of term premia via its bond buying has led to a surge in US dollar borrowing through bond markets. Time-varying regressions and VAR analysis also indicate that inflows into bond mutual funds played a significant role in transmitting monetary ease, giving evidence of the portfolio rebalancing channel of the Federal Reserve large-scale bond purchases. In particular, given the low expected returns of holding US Treasury bonds (in relation to expected short-term rates), investors have sought out and found dollar bond issuers outside the US, many rated BBB and thus offering a welcome credit spread.

Policy implications fall under three rubrics: policy transmission; the limits of policies to change the borrowing cost of dollars outside the US; and the new challenges of what Shin (2013) calls the second phase of global liquidity.

First, the scale of dollar borrowing outside the US means that US monetary policy is transmitted directly to the rest of the world in several ways. Changes in the short-term policy rate are promptly reflected in the cost of $5 trillion in US dollar bank loans. Moreover, lower short-term dollar rates quicken the pace of the expansion of the stock of dollar loans extended to borrowers outside the US. In addition, unconventional monetary policy that reduces returns on Treasury bonds has also led bond investors to step up their extension of dollar credit to bond issuers outside the US and lowered dollar bond coupons for non-US issuers. These effects of large-scale bond buying on the amount and pricing of dollar bonds issued by non-US borrowers operates in addition to any effect such unconventional policy has in lowering the yields on bonds denominated in other currencies (Neely (2014), Bauer and Neely (2014) and Rogers et al (2014)).

Second, the ability of multinational firms to borrow dollars through offshore affiliates limits the effect of national policies to restrict access to or to raise the cost of dollar credit. He and McCauley (2013) find that, despite differences in capital account openness, policy in China and Korea succeeded in raising the cost of dollar bank credit from banks at home. However, faced with more expensive local dollar bank debt, emerging market firms can borrow dollars through offshore affiliates.[34] Wider access to the global dollar bond market strengthens global forces and weakens national policies.

Finally, what Shin (2013) calls the second phase of global liquidity, one in which the fastest growth in dollar credit is coming from bond issuance rather than bank lending, not only has its own who's who and dynamics but it also has its own risks. While bonds bind borrowers and lenders over the medium term and work against sudden reversals of credit, rollover of maturing bonds can still present a challenge, especially when market sentiment as captured by the fund flows of Feroli et al (2014) turns less accommodating. If borrowers need to substitute domestic debt for dollar debt in adverse circumstances, then the exchange rate would come under pressure.

While international bonds may be stickier than bank debt, the shift towards dollar credit through bond markets in recent years does raise financial stability concerns, as argued by Shin (2013) and Turner (2013b). First there is a concern that emerging market firms are raising funds from the international bond market to fund various forms of carry trades. Second, a substantial part of dollar bond issuance has come from first-time issuers (Mizen et al (2012)), which raises questions about not only the due diligence on the part of the lenders and but also the risk management practices on the part of the borrowers. Third, there is a concern that bonds issued by offshore affiliates of emerging market firms are not captured in balance of payments statistics or national debt statistics but could weigh on national foreign exchange reserves in times of strain.[35] Finally there is a concern that, as emerging market firms shift borrowing from domestic banking systems to external bond markets, policymakers may be misled by the slower pace of domestic bank credit expansion. This would be all the worse if, as argued by Shin, the proceeds of external bond issues were in effect deposited in domestic banks. We still have a lot to learn about the risks of dollar credit through international bond issues.

34 The financial stability intention of the Korean macroprudential levy, namely to limit the build-up of short-term dollar liabilities, is not frustrated by Korean multinational firms' issuing medium-term dollar debts.

35 See Cho and McCauley (2003) on the role of offshore debt of the Korean corporate sector during the 1997-98 crisis; McCauley et al (2013) for the importance of the corporate debt of offshore affiliates of emerging market firms, particularly those headquartered in Brazil and China; and Avdjiev et al (2014) for a discussion of the relationship between offshore borrowing and the balance of payments.

