US monetary policy, leverage and offshore dollar credit

Robert N McCauley, Patrick McGuire & Vladyslav Sushko[1]

Bank for International Settlements

SUMMARY

A very substantial stock of US dollar credit has been extended to nonfinancial borrowers outside the United States. This has relevance for the discussion of global liquidity and spillovers from the very accommodative monetary policy in major countries. This article contributes to this policy discussion by analysing the links between US monetary policy, including unconventional monetary policy, leverage and dollar credit extended to non-US borrowers by banks and in the international bond market. We find that prior to the crisis, US dollar credit to non-US borrowers was extended primarily by banks supported by low interbank funding rates and low cost of leverage. After 2008 however, and especially with beginning of large scale asset purchases by the Federal Reserve, the transmission has largely shifted from banks to international bond markets with compression of long-term rates playing a key role.

1. INTRODUCTION

As discussion of global liquidity heated up in the G20, central banks studied the issue and the Basel-based Committee on the Global Financial System (CGFS) produced a report. Taking its informal name from its chair, the Landau report (CGFS,2011) suggested a combination of price and quantity indicators of global liquidity. It identified credit denominated in major currencies extended to nonfinancial borrowers outside the jurisdiction of issue as a key indicator of the global ease of financing. This is because when financing conditions become easy, foreign currency credit and cross-border

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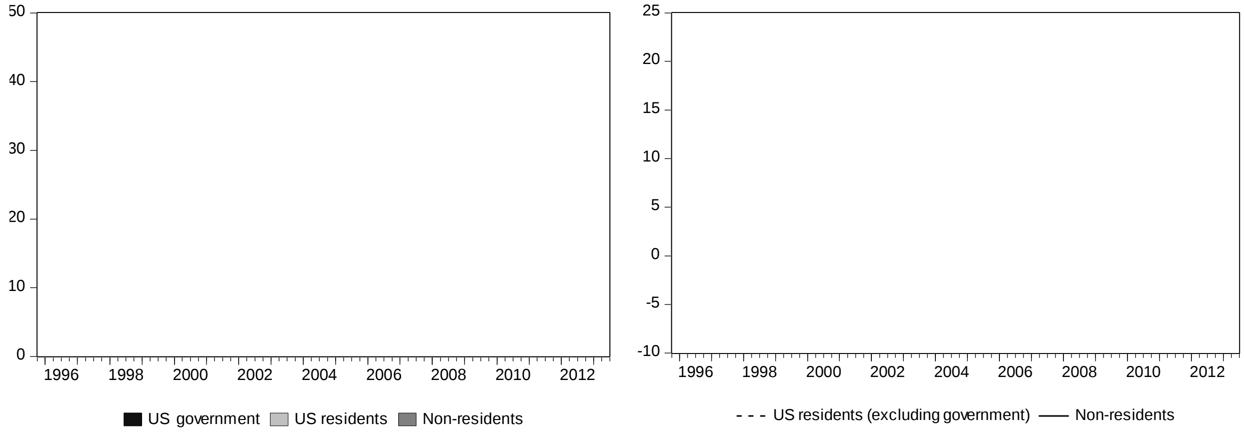
lending tend to serve as marginal financing sources in the lead-up to crises (Avdjiev et al, 2012).[2]

Recurring G20 discussion of the issue has drawn on work at the BIS (Domanski et al, 2011) and the IMF (Chen et al, 2012). The BIS now provides a note and indicators on the subject on its website twice a year as part of the Bank's support for G20 activities.[3] Drawing on Borio et al (2011), one chart shows dollar credit to the non-financial sector outside the United States, euro credit to that sector outside of the euro area and yen credit to that sector outside of Japan.[4]

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

Stocks, in trillions of US dollars — Year-on-year growth, in per cent



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 to non-resident non-financial sector is the sum of outstanding dollar debt securities issued by non-financial non-residents of the United States and cross-border and locally extended dollar loans to non-banks outside the United States.

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

Dollar credit outside the United States, in particular, is large and behaves differently from credit to US borrowers. At approximately $7 trillion, dollar credit outside the United States has reached 13% of non-US GDP (Figure 1, left-hand panel). Since the global financial crisis, private sector credit in the US only resumed its growth in late 2011 yet dollar credit outside the United States has grown at mostly double-digit rates (Figure 1, right-hand panel).[5]

2 Even if small relative to the total stock of credit outstanding, the swings in foreign currency lending can dominate flows, amplify domestic trends, and thus figure importantly in financial boom and bust cycles (see Borio et al (2011) and Domanski et al (2011)). Lane and McQuade (2012) 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.

3 See http://www.bis.org/statistics/gli.htm

4 See Borio et al (forthcoming) on the relationship of this concept to the standard flow of funds concepts.

5 Euro- or Japanese yen-denominated credit extended to those resident outside the euro area or Japan, respectively, is much smaller compared to dollar credit outside the United States, and its decoupling from domestic lending trends appears less marked than for the dollar.

Despite this policy attention, the drivers of the growth of foreign currency credit (ie credit denominated in a currency different from the home currency of the borrower) are not well understood. Existing studies concentrate on some pieces of bank credit, some analysing a number of countries and some analysing developments in a single jurisdiction. Furthermore, there are no studies that we know of that go beyond bank lending to look at drivers of US dollar bonds issued by borrowers outside the United States. This is despite the high share of US dollar in international debt markets (Goldberg, 2013).

In a cross-country study, Bruno and Shin (2012b) regress changes in BIS reporting bank external claims (mostly dollar) on 46 countries on intrabank positions of foreign banks in the United States, broker-dealer leverage or the VIX and bank capital. Bruno and Shin (2012a) analyse the same external claims on 48 countries in relation to the same intrabank positions and the VIX and argue that a 2011 tax on the foreign currency liabilities of banks in Korea reduced the sensitivity of external claims on Korea to global factors. Bruno and Shin (2013) investigate the influence of the federal funds rate on US dollar *liabilities*[6] of banks outside the United States.

Single country studies have analysed developments in Hong Kong SAR and the mainland of China. Tang and Ng (2012) address the determinants, including dollar Libor and dollar borrowing costs in the mainland, of the rapid growth of foreign currency (mostly dollar) credit in Hong Kong vis-a-vis mainland Chinese companies (see also Shin and Zhao (2013)). He and McCauley (2013) similarly do a VAR analysis of the growth of foreign currency (mostly dollar) loans extended by banks in mainland China.

Building on this work, we seek to measure the response of *strictly* dollar credit to non-US residents to its *price*.[7] A key question is the responsiveness of dollar credit outside the United States to policy interest-rate settings, to large-scale bond buying and to financial leverage. By focusing on dollar credit, we are able to precisely measure its cost. We analyse both dollar credit extended by banks and the rise in outstanding dollar bonds, which Shin (2013) takes to be critical to understanding what he calls the second phase of global liquidity. We take a long-term perspective, focusing on the relationship between policy and measures of dollar credit growth to non-residents at the quarterly frequency from 1995 onwards, allowing us to capture several cycles in dollar credit growth.

In this article, we first describe dollar credit extended to the non-financial sector outside the United States based on comprehensive estimates based on the BIS banking statistics, BIS international debt statistics and national statistics (eg Chinese data).[8]

6 Some studies have tried to come up with accurate measures of US currency in circulation outside the US and the factors driving its demand, see Judson (2012). However, both accounting and factors driving demand for US bank notes are quite different than the drivers for US dollar denominated bank liabilities or credit. Furthermore, US dollar liabilities or credit to non-residents is an order of magnitude larger than US dollars in circulation outside the United States.

7 In contrast, many papers focus not on credit but rather on more traditional measures of money; Chen et al (2012) and Forbes and Warnock (2012) use a multi-country monetary aggregate. Since Forbes and Warnock (2012) seek to explain all types of capital flows, their price measure on the source side is an average of G5 bond yields, while we can fine-turn our measure to the dollar (eg dollar Libor).

8 We hope to experiment with a broader definition of dollar credit growth outside the United States than in Borio et al (2011). In particular, and drawing on the Korean case (Bruno and Shin (2012a), He and McCauley (2013)), we hope to include the net local assets of BIS-reporting banks.

Consistent with the emphasis of Shin (2013) on the distinction between bank credit and bond finance, we decompose the aggregate between bank and bond credit. Then we seek to identify a relationship between the broad aggregate of global offshore dollar credit and measures of the US monetary policy stance, including effective federal funds rate, the deviation between the federal funds target and a backward-looking Taylor rule, and 3-month dollar Libor. In addition, we proxy for the effects of the Federal Reserve's large-scale asset purchases (aka quantitative easing) using the term premium on 10-year Treasury bonds. 10-year Treasury yields are also included for proxy for the overall long-term financing costs. We then repeat the exercise for the sub-aggregates of bank and bond credit.

Our main empirical findings are threefold. First, prior to the crisis period, offshore US dollar credit growth was primarily driven by leveraged global banks (as measured by financial CP), supported by low cost of leverage (as measured by the VIX), and low short-term funding costs (as measured by US dollar Libor or low federal funds target relative to Taylor rule benchmarks). Second, after the crisis, and especially with the beginning of large scale asset purchases by the Federal Reserve, the transmission of US financial conditions to dollar credit offshore shifted. The banking sector became less important and international debt markets became more important, spurred by the policy-induced compression of term premia on long dated debt securities. Third, looking at US dollar and euro denominated offshore credit, we find that offshore debt markets of these currencies appear to exhibit much closer association and co-movement with each other than bank credit to non-resident borrowers in the same currencies. Furthermore, offshore US dollar debt issuance responds immediately to 10-year Treasury term premia shocks, while euro-denominated debt issuance responds more sluggishly and then grows in subsequent quarters ultimately to keep pace with US dollar issuance. Thus, term premium compression from US monetary policy appears to spill over into debt issued in the other major currency in the international bond market.

We discuss three implications for policy. For one, the discussion of policy spillovers cannot begin and end with effects of conventional and unconventional monetary policy on capital flows and exchange rates. An outstanding stock of dollar credit means that a lower Federal Reserve policy rate immediately eases monetary conditions to some extent outside the United States. Moreover, dollar credit extension outside the United States does not require that funding flow out of the United States; it is mostly funded by offshore dollar deposits (He and McCauley (2012)).

Admittedly somewhat at variance with our modelling strategy that relates yields on dollars measured in the US[9] to dollar credit developments abroad, we also discuss how policy changes the interest cost of dollars borrowed outside the United States. He and McCauley (2013) show that a variety of policies in China, Hong Kong SAR and Korea all raised the locally relevant US dollar interest rate above US dollar Libor. National macroprudential and capital management policies can alter to some extent the global monetary environment.

