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Capital Flows and the Risk-Taking Channel of Monetary Policy

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Foreword

On 21–22 June 2012, the BIS held its Eleventh Annual Conference, on “The future of financial globalisation” in Lucerne, Switzerland. The event brought together senior representatives of central banks and academic institutions who exchanged views on this topic. The papers presented at the conference and the discussants’ comments are released as BIS Working Papers 397 to 400. A forthcoming BIS Paper will contain the opening address Stephen Cecchetti (Economic Adviser, BIS), a keynote address from Amartya Sen (Harvard University), and the available contributions of the policy panel on “Will financial globalisation survive?”. The participants in the policy panel discussion, chaired by Jaime Caruana (General Manager, BIS), were Ravi Menon (Monetary Authority of Singapore), Jacob Frenkel (JP Morgan Chase International) and José Dario Uribe Escobar (Banco de la Repubblica).

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	Author:	Pierre Olivier Gourinchas (University of California, Berkeley) and Olivier Jeanne (Johns Hopkins University) “Global Safe Assets”
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		"Will financial globalisation survive?"
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	Panellists:	Ravi Menon (Managing Director, Monetary Authority of Singapore) Jacob Frenkel (Chairman, JP Morgan Chase International) José Dario Uribe Escobar (Governor, Banco de la República)

Capital Flows and the Risk-Taking Channel of Monetary Policy*

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July 6, 2012

Abstract

This paper examines the relationship between low interests maintained by advanced economy central banks and credit booms in emerging economies. In a model with cross-border banking, low funding rates increase credit supply, but the initial shock is amplified through the "risk-taking channel" of monetary policy where greater risk-taking interact with dampened measured risks that are driven by currency appreciation to create a feedback loop. In an empirical investigation using VAR analysis, we find that expectations of lower short-term rates dampens measured risks and stimulate cross-border banking sector capital flows.

JEL Codes: F32, F33, F34
Keywords: Capital flows, exchange rate appreciation, credit booms

*Paper presented at the 11th BIS Annual Conference, 22-23 June 2012. We thank our discussants Lars Svensson and John Taylor and other conference participants for their comments on the first version of the paper.

1 Introduction

Low interest rates maintained by advanced economy central banks have led to a lively debate on the nature of global liquidity and its transmission across borders. A popular narrative among financial commentators is that low interest rates in advanced economies act as a key driver of cross-border capital flows, resulting in overheating and excessive credit growth in the recipient economies. However, the precise economic mechanism behind such a narrative has been difficult to pin down.

One way to shed light on the debate is to start with the empirical evidence on the cyclical nature of leverage and financial conditions. Gourinchas and Obstfeld (2012) conduct an empirical study using data from 1973 to 2010 for both advanced and emerging economies on the determinants of financial crises. They find that two factors emerge consistently as the most robust and significant predictors of financial crises, namely a rapid increase in leverage and a sharp real appreciation of the currency. Their finding holds both for emerging and advanced economies, and holds throughout the sample period. Thus, one way to frame the debate on the role of monetary policy in the transmission of global liquidity is to ask how monetary policy in advanced economies may influence leverage and real exchange rates in capital flow recipient economies.[1]

One channel that is often neglected in conventional monetary economics is the role of the banking sector in driving financial conditions and risk premiums over the cycle. Banks are intermediaries who borrow short and lend long, so that the size of the term spread (i.e. slope of the yield curve) influences the profitability of new lending. Since long rates are less sensitive than short rates to shifts in the central bank's policy rate, monetary policy exerts considerable influence on the size of the term spread, at least for short periods of time. Through this channel, the central bank's policy rate may act directly on the economy through greater risk-taking by the banking sector. Borio and Zhu (2008) coined the term "risk-taking channel of monetary

[1]Our questions is related to the debate on whether monetary policy was "too loose" in the run-up to the crisis with respect to the Taylor Rule (Taylor (2007), Bernanke (2010)). However, our focus is narrower in that we examine the risk-taking channel more explicitly.

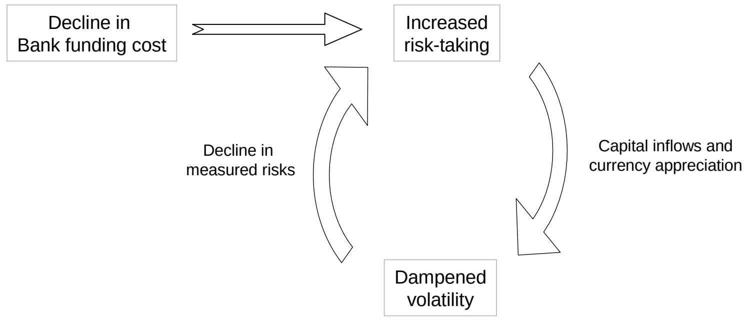


Figure 1. Risk-taking channel of monetary policy in the cross-border context

policy", and Adrian and Shin (2008, 2011) and Adrian, Estrella and Shin (2012) have explored the workings of the risk-taking channel empirically, finding empirical support for the risk-taking channel for the United States. In this paper, we will explore the workings of the risk-taking channel in an international setting through the cross-border activity of global banks.