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Appendix 1: Supplementary tables and graphs

Determinants of US dollar credit growth at the global level — Table A1

Factor	Concept	Market metrics	Monetary policy
1	Short-term rates/ borrowing costs	Effective federal fund rate, LIBOR	Federal funds Taylor rule deviations (conventional)
2	Long-term rates/ yield on investment	10-year government bond yields	Term-premium compression (unconventional)
3	Equity market volatility, leverage of financial intermediaries	VIX, Financial CP, primary dealer repo	
4	Bond market volatility, risk appetite of bond investors	MOVE, Bond mutual fund flows	
5	Global controls	World trade, US dollar NEER	Policy rates

Notes: Taylor rule specification of Hofmann and Bogdanova (2012) is the mean of Taylor rule rates for combinations of various inflation and output gap measures for $i=r^*+\pi+1.5(\pi-\pi^*)+0.5y$. An alternative simple Taylor rule takes the form $i=r^*+\pi+0.5(\pi-\pi^*)+0.5y$, where π is the inflation rate of the personal consumption expenditure (PCE) index and y denotes the output gap from the Hodrick-Prescott (HP) filtered trend. r^* and π^* are set to 2% as the assumed equilibrium real interest rate and target inflation rate. The ten-year real term premium is estimated using term structure models as the deviation in nominal yield from the sum of expected growth rate, expected inflation, and inflation risk premium. VIX is the Chicago Board of Exchange S&P500 index option implied volatility; in unit of annualised volatility, per cent. MOVE is the Merrill Option Volatility Expectations Index of Treasury bond yields. Bond fund flow indicator is constructed following the methodology of Feroli et al (2014), where we take the first principal component of emerging markets, high-yield, investment grade, and MBS bond fund net inflows adjusted by asset under management.

Sources: Bloomberg; Consensus Economics; EPFR; Federal Reserve Bank of New York; Hofmann and Bogdanova (2012); BIS calculations; authors' calculations.

Unit root test results in levels and first differences — Table A2

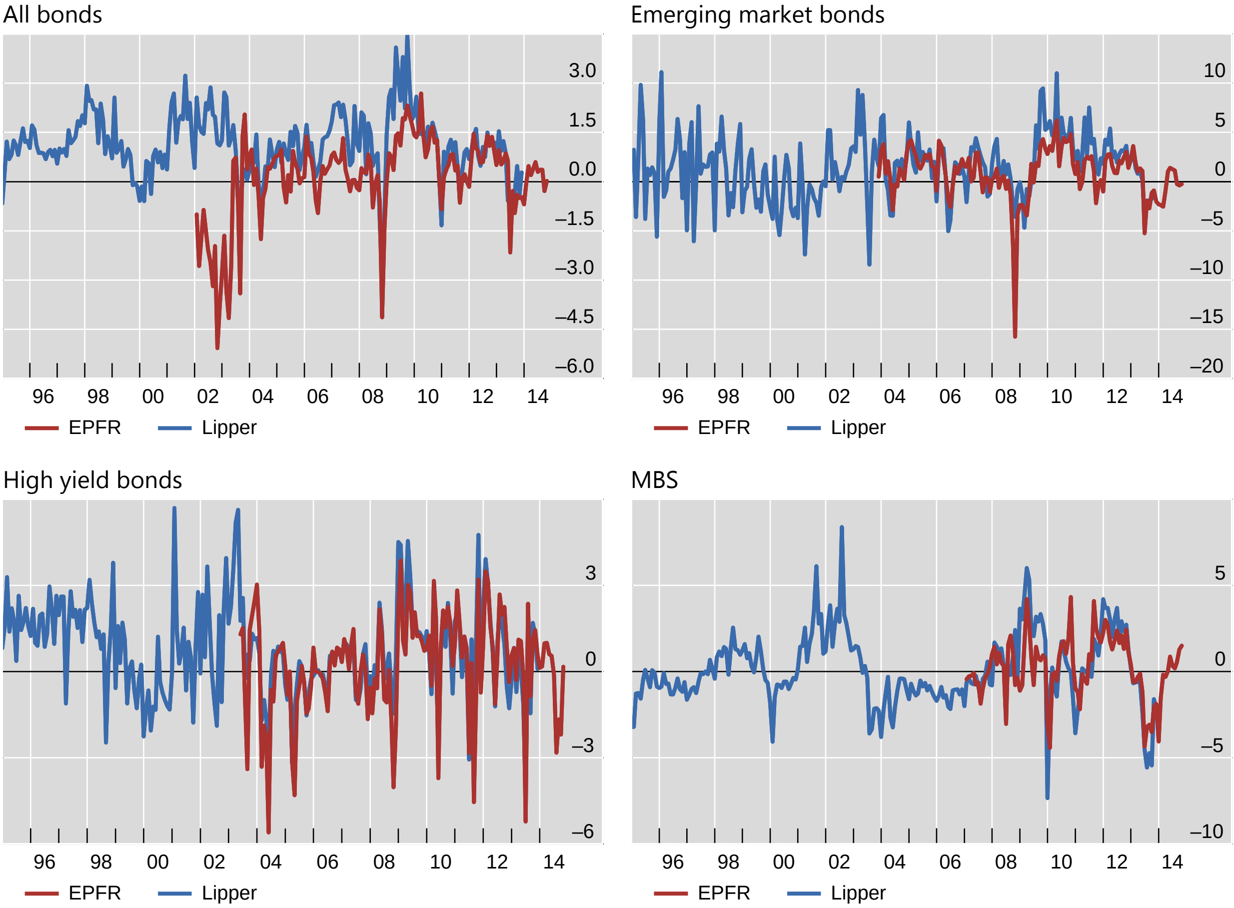
	Augmented Dickey-Fuller test statistics: p-value	
	Levels	First-differences
US dollar-denominated offshore bank loans (in logs)	0.9961	0.0000
US dollar-denominated offshore debt (in logs)	0.9988	0.0000
Federal funds rate target	0.7991	0.0065
Yield, 10-year Treasuries	0.7233	0.0000
Real term premium, 10-year Treasuries	0.6701	0.0000
VIX	0.0106	0.0000
Leverage = financial CP + primary dealer repo & reverse repo (in logs)	0.3423	0.0040
MOVE	0.0369	0.0000
Bond flows indicator (z-scores)	0.0017	0.0000
Trade volume (in logs)	0.9109	0.0000
US dollar NEER	0.5082	0.0000