9 Or strictly speaking as measured in the UK in the case of dollar Libor.

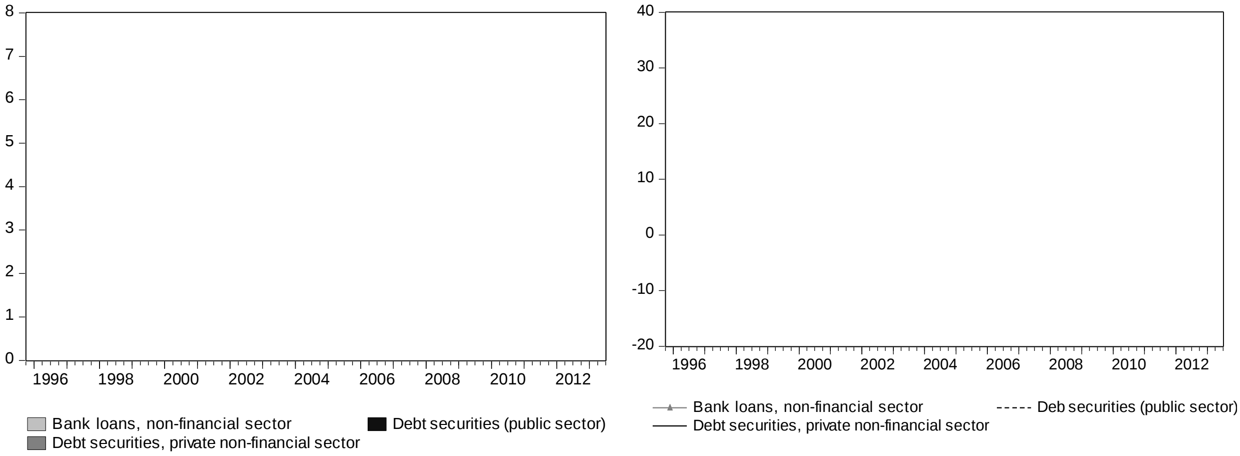
Finally, we discuss the policy issues raised by what Shin calls the second phase of global liquidity. The recent importance of dollar credit extended in bond markets changes the way that we should think about the policy challenges of offshore dollar credit.

2. GLOBAL DOLLAR CREDIT: EVOLUTION AND COMPOSITION

Dollar credit to the non-financial sector outside the United States has reached substantial *levels* from a number of perspectives. Figure 1 shows that the $7 trillion in dollar credit to non-US residents represents about a sixth of the US aggregate. As a share of credit to US firms and households (ie excluding government debt), credit to firms and households offshore was approximately 22% as of Q2 2013. Viewed from another perspective, dollar credit to the non-US nonfinancial sector represents about 13% of non-US GDP, less in the euro area and Japan, and correspondingly more in other jurisdictions.

US dollar credit to firms, households, and governments outside the United States — Figure 2

Stocks, in trillions of US dollars — Year-on-year growth, in per cent



The vertical lines indicate the 2007 beginning of the global financial crisis and the 2008 collapse of Lehman Brothers.

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.

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

From a flow or growth perspective, the smaller offshore aggregate behaves quite differently from the US aggregate. Looking over the cycle of the 2000s, dollar credit to non-US residents tended to grow more slowly than that to US residents in the recession in the early years of the decade. Then in the later boom years of the 2000s, offshore dollar credit grew more rapidly than its larger US counterpart. The growth of dollar credit to non-US residents dropped more during the 2008-09 financial crisis than such credit to US residents, which of course benefitted from the stabilising influence of federal government borrowing.

Since 2009, dollar credit to non-US residents has consistently grown faster than that extended to US residents. In particular, dollar credit to nonfinancial borrowers outside of the United States has grown at a rate that varies around 10% and even approached 20% before the worst of the European sovereign and bank strains. Meanwhile, even with the lift of large federal government deficits, dollar credit to US nonfinancial borrowers only started growing again in 2011. 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 yields. But the distinction between the behaviour of dollar borrowing by US residents and those outside the United States is not the only distinction of interest.

Dollar credit extended to the nonfinancial sector outside the United States can itself be decomposed between that extended by banks and that extended in the bond market.[10] Figure 2, left-hand panel, shows the stock of US dollar credit to non-financial borrowers outside the United States broken down into its bank loan and international debt securities components. Figure 2, right-hand panel, shows the growth rates of the dollar credit to those resident outside the United States. This distinction allows some further observations.

Looking back over the cycle of the 2000s, much of the procyclicality of the growth of dollar credit extended to those resident outside the United States arose from the behaviour of banks. Indeed, it is remarkable that 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 nonfinancial firms never turned negative.

Since 2009, the stock of outstanding bonds issued by non-US nonfinancial firms has tended to grow faster than bank credit to non-US non-banks. Though bonds outstanding are smaller than bank debt outstanding (Figure 2, left-hand panel), their growth has been contributing much to the overall growth of dollar debt extended to non-US borrowers. Moreover, the stock of dollar bonds outstanding has been growing steadily at its 15% rate. Whereas the bank debt growth peaked and then fell in response to the worsening of the European sovereign and banking strains into mid-2012, the bond market kept accommodating firms and governments outside the United States. A similar divergence in growth trends between US dollar bank and bond market credit was also observed during the Asian financial crisis (Figure 2, right-hand panel).

These observations 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

10 Borio et al (2011) provides detail on the measure. Suffice it to say here that the banking data allow us only to exclude interbank credit, and not to exclude credit to non-bank financial institutions. By contrast, with the securities data we are able to isolate credit to non-financial borrowers.

has introduced a new policy influence on the borrowers’ choice between bank borrowing and bond issuance offshore. Still, to the extent that borrowers have turned to the bond market to substitute for impaired credit supply by European banks, the aggregate could be more telling about overall supply and demand conditions for US dollar denominated borrowing than each component taken separately.

3. DRIVERS OF DOLLAR CREDIT TO NON-US RESIDENTS

In this section, we examine the association between US dollar funding costs (with a specific focus on proxies of US monetary policy stance), cost of leverage, and growth in the stock of US dollar credit to non-residents. First, we regress total dollar credit to non-US residents on various US dollar interest rates and proxies for financial sector leverage (also controlling for international trade and the dollar’s nominal index). Then we do a similar analysis of bank loans only, which represent the bulk of dollar credit to non-US residents. Finally, we repeat the exercise for outstanding bonds only, which has since the crisis been the faster growing component.

Short-term and long-term financing conditions in US dollars — Figure 3

Fed funds, Libor, and Taylor-rule implied target rate — Yield on 10-year Treasury bond and its term premium

Notes: Here, we plot a simple Taylor rule which 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^*, each set to 2%, represent the equilibrium real interest rate and the assumed target for the 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.

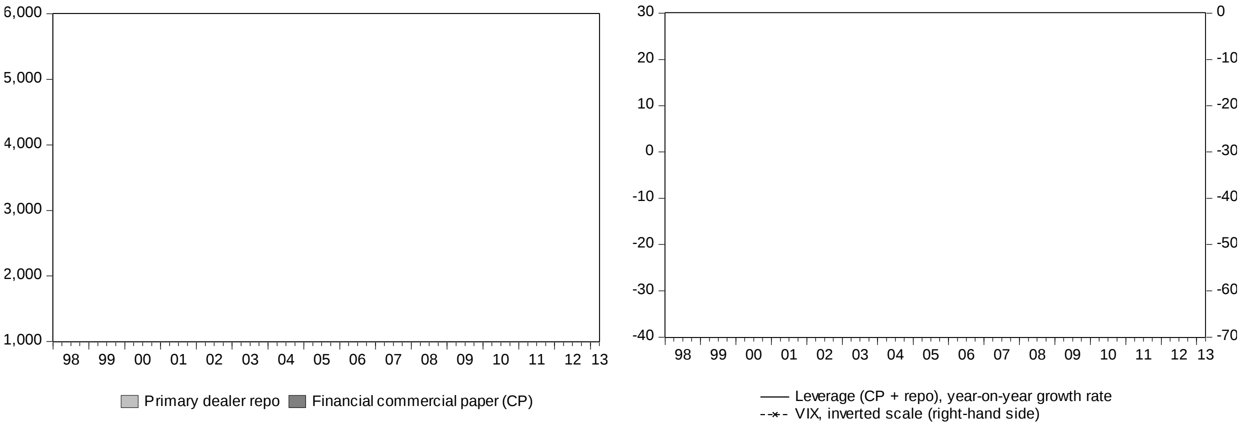
Sources: Bloomberg; Consensus Economics; Haver Analytics; authors’ calculations.

A major limitation we are facing is that we do not have a parsimonious model of offshore US dollar credit demand that could be applied globally. As mentioned above, so far the analysis of demand factors has been conducted at the country level, which allows one to carefully account for specific institutional and market forces driving US dollar denominated borrowing in these jurisdictions. In fact, the findings of He and McCauley (2012) suggest that such demand factors may be quite difference between regions. Instead, here we are focusing on obtaining unbiased estimates of supply side drivers of US dollar credit to non-residents, which, a priori, are much more likely to be common for a given hard currency, irrespective of the location of the borrower.

Hence, we pursue a simple but parsimonious estimation technique based on OLS time-series regressions with stationary mean-zero explanatory variables, thus assessing short-run effects from lagged shocks to explanatory variables on shocks to US dollar credit growth. All the credit series are also log-differenced and tested for unit roots (see Appendix Table A1 for unit root test results). Any remaining short-run autoregressive effects are accounted for with lagged dependent variable, which also serves to capture unobserved demand shocks. We do however, also find support for the main results using an unrestricted vector autoregression (VAR) methodology, also controlling for global trade growth and returns to weighted nominal US dollar index. Furthermore, in our analysis of the international debt component of offshore borrowing in US dollars, we are able to put additional restrictions on the VAR based on the long-run stable relationship (cointegration) between offshore debt in US dollars and that in the euro. In contrast, we fail to reject the null of no cointegration for bank lending to non-residents in US dollar and euro, therefore stop with an unrestricted VAR for the bank lending component (see Appendix Table A2 for cointegration test results).

Quantity and price indicators of financial sector leverage — Figure 4

Amounts outstanding, in billions of US dollars — Year-on-year growth, in per cent; VIX on right-hand side



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

The explanatory variables span yields, leverage/volatility measures and other factors. *Monetary policy stance*: we employ the effective federal funds rate, three-month US dollar Libor, deviations between a backward-looking Taylor rule and the target federal funds rate (Figure 3, left-hand panel). To proxy for long-term financing costs and unconventional monetary policy measures, we employ 10-yield Treasury note yield and 10-year term premium (Figure 3, right-hand panel).

Leverage: our indicators of financial system leverage include the VIX, financial commercial paper outstanding and commercial paper plus primary dealer repo outstanding. McGuire and von Kleist (2008) spotted a close link between global equity volatility as captured by the VIX and the growth of international credit aggregates (Figure 1, right-hand panel). CGFS (2011) took this on board. Bruno and Shin (2012b) relate the VIX to credit flows through international banks, Forbes and Warnock (2012) confirm its importance in gross flows, and McCauley (2012) points to a high frequency link with international portfolio flows. The commercial paper and repo measures are based on the work of Adrian and Shin (2010). In fact, Figure 4, right-hand panel show that these 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 (VaR) constraint of leveraged investors.[11] Hence, one way to meaningfully 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 cost of leverage by financial institutions employing a VaR or similar risk management framework. Thus, one may expect that the VIX, along with other measure of leverage, would have a closer association with behaviour of global banks compared to bond investors, which would include not only leveraged investors (eg hedge funds) but also real money accounts like pension funds.

1.1. Aggregate dollar credit to borrowers outside the United States

Table 1 shows regression results with the growth rate of dollar credit aggregate (both bank loans and debt securities) as the dependent variable. While measured US monetary policy stance (as proxied by deviations from PCE or CPI based Taylor rule) is not significant, lower long-term rates (as measured by the 10-year Treasury yield) are associated with higher growth of US dollar credit to non-residents.