The risk-taking channel works through the incentives of banks to take on leverage, thereby influencing financial conditions directly. Focusing attention on the banking sector allows us to connect the two factors identified by Gourinchas and Obstfeld (2012) - real appreciation of the currency and increased leverage. The link can be traced to an amplification mechanism built into the risk-taking channel, which can be illustrated schematically as in Figure 1.

Figure 1 traces the impact of a monetary policy shock that lowers the dollar funding cost of banks in capital flow-recipient economies. The lowering of funding costs gives an initial impetus for greater risk-taking, as banks in the recipient economy take advantage of lower dollar funding costs by increasing lending to domestic entities - either corporates or households, or both. However, any initial appreciation of the recipient economy's currency strengthens the balance sheet position of domestic borrowers. From the point of view of the banks that have lent to them, their loan book becomes less risky, creating spare capacity to lend even more. In this way, the initial impetus is amplified through a reinforcing mechanism in which greater risk-taking by banks dampens volatility, which elicits even greater risk-taking, thereby completing the circle.

The upward phase of the cycle will give the appearance of a virtuous circle, where the mutually reinforcing effect of real appreciation and improved balance sheets operate in tandem. However, once the cycle turns, the amplification mechanism works exactly in reverse, serving to reinforce the financial distress of borrowers and the banking sector. Our formal model will provide a more precise analysis of the amplifying mechanism depicted in Figure 1.

The risk-taking channel stands in contrast to models of monetary economics commonly used at central banks, which tend to downplay the importance of short-term interest rates as price variables in their own right. Instead, the emphasis falls on the importance of managing market expectations. The emphasis is on charting a path for future short rates and communicating this path clearly to the market, so that the central bank can influence long rates such as mortgage rates, corporate lending rates, as well as other prices that affect consumption and investment.[2]

We complement our theoretical exposition of the risk-taking channel by examining how it operates in the international context. We conduct a vector autoregression (VAR) study and study the impulse responses of balance sheet adjustments to changes in monetary policy. We build on the work of Bekaert, Hoerova and Lo Duca (2010) who conduct a VAR study of the relationship between the policy rate chosen by the Federal Reserve (the target Fed Funds rate) and measured risks given by the VIX index of implied volatility on US equity options, and show that there is a close two-way interaction between the two variables. In particular, they show that a cut in the Fed Funds rate is followed by a dampening of the VIX index, while an increase in the VIX index elicits a response from the Federal Reserve who react by cutting the target Fed Funds rate.

We extend their analysis in two ways. First, in line with the underlying mechanism of the risk-taking channel, we show the importance of the term spread in influencing market conditions. An upward shock to the VIX index elicits a sharp widening of the 12 month forward term spread, indicating market expectations of imminent cuts in the Fed Funds rate. In turn, the widening of the 12 month forward term spread is followed by cuts in the Fed funds rate over the next

[2] This "expectations channel" of monetary is explained in Blinder (1998), Bernanke (2004), Svensson (2004), and Woodford (2003, 2005).

several quarters.

Second, we find that an increase in the expected term spread feeds through eventually to an increased pace of capital flows through the cross-border operation of the global banks. We find evidence that cross-border claims of the BIS-reporting banks respond sensitively to the forward term spread, adding weight to the conclusion that the risk-taking channel channel of monetary operates through the balance sheet management of the global banks.

The combination of the theory and empirical evidence paints a consistent picture of the fluctuations in "global liquidity" and what role monetary policy has in moderating global liquidity. By identifying the mechanisms more clearly, we may hope that policy debates on the global spillover effects of monetary policy can be given a firmer footing. The recent BIS report on global liquidity (BIS (2011)) has served as a catalyst for further work in this area, and our paper can be seen as one component of the analytical follow-up to the report.

2 Background

2.1 Institutional Background

Understanding the institutional backdrop for the banking sector is important in addressing the link between capital flows and leverage. As well as being the world's most important reserve currency and an invoicing currency for international trade, the US dollar is the funding currency of choice for global banks. A recent BIS (2010) study notes that as of September 2009, the United States hosted the branches of 161 foreign banks who collectively raised over $1 trillion dollars' worth of wholesale bank funding, of which $645 billion was channeled for use by their headquarters. Money market funds in the United States are an important source of wholesale bank funding for global banks. Baba, McCauley and Ramaswamy (2009) note that by mid-2008, over 40% of the assets of U.S. prime money market funds were short-term obligations of foreign banks, with the lion's share owed by European banks.