Notes: The table reports MacKinnon approximate p-value for Z-statistics based on n-lags, number of lags for each variable selected using SIC; Q4 1995 (or earliest available) to Q2 2014.

Bond fund flows used in the construction of the PCA-based composite indicator

As a percentage of net total assets

Graph A1



Notes: We use EPFR data to construct net inflows adjusted by total asset, which are then fed into the composite bond fund flow indicator. Since EPFR data is not available going back to Q1 1995, we backdate the EPFR series for each fund type (red) using changes in the Lipper fund flow data (blue) obtained from Feroli et al (2014).

Sources: EPFR; Lipper; Feroli et al (2014) ; and authors' calculations.

Appendix 2: Bayesian time-varying parameter VAR, methodology and additional results

We rely on the methodology developed by Primiceri (2005) and applied by Nakajima (2011) to estimate the evolution of the relationship between offshore US dollar credit growth and interest rate and leverage measures over time. Consider the time-varying parameter Bayesian VAR (TVP-VAR) model with stochastic volatility:

$$y_t = y_{t-1}\beta_t + A_t^{-1}\Sigma_t\varepsilon_t, t = s+1, \dots, n \quad \text{(A.1)}$$

where the coefficients β_t and the parameters $\mathrm{A}_{\boldsymbol{t}}$ and $\boldsymbol{\Sigma_t}$ are all time-varying and $\boldsymbol{y}'_t = (\Delta TERMPREM_t, MOVE_t, FUNDFLOWS_t, \Delta logBOND_t)$. We estimate the three-variable TVP-VAR model using quarterly data from Q2 1995 to Q2 2014.

Following Primiceri (2005), let $\boldsymbol{a_t} = (a_{21}, a_{31}, a_{32}, a_{41}, \dots, a_{k,k-1})'$ be a stacked vector of the lower-triangular elements in $\mathrm{A}_{\boldsymbol{t}}$ and $\boldsymbol{h}_t = (h_{1t}, \dots, h_{kt})'$ with $h_{jt} = log\sigma_{jt}^2$capturing the variance of epsilon $\boldsymbol{\varepsilon_{jt}}$ *for j=1, .., k, t=s+1, …, n* where *k* is the number of variables. We assume that the parameters in equation (1) follow a driftless random walk process for *t=s+1,…, n*, where $\boldsymbol{\beta_{s+1}} \sim N(\mu_{\beta_0}, \Sigma_{\beta_0})$, $\boldsymbol{a_{s+1}} \sim N(\mu_{a_0}, \Sigma_{a_0})$and $\boldsymbol{h_{s+1}} \sim N(\mu_{h_0}, \Sigma_{h_0})$. The variance and covariance structure for the innovations of the time-varying parameters are governed by the parameters collected in the matrices Σ_{β_0}, Σ_{a_0}, and Σ_{h_0}, where Σ_{a_0}, and $\Sigma_{h_0}$are diagonal matrices.