The most robust result, however, is for the impact of leverage (either measured by VIX or as the sum of financial CP + repo). For example, estimates in column (1) indicate that a one point lower reading of the VIX is associated with 0.15 per cent higher growth rate of aggregate dollar credit in the following quarter. Similarly, the coefficient of the quantity based measure of leverage in column (2) indicates that one per cent higher growth in the volume of financial CP is associated with 0.12 per cent increase in the growth rate of the stock of US dollar credit to non-residents the following quarter.

11 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 VaR 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.

Table : Shocks to growth rates of supply-side drivers in the previous quarter and growth in US dollar credit

	(1)	(2)	(3)	(4)
	Dependent variable: offshore US dollar credit[e]			
Fed funds deviation from Taylor rule (PCE based)[a]	-0.379	-0.507		
	(0.375)	(0.386)		
Fed funds deviation from Taylor rule (CPI based)[b]			-0.264	-0.309
			(0.310)	(0.306)
10-year Treasury yield	-1.499*	-0.253	-1.523*	-0.288
	(0.764)	(0.951)	(0.771)	(0.976)
VIX[c]	-0.149***		-0.150***	
	(0.039)		(0.042)	
Leverage (financial CP + primary dealer repo)[d]		0.128**		0.116*
		(0.063)		(0.063)
Lag dependent variable	0.048	0.191	0.049	0.198*
	(0.094)	(0.115)	(0.095)	(0.118)
Constant	5.044***	1.574***	5.051***	1.559***
	(0.960)	(0.419)	(0.996)	(0.428)
Observations	69	60	69	60
R-squared	0.159	0.109	0.156	0.098

Notes:
All the variables enter in first-differences or in log-differences, expressed in per cent; the dependent variable persistency is controlled for via the lag term.
[a] Fed funds target rate and rate implied by the Taylor rule using output gap and PCE inflation: i = r* + p + 0.5 (p-p*) + 0.5 (y-y*); in first differences, per cent.
[b] Fed funds target rate and rate implied by the Taylor rule using output gap and CPI inflation: i = r* + p + 0.5 (p-p*) + 0.5 (y-y*); in first differences, per cent.
[c] Chicago Board of Exchange (CBOE) S&P500 index option implied volatility; in unit of annualized volatility, per cent.
[d] Per cent changes of amounts outstanding.
[e] US dollar denominated loans by BIS reporting banks to non-resident non-financial sector plus US dollar denominated international debt securities outstanding issued by non-resident, private non-financial borrowers; in per cent changes of stock outstanding.
Sources: Bloomberg, Consensus Economics; BIS international debt statistics; BIS locational banking statistics by residence; Federal Reserve Bank of New York; Authors' calculations.

1.2. Dollar bank credit to borrowers outside the United States

The results for the bank loan component of US dollar credit to non-residents reported in Table 2 are qualitatively similar to those obtained using the broad aggregate measure. This is not surprising considering that bank lending dominates the overall stock of credit. One notable observation is that the coefficients on the measure of leverage increase in absolute value. This is particularly the case for the quantity-based measures (columns (2) and (4)), which, arguably, are more closely related to banks' leverage while the VIX is a broader price-based measure also associated with broader financial market sentiment overall.

Table 2: Shocks to growth rates of supply-side drivers in the previous quarter and growth in US dollar bank lending

	(1)	(2)	(3)	(4)
	Dependent variable: offshore US dollar bank lending[e]			
Fed funds deviation from Taylor rule (PCE based)[a]	-0.419	-0.660		
	(0.496)	(0.501)		
Fed funds deviation from Taylor rule (CPI based)[b]			-0.286	-0.394
			(0.406)	(0.388)
10-year Treasury yield	-1.855*	-0.161	-1.884*	-0.210
	(0.983)	(1.219)	(0.990)	(1.256)
VIX[c]	-0.193***		-0.193***	
	(0.055)		(0.058)	
Leverage (financial CP + primary dealer repo)[d]		0.197**		0.182**
		(0.083)		(0.082)
Lag dependent variable	0.083	0.199*	0.083	0.206*
	(0.091)	(0.118)	(0.092)	(0.120)
Constant	5.721***	1.419***	5.728***	1.406***
	(1.294)	(0.496)	(1.340)	(0.504)
Observations	69	60	69	60
R-squared	0.163	0.134	0.161	0.122

Notes:
All the variables enter in first-differences or in log-differences, expressed in per cent; the dependent variable persistency is controlled for via the lag term.
[a] Fed funds target rate and rate implied by the Taylor rule using output gap and PCE inflation: i = r* + p + 0.5 (p-p*) + 0.5 (y-y*); in first differences, per cent.
[b] Fed funds target rate and rate implied by the Taylor rule using output gap and CPI inflation: i = r* + p + 0.5 (p-p*) + 0.5 (y-y*); in first differences, per cent.
[c] Chicago Board of Exchange (CBOE) S&P500 index option implied volatility; in unit of annualized volatility, per cent.
[d] Per cent changes of amounts outstanding.
[e] US dollar denominated loans by BIS reporting banks to non-resident non-financial sector; in per cent changes of stock outstanding.
Sources: Bloomberg, Consensus Economics; BIS international debt statistics; BIS locational banking statistics by residence; Federal Reserve Bank of New York; authors' calculations.

The coefficients on short-term policy stance (federal funds rate deviations from the Taylor rule) are negative, but not statistically significant. Since the variable measures the actual rate minus the rule, a negative coefficient indicates that a policy rate setting lower than the benchmark given inflation and the output gap is associated with faster growth in dollar bank credit extended to borrowers outside the United States.

One way to assess the stability of these estimates over time is via rolling regressions. Figure 5 shows estimated coefficient from specifications (1) for the Taylor rule adjusted federal funds rate and the VIX (see Appendix 1, Figure A1, for the full results). The rolling coefficient estimates on short-term US monetary policy stance are mostly negative, with the exception of the late 2000-2001 period which renders the full sample estimate insignificant (Figure 5, left-hand panel). The 2001 period is special because policy rates were reduced

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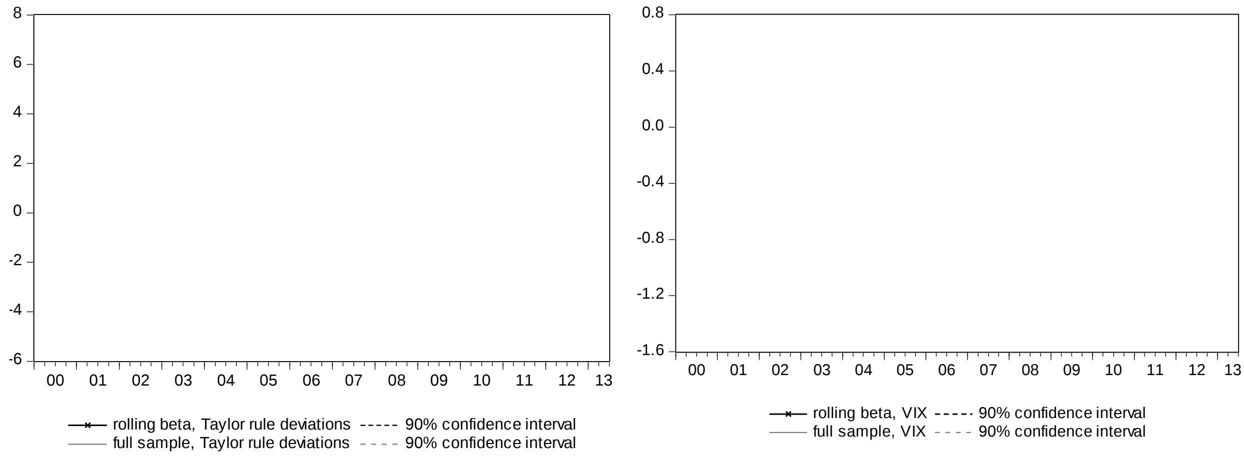
rapidly as the US economy entered into a recession (the actual policy rate matched the Taylor rule rate almost perfectly, see Figure 3), at the time as US dollar denominated bank lending to non-residents contracted (see Figure 2), thus yielding a positive coefficient on short-term rates. Starting in 2002, however, coefficient estimates suggest that lower Taylor rule adjusted fed funds rates were associated with higher growth in US dollar denominated bank lending to borrowers outside the United States.

Select rolling regression estimates

Dependent variable: growth in US dollar denominated bank lending to non-residents — Figure 5

Federal funds rate Taylor rule deviations — VIX



Estimates based on 16-quarter rolling regressions. All the variables enter in first-differences or in log-differences, expressed in per cent; the dependent variable persistency is controlled for via the lag term.

Sources: Bloomberg; Consensus Economics; BIS international debt statistics; BIS locational banking statistics by residence; authors' calculations.

Rolling coefficient estimates on the VIX also point to a more nuanced story. While the full sample regression coefficient is negative and statistically significant, this appears to be primarily driven by crisis episodes, such as the 2000 dot-com and 2007-08 subprime crises (Figure 5, right-hand panel). In other words, the association of offshore US dollar bank lending with VIX tends to become significant when VaR constraints become binding as financial conditions deteriorate and banks scale back on lending (especially its most volatile marginal cross-border and foreign currency components). However, the association with bank lending growth in tranquil times is less clear.

Taken together, the rolling coefficient estimates reported in Figure 5 an alternation of effects. In tranquil times easy monetary policy stance (as proxied by fed funds rate deviation from Taylor rule) drives US dollar bank lending, whereas in crisis times, a spike in financial market volatility and the price of leverage forces a contraction of bank lending.

The relative importance of short-term rates over the VIX in driving US dollar bank lending is further corroborated by impulse responses of a VAR system, which also controls for US dollar nominal exchange rate index and world trade volume (two global demand