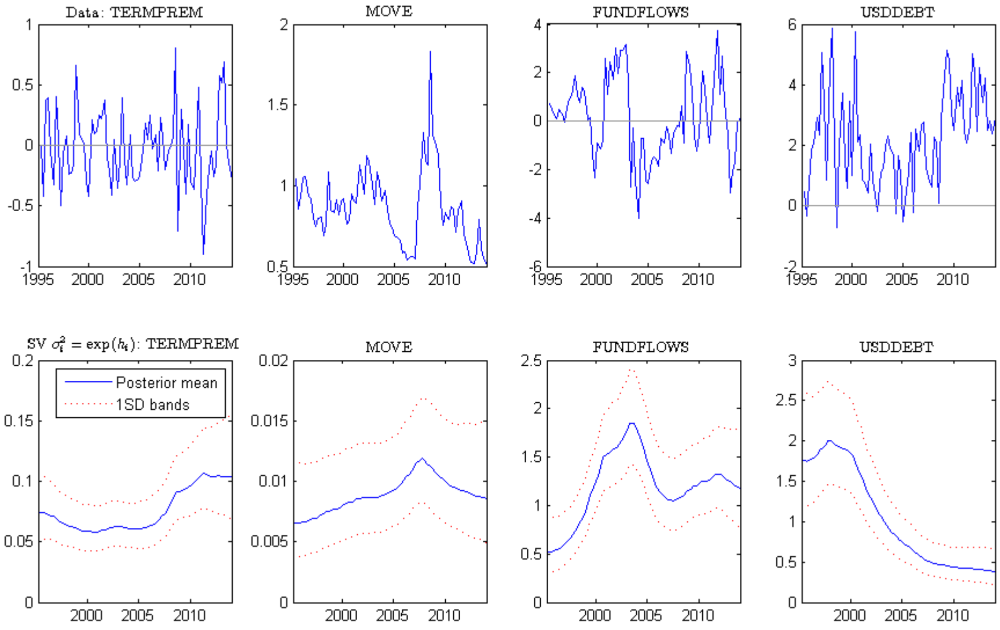
We set the number of lags to one. We assume that is a diagonal matrix following Nakajima (2011). The following priors are assumed for each i-th diagonal element of the covariance matrices:

$$(\Sigma_\beta)_i^{-2} \sim Gamma(20,0.01), (\Sigma_a)_i^{-2} \sim Gamma(10,0.04), (\Sigma_h)_i^{-2} \sim Gamma(20,0.2) \quad \text{(A.2)}$$

We set the shape parameter in the Gamma distribution for $\Sigma_a$relatively larger that the scale parameter so as to allow for greater time variation in 0-period impulse responses (eg make the lag dependence of the system, captured by Σ_β, relatively less constraining. For the initial state of the time-varying parameters, we set flat priors: $\mu_{\beta_0} = \mu_{a_0} = \mu_{h_0} = 0$ and $\Sigma_{\beta_0} = \Sigma_{a_0} = \Sigma_{h_0} = 10 \times I$. To compute the posterior estimates we draw M=10,000 with the initial 1,000 samples discarded as burn-in. See Nakajima (2011) for the details of prior specification and for the Bayesian MCMC parameter sampling procedure.

Endogenous variables and the volatility of structural shocks

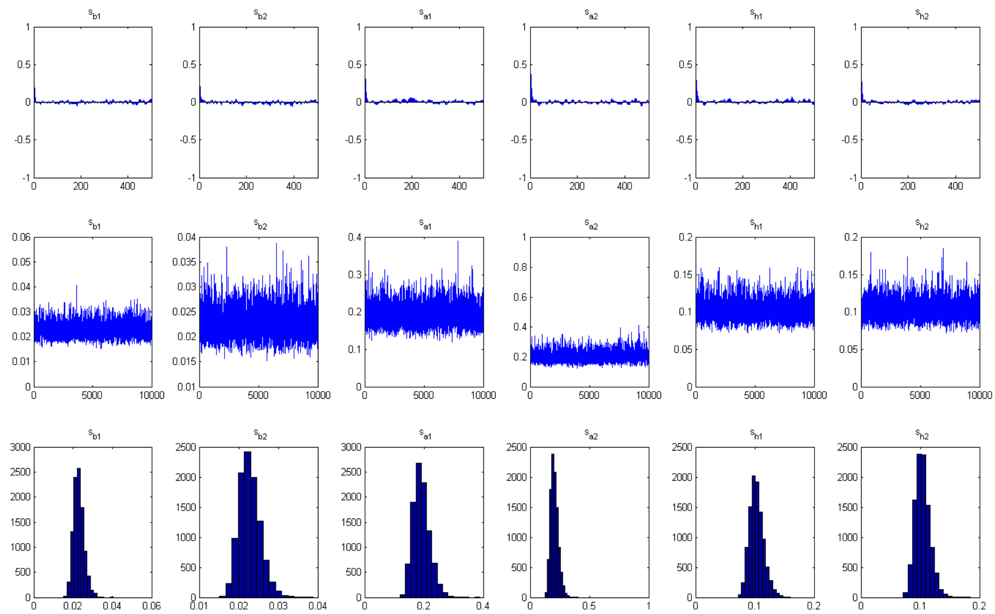
Graph A2



Notes: The graph shows endogenous variables and estimated volatility of the structural shocks of the following system: $\boldsymbol{y}_t' = (\Delta TERMPREM_t, MOVE_t, FUNDFLOWS_t, \Delta logBOND_t)$. We estimate the three-variable TVP-VAR model using quarterly data from Q2 1995 to Q2 2014.