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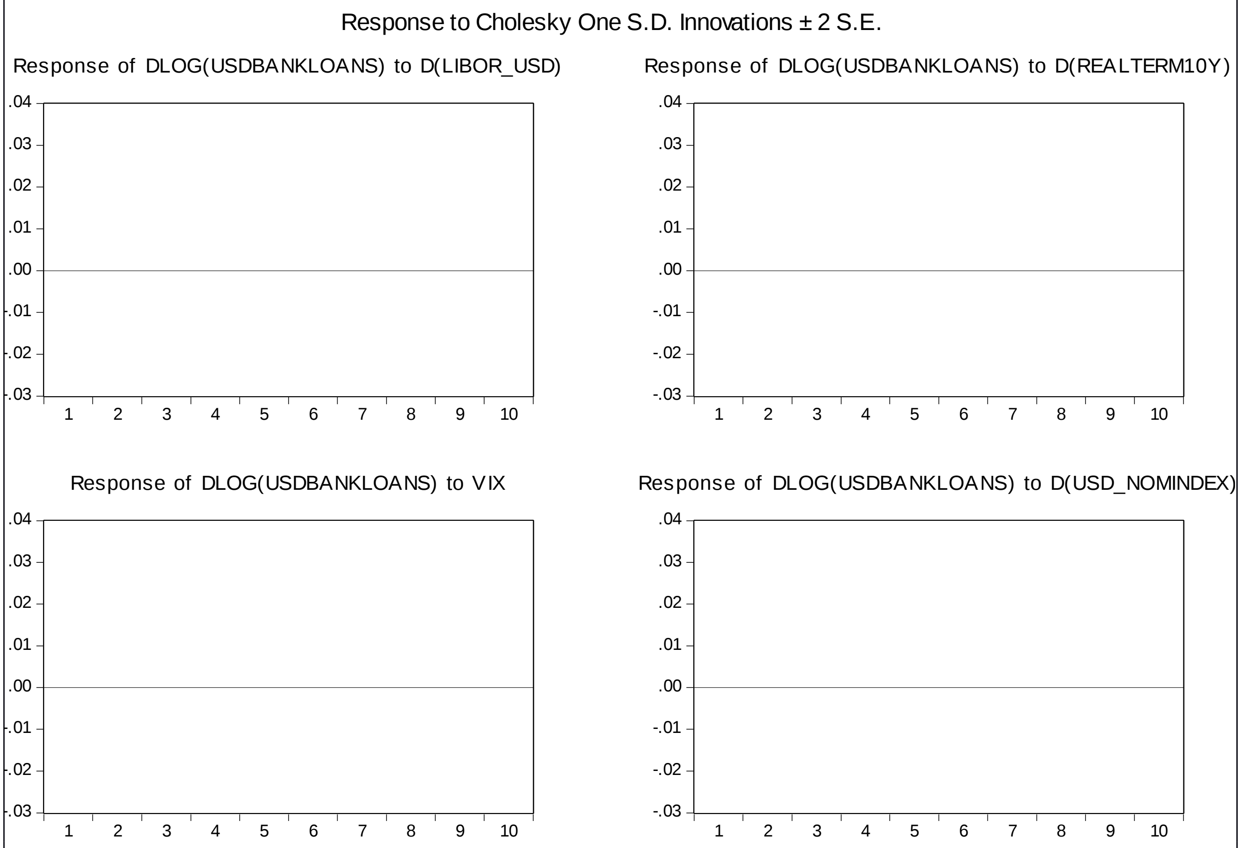
factor). While we omitted reporting OLS regression coefficients on the Libor because of insignificant estimates over the full sample, VAR impulse responses reported in Figure 6 upper left-hand panel point at Libor as a significant determinant of US dollar lending offshore. The response growth of US dollar bank lending offshore to a positive one standard deviation shock to Libor is negative and significant, and approximately twice as large that the response to the VIX. When Libor is replaced with fed funds deviation from the Taylor rule, impulse response of bank lending is also negative in the first period following the shock, but not statistically significant (see Appendix 1 Figure A3).

Impulse responses of US dollar bank loans to non-residents to interest rate, VIX, and exchange rate shocks

Figure 6



Notes: 1996Q3 2013Q2; Included observations: 68; 2-lag specification chosen based on Akaike information criterion (AIC) and Schwarz selection criterion. Cholesky ordering in the order of exogeneity is: fed funds devations from the PCE-based Taylor rule, D(FF_TAYLORPCE), 10-year term premium, D(REALTERM10Y), the VIX, nominal US dollar trade weighted exchange rate index, D(USD_NOMINDEX), world trade volume, DLOG(TRADE), and US dollar denominated bank lending to non-residnets, DLOG(USDBANKLOANS); Impulse response to DLOG(TRADE) insignificant and omitted for brevity

Finally, we look at whether lending in the second most widely used offshore currency, the euro, behaves similarly to the US dollar. We do this by testing for the cointegration in bank lending and debt securities outstanding in the two currencies. The results (reported in

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Appendix 1, Table A2) provide evidence of cointegration between US dollar and euro denominated debt issuance by non-residents, but not between bank credit to non-residents denominated in dollar and euro. Therefore, we stop at the unrestricted VAR for bank lending component, while for debt securities issuance, we are able to put further restrictions on the VAR in Section 3.3 based on the cointegration between US dollar and euro denominated debt issued by non-residents.

1.3. Dollar bond debt of borrowers outside the United States

Table 3 reports analogous regression results for the internal debt securities component of US dollar denominated borrowing by non-residents. The most notable difference compared to bank lending is the insignificant coefficients on the VIX and small and perverse coefficients on the quantity proxy for financial institutions' leverage. The coefficient on Taylor rule deviations of the fed funds rate are negative and significant in specifications (1) and (3), suggesting that short-term US monetary policy stance may have been an important driver of debt issuance over the whole sample period. Long-term funding costs in US debt markets also appear to matter, with negative and significant coefficients on 10-year yields in specifications (2) and (4). This mixed result concerning the relative importance of short- versus long-term funding costs of US dollar debt issuance offshore calls for a more granular look over time.

Table 3: Shocks to growth rates of supply-side drivers in the previous quarter and growth in US dollar denominated international debt securities outstanding

	(1)	(2)	(3)	(4)
	Dependent variable: offshore US dollar debt issuance[e]			
Fed funds deviation from Taylor rule (PCE based)[a]	-0.393**	-0.185		
	(0.149)	(0.161)		
Fed funds deviation from Taylor rule (CPI based)[b]			-0.311***	-0.162
			(0.105)	(0.116)
10-year Treasury yield	-0.406	-0.937*	-0.435	-0.921*
	(0.522)	(0.485)	(0.515)	(0.484)
VIX[c]	0.021		0.018	
	(0.024)		(0.024)	
Leverage (financial CP + primary dealer repo)[d]		-0.076*		-0.074*
		(0.042)		(0.042)
Lag dependent variable	0.438***	0.471***	0.448***	0.478***
	(0.111)	(0.131)	(0.111)	(0.131)
Constant	1.018*	1.271***	1.054**	1.253***
	(0.520)	(0.367)	(0.520)	(0.368)
Observations	69	60	69	60
R-squared	0.255	0.358	0.258	0.362

Notes:
All the variables enter in first-differences or in log-differences, expressed in per cent; the dependent variable persistency is controlled for via the lag term.
[a] Fed funds target rate and rate implied by the Taylor rule using output gap and PCE inflation: i = r* + p + 0.5 (p-p*) + 0.5 (y-y*); in first differences, per cent.
[b] Fed funds target rate and rate implied by the Taylor rule using output gap and CPI inflation: i = r* + p + 0.5 (p-p*) + 0.5 (y-y*); in first differences, per cent.
[c] Chicago Board of Exchange (CBOE) S&P500 index option implied volatility; in unit of annualized volatility, per cent.
[d] Per cent changes of amounts outstanding.
[e] US dollar denominated international debt securities outstanding issued by non-resident, private non-financial borrowers; in per cent changes of stock outstanding.
Sources: Bloomberg, Consensus Economics; BIS international debt statistics; BIS locational banking statistics by residence; Federal Reserve Bank of New York; authors' calculations.

Figure 7 shows rolling regression coefficient estimates for debt securities. In this specification, we replace 10-year Treasury yield with 10-year term premium, which is a more direct measure of whether or not long-term yields are high or low relative to a benchmark (analogous to Taylor rule use for the short-term rates). Another way of interpreting the term premium from a borrower's perspective is as the cost of fixing the yield on debt as compared to the expected cost of floating-rate debt.

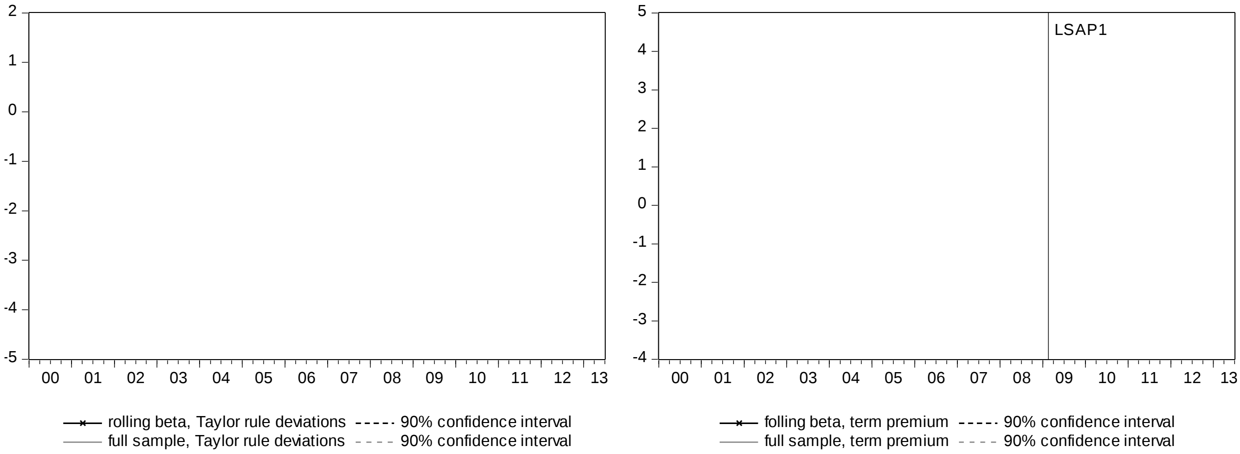
Select rolling regression estimates

Dependent variable: growth in US dollar denominated international debt securities outstanding

Figure 7

Federal funds rate Taylor rule deviations

Term premium compression



Estimates based on 16-quarter rolling regressions. All the variables enter in first-differences or in log-differences, expressed in per cent; the dependent variable persistency is controlled for via the lag term. 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.

Sources: Bloomberg; Consensus Economics; BIS international debt statistics; BIS locational banking statistics by residence; authors' calculations.

The full sample coefficient on ease of short-term funding conditions in US dollar (fed funds deviations from the Taylor rule) is negative and significant, with rolling estimates also negative for the entire post-2002 period (Figure 7, left-hand panel). In the post-2002 period, the coefficients estimates are lowest in 2005 through 2007.

In the more recent period, there appears to be a more significant dynamic coming from the compression of long-term yields. As Figure 7, right-hand panel shows, the coefficient on the lagged change in the term premium turns significantly negative abruptly around the time that the Federal Reserve began implementing the first round of large scale asset purchases. As Bernanke (2013) argued, one measure of the effect of this unconventional policy is the compression of term premia, basically the extra cost to an issuer of securing fixed interest payments over a given horizon rather than bearing the risk of paying the succession of floating-rate interest rates. Consistent with lowering of such costs, the term premium compression has induced more bond issuance (a negative coefficient). The estimates of coefficient in the regression for bank loans (see Appendix 1, Figure A1, centre panels) had been positive, though not consistently significantly so, before the crisis, suggesting that higher term premia led to faster growth in the stock of (mostly floating-rate) bank credit. The estimates fell to near zero after the crisis. It would seem that when monetary policy

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shifted to pushing down the term premium, its measurable effect shifted to the fast-growing market for dollar bonds issued by borrowers outside the United States.

Thus, rolling regression results suggest that post-2008 the compression of term premia has tended to boost the growth of offshore US dollar debt securities issuance, but this result needs to be better understood. For one, the small sample size within each rolling regression leads to wide uncertainty bounds, which complicates statistical inference. Furthermore, the OLS regression results only capture short-run dynamics, whereas there are a number of other factors that would, over time, shift parts of financial intermediation into offshore bond market borrowing in major hard currencies. Some of these factors are not specific to the dollar: for example, high domestic interest rates may induce businesses and households to borrow in foreign currencies so as to drive demand for offshore borrowing in a number of currencies, including the euro. Other factors may be dollar specific, such as US monetary policy stance of financing conditions in US dollar more generally.

The cointegration between US dollar and euro debt issuance (see Appendix 1, Table A1) allows for a more structural analysis that has two advantages. First, it makes use of the entire sample period in the estimation. Second, it allows the recent very rapid growth in US dollar denominated international debt securities to be considered at the same time as issuance of such bonds denominated in the euro, the second most used currency for offshore borrowing after the dollar (see Appendix 2, Figure A5). Given these results, we estimate a vector error correction model (VECM) that looks at the deviations of US dollar and euro bond issuance from their long-run relationship cause by the impact of term premium shocks as well as other exogenous controls (see Appendix 2 for detailed description of the methodology and the results).[12]

We find that unconventional monetary policy that lowers the term premium on US Treasury bonds by a given amount works more speedily to raise the stock of US dollar debt of non-US residents than the same decline in the premium on German bunds would raise the stock of euro-denominated debt of non-euro area residents. This is despite our finding of a long-run stable (cointegrating) relationship between offshore bond issuance in US dollar and the euro. The difference in the reaction of the two series to US dollar funding cost shocks is illuminating. A negative shock to the term premium on US long-term bonds is associated with higher growth rate of US dollar debt issuance by non-residents in the following quarter, followed by a rise in euro debt issuance in subsequent periods. A similar shock to the term premium on long-term bunds, by contrast, does not appear to significantly boost US dollar or euro denominated debt issuance. Following the US long-term bond term premium shock, adjustment is quicker in US dollar denominated offshore bond issuance, whereas the adjustment in the issuance pattern of euro denominated offshore bonds lags, playing catch-up until the long-run equilibrium relationship between the two series is restored. Taking it all together, these results suggest that the familiar difference between the US and European central banks in their bond market intervention matters less to the ultimate stocks

12 Analogously to our approach with US dollar bank lending, we also check the robustness of the results using the less restrictive, full sample VAR framework. Similar to the full sample OLS, we do not find significant evidence of term premium compression effect on debt issuance over the entire sample period (Appendix 1, Figure A4 reports the results).

of non-resident debt than the less familiar difference in market dynamics in response to those policies.

4. CONCLUSIONS AND POLICY IMPLICATIONS

We examined the role of benchmark policy rates, long-term yield compression, and the cost of leverage in the extension of US dollar credit to non-US borrowers through banks and debt markets. Overall, we find significant impact of both US monetary policy stance and cost of leverage on offshore US dollar credit growth, but the relative importance of these factors is sensitive to the chosen time-sample and estimation methodology.

Our main empirical findings are threefold. First, prior to the crisis period, offshore US dollar credit growth was primarily enabled by global banks who took on large leveraged positions (as measured by financial CP), supported by low cost of leverage (as measured by the VIX), and low short-term funding costs in the interbank markets (as measured by US dollar Libor). Time-varying estimates also indicate a significant knock-on effect from low federal funds rate (relative to Taylor rule benchmarks), especially during the mid-2000s. Specifically, it appears that low benchmark rates drive offshore credit during the build-up phase, whereas forces proxied by the VIX take over during crisis times.

Second, after the crisis, and especially with the beginning of large-scale asset purchases by the Federal Reserve, the transmission of US financial conditions to dollar credit offshore shifted. The banking sector became less important and international debt markets became more important, spurred by the policy-induced compression of term premia on long dated debt securities.

Third, looking at US dollar and euro denominated offshore credit, we find that offshore debt markets of these currencies appear to exhibit much closer association and co-movement than bank credit. In particular we find robust evidence of cointegration between US dollar and euro denominated debt issuance by non-residents, but not between bank credit to non-residents denominated in dollar and euro. Focusing on non-resident debt security issuance, offshore US dollar debt issuance responds immediately to 10-year Treasury term premia shocks, euro denominated debt issuance plays catch-up in subsequent quarters until the long-run association between the two hard currency debt markets is restored. Thus, term premium compression from US monetary policy appears to spill over into debt issued in other currencies, and they tend to follow the dollar. This may have financial stability implications, in particular as US term premium compression has come to a halt as of May 2013, and the full scope of adjustment is yet to be felt.

The discussion of the associated policy implications takes up three themes: policy interdependence; the variety of policies that can change the borrowing cost of dollars outside the United States and the new challenges of what Shin (2013) calls the second phase of global liquidity.

Policy interdependence arises out of the sheer scale of dollar borrowing outside the United States. At $7 trillion, this is a substantial fraction of credit in the United States and that outside it. True, only in generally smaller, dollarized economies does dollar credit represent the bulk of credit or credit growth. But the availability of dollar credit, especially through the interbank market, can and does supplement credit financed with domestic deposits and other savings and enables credit to grow quickly with often untoward effects (Avdjiev et al, 2012).

The US central bank has been called upon to internalise the effects of its policy on the rest of the world (Caruana, 2012a, 2012b, 2013). He and McCauley (2013) cite the episode of 1997-2000. The Federal Reserve had started a tightening cycle when the devaluation of the Thai baht set off the Asian financial crisis. The resulting deflationary shock led the Federal Reserve to pause in its tightening, and the subsequent Russian default further delayed it. By the time the Federal Reserve got back to tightening, it had to deal with an equity price bubble. There is arguably a shared interest that developments in dollar credit to borrowers outside the United States not stand in the way of the timely normalisation of US monetary policy.

Regarding policy measures that recipients of dollar credit can take, He and McCauley (2013) find that much can be done. Despite huge differences in capital account openness, China, Korea and Hong Kong SAR (henceforward Hong Kong) all implemented policies that somehow affected the cost of dollar credit. The Chinese authorities have been able to split its domestic foreign exchange, money, bond and equity markets from their offshore counterparts (Ma and McCauley, 2013) and the flip side is that they have been able to split the dollar market in Shanghai from that in London. In short, controls on banks' ability to import dollars from the rest of the world means that a Chinese company faces higher dollar borrowing costs in Shanghai than its affiliate would in Hong Kong, with consequences discussed below in connection with the growth of dollar credit in Hong Kong.

In the case of Korea, even before the global financial crisis, the authorities had taken measures that tended to raise the cost of dollar borrowing (McCauley and Zukunft, 2008). Moral suasion applied to foreign banks was judged by IMF observers to be the most effective. While regulation since the Asian financial crisis had required Korean banks to match foreign currency assets against foreign currency liabilities in a series of maturity buckets, the regulation did not cover foreign branches operating in the country. Since the more recent global financial crisis, the authorities have limited forward positions in won/dollar in relation to banks' capital and starting in 2011 imposed a macroprudential levy on short-term foreign currency bank borrowing. The measurable effect of the Korean cocktail of measures is to raise the cost of borrowing dollars in Korea to levels substantially above those implied by the US federal funds range of 0-0.25% or three-month US dollar Libor. Korean shipbuilders that want to sell export proceeds two years forward (who in effect are borrowing dollars) have to pay up.

Policy that raises the effective cost of dollar borrowing outside the United States can be seen as a push-back by the authorities on the receiving end of dollar credit. And it must be admitted that the analysis in the body of this paper does not really take into account this push-back when it uses US dollar yields like the federal funds target rate, US dollar Libor, the US Treasury 10-year yield or In the case of Hong Kong, with its wide-open capital account, the policy measure has been the bank supervisors drawing attention to rising loan-to-deposit ratios and liquidity requirements (Chan, 2011). The underlying development is rapid expansion of foreign currency credit to China-related firms. These firms might be funding the acquisition of corporate assets outside of China or financing the trade of their mainland affiliates. To some extent, the build-up of dollar debt in Hong Kong is drawn down against letters of credit written by Mainland banks against the security of domestic renminbi deposits. The rapid growth of dollar credit in Hong Kong is shifting the territory's role in the international banking market from a source of dollar deposits for international banks to a more balanced position in terms of deposits and loans (Hong Kong Monetary Authority, 2013). As the loan to deposit the term premium derived from it. He and McCauley (2013) report two VAR analyses of the growth of foreign currency loans extended by banks in China, one using Libor and the other using the Shanghai dollar lending rate. In their VAR analysis of the growth of foreign currency loans in Hong Kong, Tang and Ng (2012) enter both. There is work to be done at the country level that can incorporate idiosyncratic dollar borrowing costs.

Finally, what Shin (2013) calls the second phase of global liquidity is one in which the fastest growth in dollar credit is coming from bond issuance rather than bank lending. This development has some beneficial effects from a financial stability perspective. While debt issuance in the form of commercial paper is subject to investor runs (Baba et al, 2009), bonds bind borrowers and lenders over the medium term and work against sudden reversals of credit. Thus when He and McCauley (2013) found that Korean firms had ramped up their sales of international bonds in recent years as policy made bank loans funded with short-term loans more expensive, they interpreted this as a demonstration that the policies were working.

The data to demonstrate some stability of bond credit to borrowers outside the United States during the recent episode of a possible reduction ("tapering") in Federal Reserve purchases of Treasury and mortgage-backed securities are in hand. (We have already highlighted above the extraordinary observation that year-on-year growth of the stock of bond debt of borrowers outside the United States continued to grow through the global financial crisis of 2007-09; see Figure 2.) With the strains in the bond market in July and August, but a rebound in issuance in September, net issuance of dollar bonds by borrowers outside the United States fell by a half, but this means that the stock continued to grow. Third quarter banking data are not in hand, but the second quarter data already showed a reduction in the stock of cross-border (mostly dollar) bank credit to Latin America by a hefty $47 billion, mostly vis-à-vis Brazil but including contractions of cross-border credit to Mexico and Peru (Gyntelberg and van Rixtel (forthcoming 2013); Garcia-Luna and van Rixtel (forthcoming 2013)). Cross-border credit to Asia only decelerated in aggregate, although that to India declined. Chinese data show a striking decline in foreign currency loans extended by banks in China over the summer. On the basis of incomplete information, it seems safe to say that the stock of dollar debt securities of borrowers outside the United States showed more stability than the stock of dollar bank loans to borrowers outside the United States, notwithstanding the fact that the taper talk raised bond yields much more than the money market yields payable on most bank loans.

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While international debt securities look stickier than bond debt, the shift toward dollar credit through bond markets in recent years does raise financial stability concerns, as argued by Shin (2013). First is a concern that emerging market firms are raising funds from the international bond market to fund various forms of carry trades (Caruana, 2013). Second 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.[13] Finally 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.

13 See Cho and McCauley (2003) on the role of offshore debt of the Korean corporate sector during the 1997-98 crisis and 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.

Appendix 1: Supplementary Tables and Figures

Table A1: Unit root test results in levels and first differences

	Augmented Dickey-Fuller test statistic	
Prob	levels	first-differences
US dollar denominated offshore bank loans (in logs)	0.9675	0.0000
Euro denominated offshore bank loans (in logs)	0.4614	0.0000
US dollar denominated offshore debt (in logs)	0.9802	0.0000
Euro denominated offshore debt (in logs)	0.9619	0.0000
Effective fed fund rate	0.1256	0.0000
Yield, 10-year Treasuries	0.467	0.0000
Term premium, 10-year Treasuries	0.8615	0.0000
Term premium, 10-year Bunds	0.6049	0.0000
US dollar Libor	0.3172	0.0004
Eurobor	0.8029	0.0000
VIX	0.0056	0.0000
Leverage = financial CP + primary dealer repo (in logs)	0.3095	0.0040
Trade volume (in logs)	1	0.0843
Dollar-euro exchange rate	0.6477	0.0000
US dollar trade weighted index	0.6205	0.0000

Notes:
Sample: 1998Q1 2013Q1, number of lags for each variable selected using SIC.