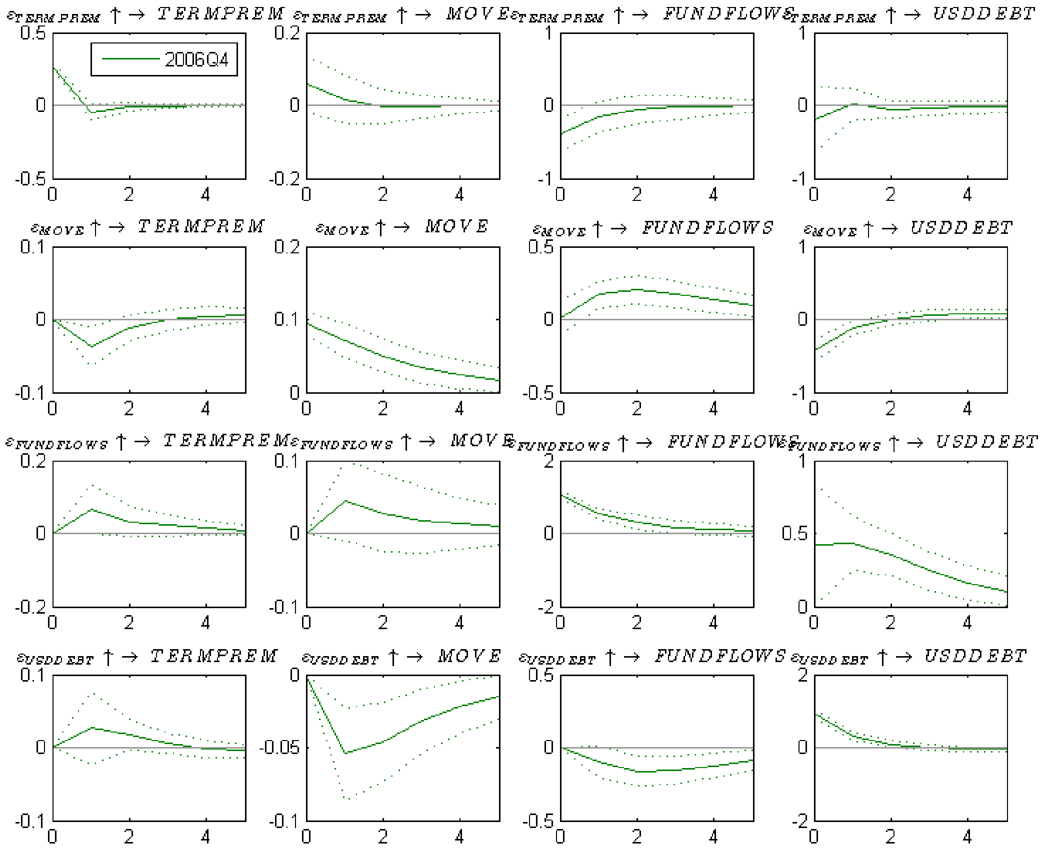
Selected parameter diagnostics

Graph A3



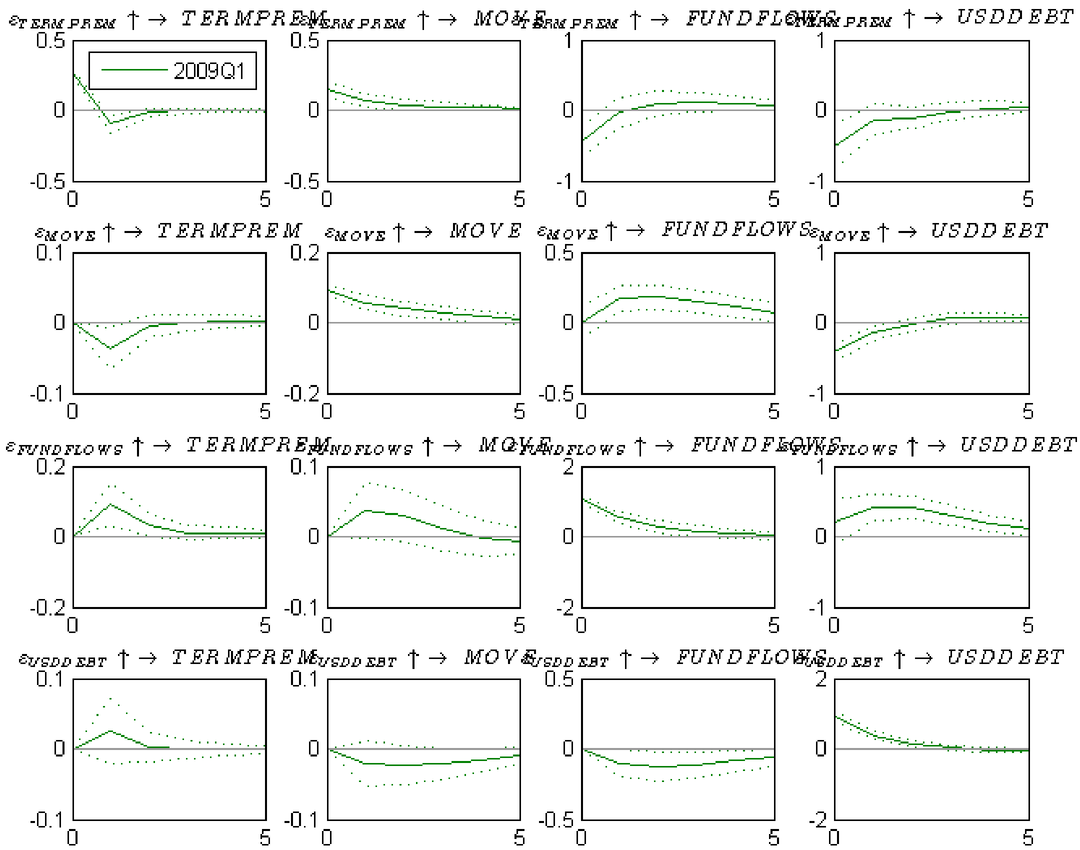
Notes: The graph shows parameter diagnostics based on estimating a TVP-VAR model of the following system: $\boldsymbol{y}_t' = (\Delta TERMPREM_t, MOVE_t, \Delta logBOND_t)$. We estimate the three-variable TVP-VAR model using quarterly data from Q2 1995 to Q2 2014. Based on 10,000 draws. Markov Chain Monte Carlo (MCMC) diagnostics: sample autocorrelation plots (top); Markov chain (centre), posterior parameter densities (bottom).