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Table A2: Cointegration test between US dollar and euro denominated offshore bank lending and offshore debt outstanding, with additional tests for a third series in the system.

	Trace test			Meximum eigenvalue test		
US dollar bank lending to non-residents	None	At most 1	At most 2	None	At most 1	At most 2
with						
euro bank lending to non-residents	0.264	0.212		0.316	0.212	
US dollar denominated offshore debt	None	At most 1	At most2	None	At most 1	At most 2
with						
euro denominated offshore debt	0.001	0.021		0.006	0.021	
plus						
Term premium, 10-year Treasuries	0.005	0.057	0.115	0.029	0.090	0.115
Term premium, 10-year Bunds	0.052	0.076	0.073	0.262	0.152	0.073
US dollar Libor	0.014	0.015	0.020	0.253	0.066	0.020
Eurobor	0.001	0.007	0.020	0.036	0.033	0.020
VIX	0.055	0.110	0.107	0.206	0.180	0.107
Trade volume	0.006	0.128	0.118	0.015	0.198	0.118
Dollar-euro exchange rate	0.056	0.305	0.235	0.079	0.351	0.235
US dollar trade weighted index	0.060	0.314	0.184	0.083	0.397	0.184

Notes:

1999Q4 to 2013Q1sample, 54 observations; trend assumption: linear deterministic trend .p-values reported for two tests: Unrestricted Cointegration Rank Test (Trace) and the Unrestricted Cointegration Rank Test (Maximum Eigenvalue). The results indicate an absence of a cointegrating relationship between US dollar and euro denominated bank loans to non-resident, non-financial borrowers. However, there is evidence of a cointegrating relationship between US dollar and euro denominated stock of international debt securities outstanding issued by non-residents. This suggests that offshore debt markets of major hard currencies have more common drivers that offshore bank lending , and tend to equilibrate to their long-run relationship following exogenous shocks, such as US monetary policy shocks.

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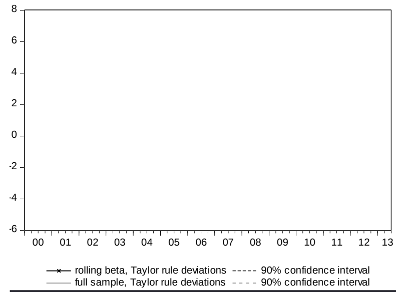
Dependent variable: growth in US dollar bank lending to non-residents

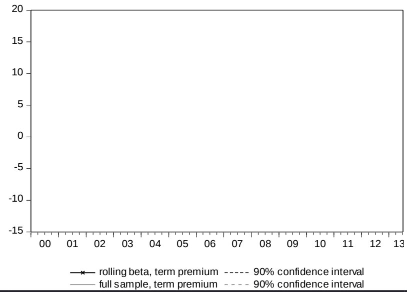
Rolling regression estimates (2000-2013); with VIX

Figure A1

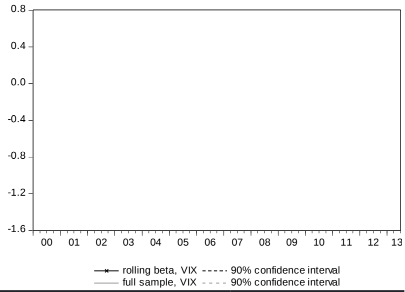
Fed funds rate Taylor rule deviations



10-year term premium

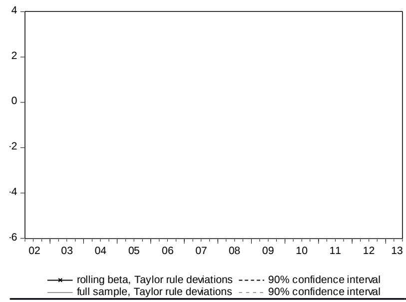


VIX

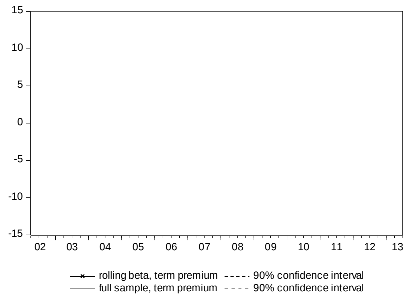


Rolling regression estimates (2002-2013); with financial CP + repo outstanding

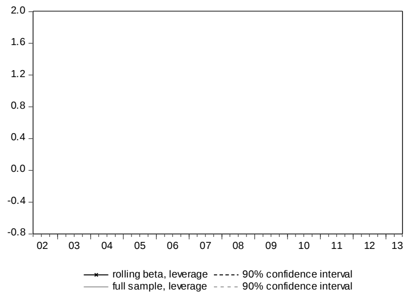
Fed funds rate Taylor rule deviations



10-year term premium

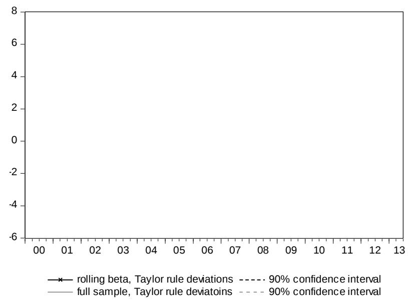


Financial CP + primary dealer repo

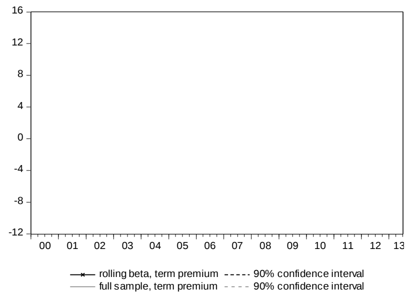


Rolling regression estimates (2000-2013); with financial CP only

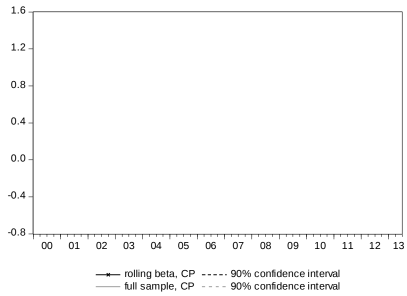
Fed funds rate Taylor rule deviations



10-year term premium



Financial CP



Estimates based on 16-quarter rolling regressions. All the variables enter in first-differences or in log-differences, expressed in per cent; the dependent variable persistency is controlled for via the lag term. Coefficient estimates on lagged dependent variable omitted for brevity.

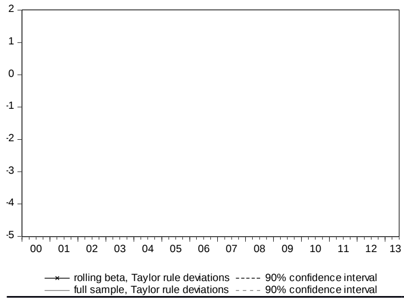
Sources: Bloomberg; Consensus Economics; BIS international debt statistics; BIS locational banking statistics by residence; authors' calculations.

 25

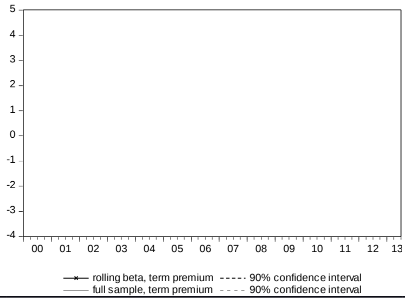
Dependent variable: growth in US dollar debt securities issued by non-residents

Rolling regression estimates (2000-2013); with VIX — Figure A2

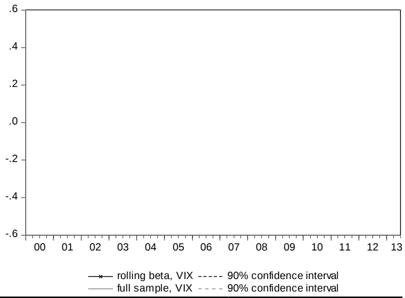
Fed funds rate Taylor rule deviations



10-year term premium

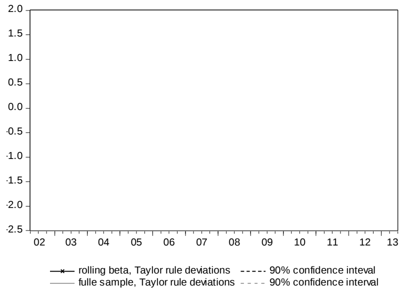


VIX

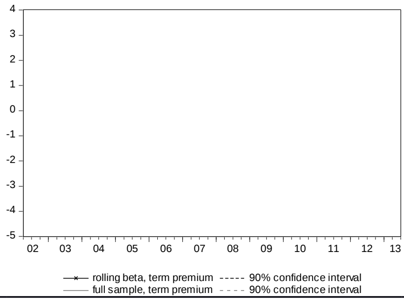


Rolling regression estimates (2002-2013); with financial CP + repo outstanding

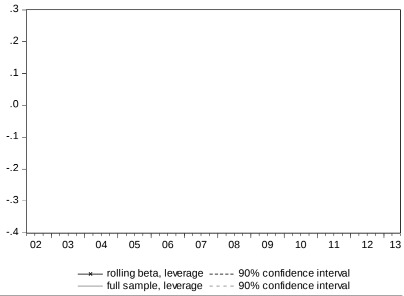
Fed funds rate Taylor rule deviations



10-year term premium

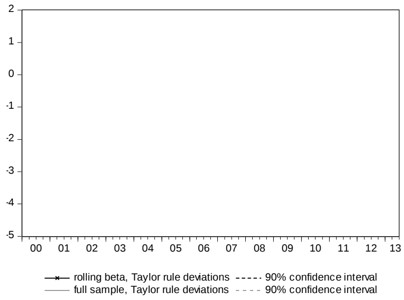


Financial CP + primary dealer repo

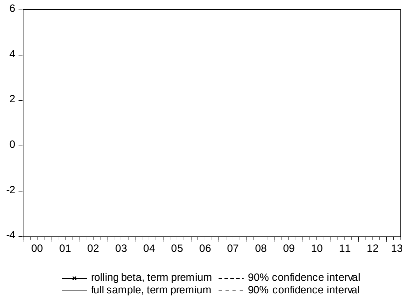


Rolling regression estimates (2000-2013); with financial CP only

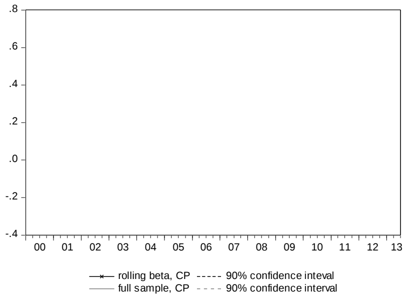
Fed funds rate Taylor rule deviations



10-year term premium



Financial CP



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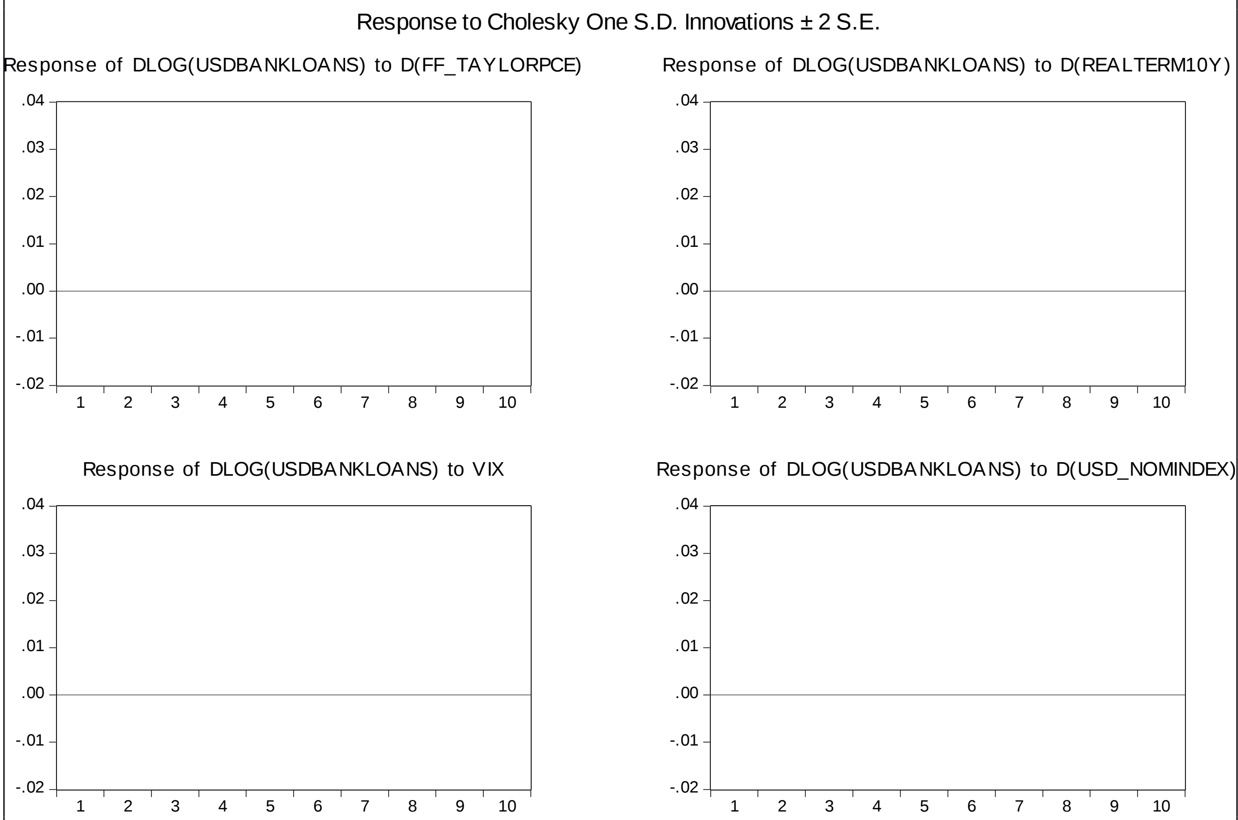
Estimates based on 16-quarter rolling regressions. All the variables enter in first-differences or in log-differences, expressed in per cent; the dependent variable persistency is controlled for via the lag term. Coefficient estimates on lagged dependent variable omitted for brevity.

Sources: Bloomberg; Consensus Economics; BIS international debt statistics; BIS locational banking statistics by residence; authors' calculations.

Impulse responses of US dollar bank loans to non-residents to interest rate, VIX, and exchange rate shocks

Figure A3



Notes: 1996Q3 2013Q2 sample; Included observations: 68; 2-lag specification chosen based on Akaike information criterion (AIC) and Schwarz selection criterion. Cholesky ordering in the order of exogeneity is: fed funds deviations from the PCE-based Taylor rule, D(FF_TAYLORPCE), 10-year term premium, D(REALTERM10Y), the VIX, nominal US dollar trade weighted exchange rate index, D(USD_NOMINDEX), world trade volume, DLOG(TRADE), and US dollar denominated bank lending to non-residents, DLOG(USDBANKLOANS); Impulse response to DLOG(TRADE) insignificant and omitted for brevity.

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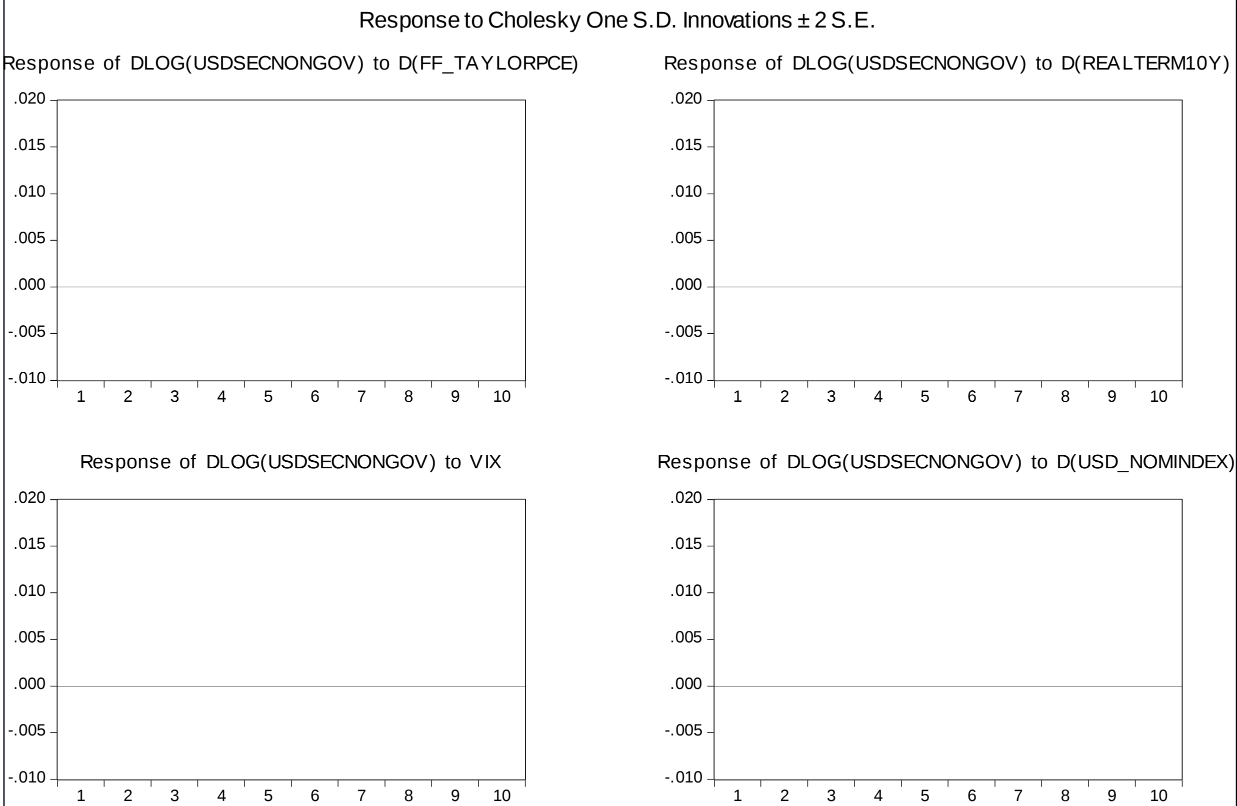
Impulse responses of US dollar debt securities issued by non-residents to interest rate, VIX, and exchange rate shocks

Figure A4



Notes: 1996Q3 2013Q2 sample; Included observations: 68; 2-lag specification chosen based on Akaike information criterion (AIC) and Schwarz selection criterion. Cholesky ordering in the order of exogeneity is: fed funds deviations from the PCE-based Taylor rule, D(FF_TAYLORPCE), 10-year term premium, D(REALTERM10Y), the VIX, nominal US dollar trade weighted exchange rate index, D(USD_NOMINDEX), world trade volume, DLOG(TRADE), and US dollar denominated debt securities issued by non-residents, DLOG(USDSECNONGOV); Impulse response to DLOG(TRADE) insignificant and omitted for brevity.

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Appendix 2: Analysis Based on the Cointegration of US Dollar and Euro Offshore Bonds

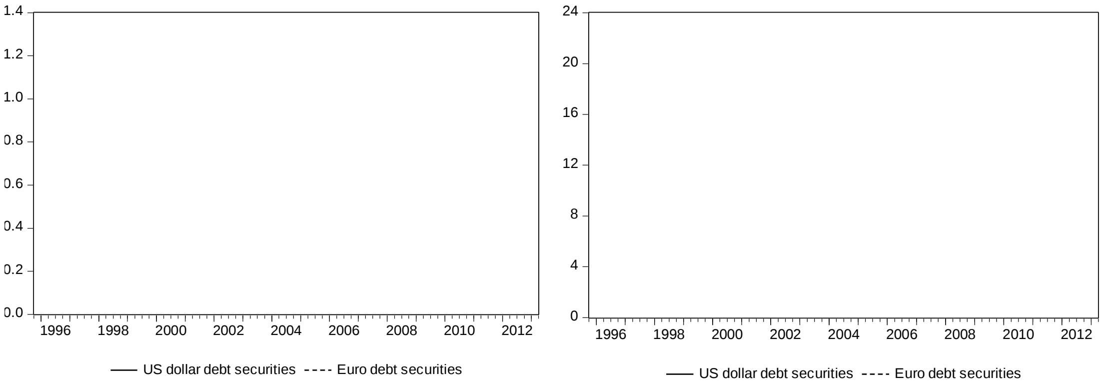
Long-run relation between offshore debt in US dollar and the euro

Estimated coefficients[1]

Figure A5

Amounts outstanding, trillions US dollars

Year-on-year growth rates



[1] Johansen cointegration tests results in Table A2 show that the time series of outstanding non-resident debt issued in US dollars and in the euro are cointegrated. The null of no cointegration is rejected at significance level of 0.001.

Sources: BIS international debt statistics; authors' calculations.

The cointegration between the two series indicates that offshore debt issuance in the US dollar and the euro has a stable long-run relationship.[14] Given these results, we proceed to estimate a vector error correction model (VECM) of the following form:

$$\Delta logCRED_t^D = \lambda_{USD} \left(logCRED_{t-1}^D - \alpha_0 - \alpha_1 logCRED_{t-1}^{D,EUR} \right) + \gamma_{1,USD} \Delta logCRED_{t-1}^D + \gamma_{2,USD} \Delta logCRED_{t-1}^{D,EU} \quad (1)$$

$$\Delta logCRED_t^{D,EUR} = \lambda_{EUR} \left(logCRED_{t-1}^D - \alpha_0 - \alpha_1 logCRED_{t-1}^{D,EUR} \right) + \gamma_{1,EUR} \Delta logCRED_{t-1}^D + \gamma_{2,EUR} \Delta logCRED_{t-1}^{D,EUR} + \beta_{USD}^{D,EUR} \Delta TERMPREM_{t-1}^{USD} + \beta_{EUR}^{D,EUR} \Delta TERMPREM_{t-1}^{EUR} + \delta_{EUR} X_{t-1} + \epsilon_t^{EUR} \quad (2)$$

Equations (1) and (2) constitute a vector autoregressive models with an additional error correction term. The endogenous variables in the system are offshore debt securities

14 First we perform unit root and stationarity tests, which confirm that the US dollar and the euro offshore debt series contain a unit root, Table A1. Next, we run cointegration tests, which show that the time series of outstanding non-resident debt issued in US dollars and in the euro are indeed cointegrated. Table A2 shows the results of Johansen cointegration tests between outstanding international debt securities denominated in US dollar and those denominate in euro. The null of no cointegration is rejected at significance level of 0.001.

issued in US dollar and the euro, $CRED_t^D$ and $CRED_t^{D,EUR}$ respectively. The error correction terms (in parenthesis in equations (1) and (2)) represent the long-run equilibrium of the two time series, the VAR-terms that follow, $\Delta logCRED_{t-1}^D$ and $\Delta logCRED_{t-1}^{D,EUR}$ account for short-run dynamics in the endogenous variables, and ϵ_t^{USD} and ϵ_t^{EUR} are i.i.d. shocks. The adjustment parameters associated with the error correction terms, λ_{USD} and λ_{EUR} , measure the degree to which debt issuance in the US dollar and the euro respectively adjusts to correct for the deviations from their long-run relationship.