Impulse responses of US dollar debt securities issuance by non-residents to 10-year term premium and mutual funds flow shocks: Q4 2006 Graph A4



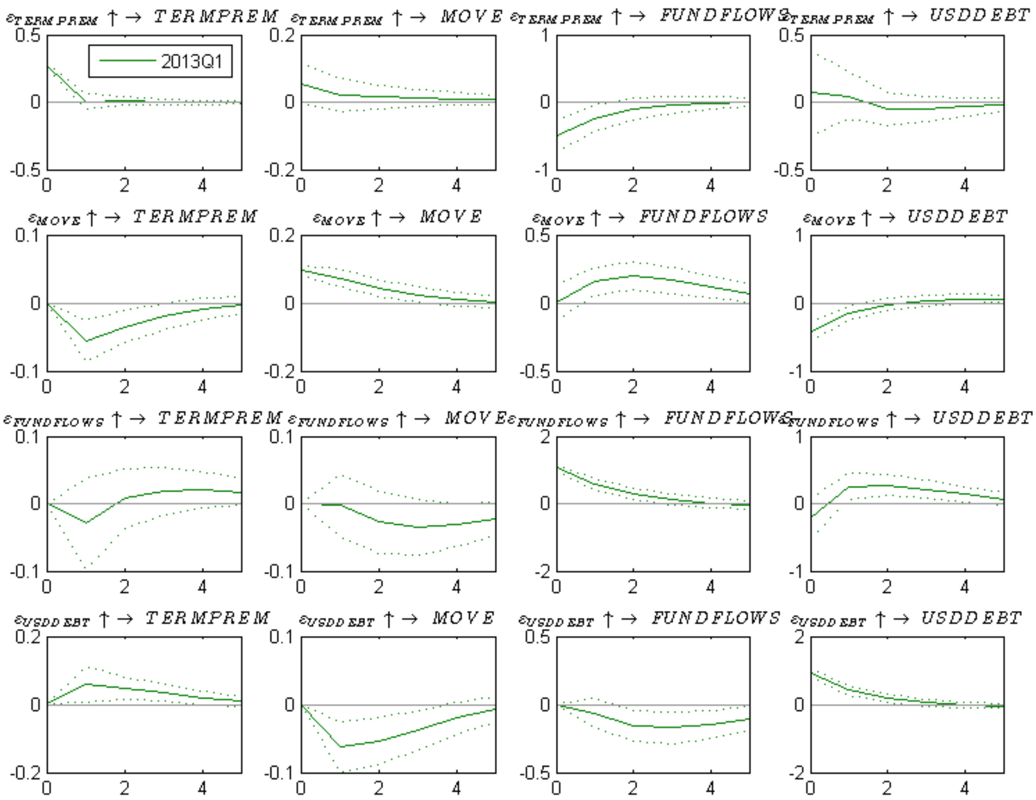
Notes: Select Bayesian time-varying VAR impulse responses with 68% credible interval bands. Estimated system parameters sampled in Q4 2006 based on 10,000 samples after discarding first 1000 as burn-in. Graph shows impulse responses sampled from the following system: $y_t' = (\Delta TERMPREM_t, MOVE_t, FUNDFLOWSt\ \Delta logBOND_t)$. We estimate the three-variable TVP-VAR model using quarterly data from Q2 1995 to Q2 2014.

Impulse responses of US dollar debt securities issuance by non-residents to 10-year term premium and mutual funds flow shocks: Q1 2009 Graph A5



Notes: Select Bayesian time-varying VAR impulse responses with 68% credible interval bands. Estimated system parameters sampled in Q1 2009 based on 10,000 samples after discarding first 1000 as burn-in. Graph shows impulse responses sampled from the following system: $\boldsymbol{y}_t' = (\Delta TERMPREM_t, MOVE_t, FUNDFLOWSt\ \Delta logBOND_t)$. We estimate the three-variable TVP-VAR model using quarterly data from Q2 1995 to Q2 2014.

Impulse responses of US dollar debt securities issuance by non-residents to 10-year term premium and mutual funds flow shocks: Q1 2013 Graph A6



Notes: Select Bayesian time-varying VAR impulse responses with 68% credible interval bands. Estimated system parameters sampled in Q1 2013 based on 10,000 samples after discarding first 1000 as burn-in. Graph shows impulse responses sampled from the following system: $\boldsymbol{y}_t' = (\Delta TERMPREM_t, MOVE_t, FUNDFLOWSt\ \Delta logBOND_t)$. We estimate the three-variable TVP-VAR model using quarterly data from Q2 1995 to Q2 2014.