The main coefficient of interest, β_{USD}^D , captures the deviations from long-run equilibrium in the offshore US dollar debt issuance due to US term premium shocks. Both equations also control for analogous long-term financing costs in euros via the nominal term premium component of 10-year bund yields, $TERMPREM_t^{EUR}$.

Finally, X_{t-1} represents a vector of additional exogenous controls which we add sequentially to the baseline specification. These include: 3-month US dollar and euro LIBOR rates, US dollar exchange rates, euro exchange rates, index of world trade volume, and the VIX. All variables except for the VIX display a unit root in levels, therefore are first-differenced prior to the estimation.

Table A3 shows estimation results of the baseline model for 1-, 2-, and 3-lag specification of the VAR-terms. In terms of model selection, F-statistic, Schwarz selection criteria, and log likelihood all favour a 1-lag specification. Therefore, we interpret results based on the 1-lag specification, although the coefficient on $\Delta TERMPREM_{t-1}^{USD}$ is negative and significant in all specifications.

In terms of endogenous variables, the adjustment parameter is greater for the error correction terms in the euro bond issuance, $\Delta logCRED_t^{D,EUR}$, equation than in the US dollar bond issuance equation, $\Delta logCRED_t^D$ (λ_{EUR} =0.12 in absolute value compared to λ_{USD} =0.06), indicating that, following an initial shock, the adjustment back towards the long-run equilibrium in the two series tends to happed via changes in issuance pattern of euro denominated offshore bonds. In contrast, short-term dynamics are dominated by changes in US dollar denominated offshore bond issuance patterns, with the coefficient on the US dollar VAR term, $\Delta logCRED_{t-1}^D$, significant in for both equations.

The coefficients on changes in the US term premia, β_{USD}^D and $\beta_{USD}^{D,EUR}$, are negative and significant in both equations, controlling for term premia on euro are bonds, which indicates that a decline in US term premia is associated with a positive shock to issuance in US dollar as well as euro denominated offshore debt securities. The short- and long-run dynamics in the endogenous variables outlined above imply some additional adjustments to US term premia shocks, primarily through US dollar bond issuance VAR-terms, in the following quarters. In addition, smaller estimates of λ_{USD} indicate that the adjustment is quicker in US dollar denominated offshore bond issuance, while it may take some time for euro denominated issuance to fully restore the equilibrating relationship.

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Table A3: Vector error correction model (VECM) of US dollar and euro denominated international debt issuance by non-residents.

Cointegrating Equation:	(1)		(2)		(3)	
Euro debt (in logs)	-1.274 [-16.338]***		-1.348 [-14.583]***		-1.292 [-13.262]***	
constant	-0.835		-0.908		-0.847	
Error Correction:						
λ_{USD} and λ_{EUR}	-0.060 [-1.888]**	0.117 [2.273]***	-0.063 [-2.190]***	0.105 [2.237]***	-0.037 [-1.028]	0.162 [2.616]***
US dollar debt (in dlogs), 1-lag	0.422 [3.451]***	0.365 [1.824]**	0.292 [2.048]***	0.388 [1.667]	0.243 [1.757]*	0.379 [1.590]
US dollar debt (in dlogs), 2-lag			0.159 [1.170]	0.338 [1.521]	0.145 [1.029]	0.353 [1.451]
US dollar debt (in dlogs), 3-lag					0.232 [1.772]*	0.148 [0.655]
Euro debt (in dlogs), 1-lag	0.148 [1.791]*	0.018 [0.1321]	0.131 [1.566]	0.002 [0.013]	0.146 [1.783]*	0.012 [0.085]
Euro debt (in dlogs), 2-lag			0.027 [0.318]	-0.212 [-1.524]	0.024 [0.285]	-0.230 [-1.621]
Euro debt (in dlogs), 3-lag					0.028 [0.335]	-0.173 [-1.216]
Term prem. US (diff.), 1-lag	-0.021 [-2.061]***	-0.028 [-1.723]	-0.019 [-1.815]**	-0.036 [-2.148]***	-0.022 [-2.147]***	-0.042 [-2.337]***
Temr prem. euro (diff.), 1-lag	0.015 [1.731]*	0.025 [1.857]	0.015 [1.756]	0.032 [2.293]***	0.023 [2.552]***	0.037 [2.408]***
R-squared	0.350	0.223	0.392	0.270	0.469	0.298
Adj. R-squared	0.282	0.143	0.297	0.157	0.356	0.147
Sum sq. resids	0.009	0.025	0.009	0.023	0.007	0.022
S.E. equation	0.014	0.023	0.014	0.023	0.013	0.023
F-statistic	5.173	2.762	4.141	2.383	4.126	1.977
Log likelihood	157.509	130.915	155.870	129.791	156.832	128.598
Akaike AIC	-5.611	-4.626	-5.580	-4.596	-5.647	-4.561
Schwarz SC	-5.390	-4.405	-5.283	-4.298	-5.272	-4.186
Log likelihood		289.903		287.115		286.541
Akaike information criterion		-10.219		-10.155		-10.175
Schwarz criterion		-9.703		-9.486		-9.349

Notes:
Sample (adjusted): 1999Q3 2012Q; included observations: 54 after adjustments; t-statistics in [ ]. Estimation results of the baseline model for 1-, 2-, and 3-lag specification of the VAR-terms. In terms of model selection, F-statistic, Schwarz selection criteria, and log likelihood all favour a 1-lag specification. Therefore, we interpret results based on the 1-lag specification.

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Table A4: Vector error correction model (VECM) of US dollar and euro denominated international debt issuance by non-residents; additional controls.

Cointegrating Equation:	(1)		(2)		(3)	
Euro debt (in logs)	-1.254		-1.150		-1.101	
	[-18.487]***		[-24.032]***		[-24.111]***	
constant	-0.788		-0.683		-0.656	
Error Correction:						
λ_{USD} and λ_{EUR}	-0.063	0.132	-0.008	0.255	0.012	0.276
	[-1.803]**	[2.373]***	[-0.175]	[3.634]***	[0.224]	[3.945]***
US dollar debt (in dlogs), 1-lag	0.468	0.378	0.471	0.117	0.379	0.042
	[3.808]***	[1.917]	[3.507]***	[0.587]	[2.433]***	[0.203]
Euro debt (in dlogs), 1-lag	0.136	0.016	0.132	-0.002	0.142	-0.104
	[1.636]	[0.122]	[1.535]	[-0.014]	[1.503]	[-0.825]
Term prem. US (diff.), 1-lag	-0.020	-0.028	-0.019	-0.019	-0.023	-0.004
	[-1.990]***	[-1.725]*	[-1.843]**	[-1.195]	[-1.822]**	[-0.245]
Temr prem. euro (diff.), 1-lag	0.014	0.025	0.012	0.021	0.013	0.007
	[1.649]	[1.832]**	[1.309]	[1.553]	[1.246]	[0.532]
US dollar Libor (diff.), 1-lag			-0.004	-0.004	-0.005	0.000
			[-1.083]	[-0.747]	[-1.062]	[0.033]
Eurobor (diff.), 1-lag			-0.005	-0.013	-0.007	0.003
			[-0.995]	[-1.773]*	[-1.009]	[0.378]
US dollar nom. index (diff.), 1-lag					0.002	0.006
					[1.162]	[2.003]***
Dollar-euro returns, 1-lag					0.114	0.397
					[0.893]	[2.329]***
Trade volume (in dlogs), 1-lag					0.000	-0.004
					[0.360]	[-2.464]***
VIX, 1-lag					0.000	0.000
					[0.017]	[0.727]
R-squared	0.350	0.242	0.354	0.358	0.375	0.500
Adj. R-squared	0.284	0.165	0.257	0.262	0.211	0.369
S.E. equation	0.014	0.023	0.014	0.021	0.015	0.019
F-statistic	5.288	3.130	3.674	3.736	2.290	3.823
Akaike AIC	-5.592	-4.646	-5.524	-4.738	-5.428	-4.845
Schwarz SC	-5.373	-4.427	-5.232	-4.446	-4.986	-4.403
Log likelihood		295.209		298.719		301.465
Akaike information criterion		-10.226		-10.208		-10.202
Schwarz criterion		-9.715		-9.551		-9.245

Notes:

Sample (adjusted): 1999Q3 2012Q; included observations: 54 after adjustments; t-statistics in [ ]. VECM estimation results sequentially adding exogenous controls in the 1-lag autoregressive specification. Coefficient estimates with controls further underscore the differences in transition dynamics of US dollar denominated debt issuance compared to euro denominated debt. The estimated adjustment parameter in US dollar debt issuance equation, λ_{USD}, is consistently smaller than in the euro debt issuance equation adjustment parameter, λ_{EUR}, and is not significant in 2 out of 3 specifications, whereas λ_{EUR} is always statistically significant at 0.01 level of higher. In contrast, the coefficient on the VAR term in the US dollar debt issuance equation is always significant, while the coefficients on the euro debt issuance VAR term in either equation are not significant.

Table A4 shows VECM estimation results sequentially adding exogenous controls in the 1-lag autoregressive specification. Coefficient estimates with controls further underscore the differences in transition dynamics of US dollar denominated debt issuance compared to euro denominated debt. The estimated adjustment parameter in US dollar debt issuance equation, λ_{USD}, is consistently smaller than in the euro debt issuance equation adjustment parameter, λ_{EUR}, and is not significant in two out of three specifications, whereas λ_{EUR} is always statistically significant at 0.01 level of higher. In contrast, the coefficient on the VAR term in the US dollar debt issuance equation, $\gamma_{1,USD}$, is always significant, while the coefficients on the euro debt issuance VAR term in either equation, $\gamma_{2,USD}$ and $\gamma_{2,EUR}$, are never significant. The results confirm the baseline finding that short-run adjustments the system take place through changes in US dollar offshore debt issuance patterns, whereas euro denominated offshore debt issuance adjusts over the medium to long-term until its long-run relationship with US dollar debt issuance is restored.

Moving to the main result, the coefficients on changes in US dollar term premium, $\Delta TERMPREM_{t-1}^{USD}$, are negative and significant in $\Delta logCRED_t^D$ equation under all specifications. This confirms the baseline finding that a decline in the term premium on US long-term bonds is associated with higher growth rate of US dollar debt issuance by non-residents in the following quarter.

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