Even in *net terms*, foreign banks have been channeling large amounts of dollar funding to head office. That is, the funding channeled to head office is much larger than the funding

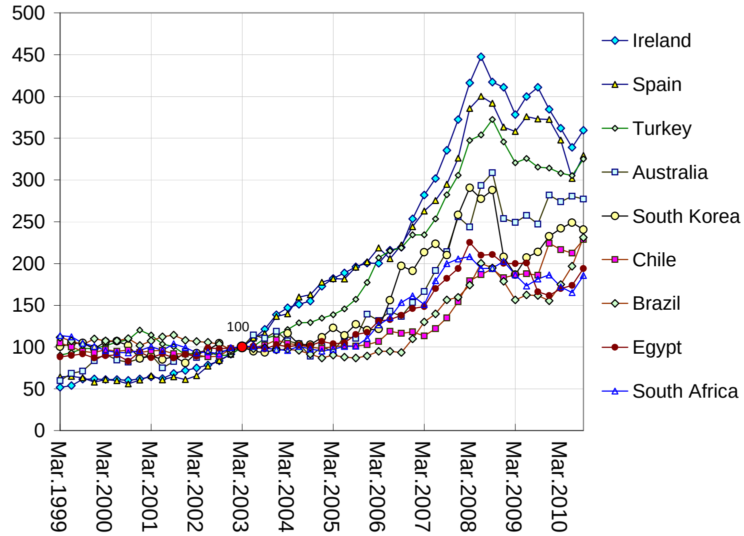


Figure 2. External claims (loans and deposits) of BIS reporting country banks on borrowers in countries listed. The series are normalized to 100 in March 2003 (Source: BIS Locational Banking Statistics, Table 7A)

received by the branch from head office. The BIS (2010) study finds that foreign bank branches had a net positive interoffice position in September 2009 amounting to $468 billion vis-à-vis their headquarters.

Some of the funds channeled to headquarters may be redirected to the US to finance the purchase of mortgage-backed securities and other assets. However, as noted by the BIS (2010) report, many banks use a centralized funding model in which available funds are deployed globally through a centralized portfolio allocation decision.[3]

Figure 2 plots the time series of the claims of the BIS reporting country banks on borrowers in countries listed on the right. The series have been normalized to equal 100 in March 2003. Although the borrowers have wide geographical spread, ranging from Australia, Chile, Korea and Turkey, there is a remarkable degree of synchronization in the boom in cross-border lending before the recent financial crisis.

[3]Cetorelli and Goldberg (2009, 2010) provide extensive evidence that internal capital markets serve to reallocate funding within global banking organizations.

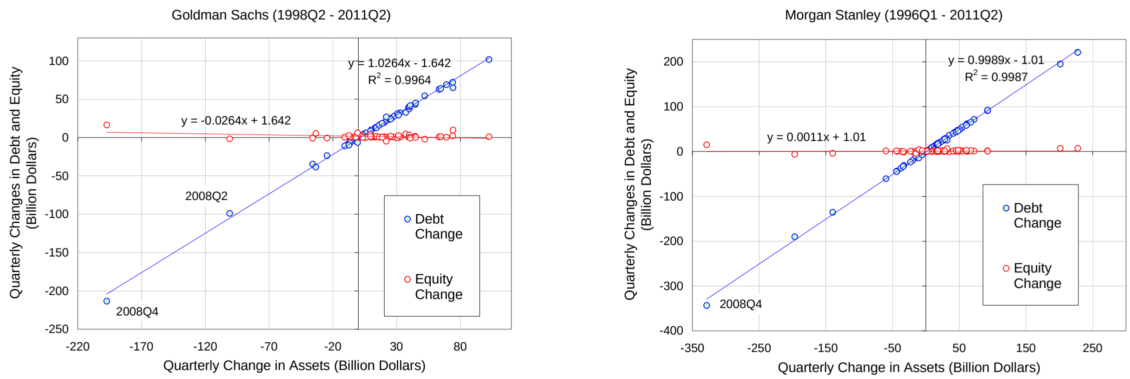


Figure 3. Scatter chart of quarterly changes in assets, equity and debt of Goldman Sachs and Morgan Stanley (Source: SEC 10Q filings)

2.2 Bank Leverage

Our model of the risk-taking channel is designed to capture some key attributes of bank balance sheet management, which depart in significant ways from standard models of portfolio choice. These departures turn out to be important in capturing the cyclical properties of capital flows.

Bank balance sheet management is illustrated in Figure 3 for Goldman Sachs and Morgan Stanley, the two US investment banks that came through the crisis unscathed. Figure 5 plots $\{(\Delta A_t, \Delta E_t)\}$ and $\{(\Delta A_t, \Delta D_t)\}$ where ΔA_t is the change in the banks' assets at quarter t, and where ΔE_t and ΔD_t are the change in equity and change in debt, respectively.

For both banks the fitted line through $\{(\Delta A_t, \Delta D_t)\}$ has slope very close to 1, meaning that the change in lending is met dollar for dollar by a change in debt, with equity remaining "sticky". The short-term nature of these institutions' assets and liabilities implies that book equity tracks closely the difference between the market value of assets and the market value of liabilities.[4] In this respect, Figure 5 yields insights on how market conditions influence balance sheet management.

[4]In contrast, market capitalization is the discounted value of free cash flows, and may differ from the gap between market values of assets and liabilities, for instance, due to fee income. The slopes of the two fitted lines add up to 1 in Figure 5 as a consequence of the balance sheet identity: $\Delta A_t = \Delta E_t + \Delta D_t$ and the additivity of covariance.

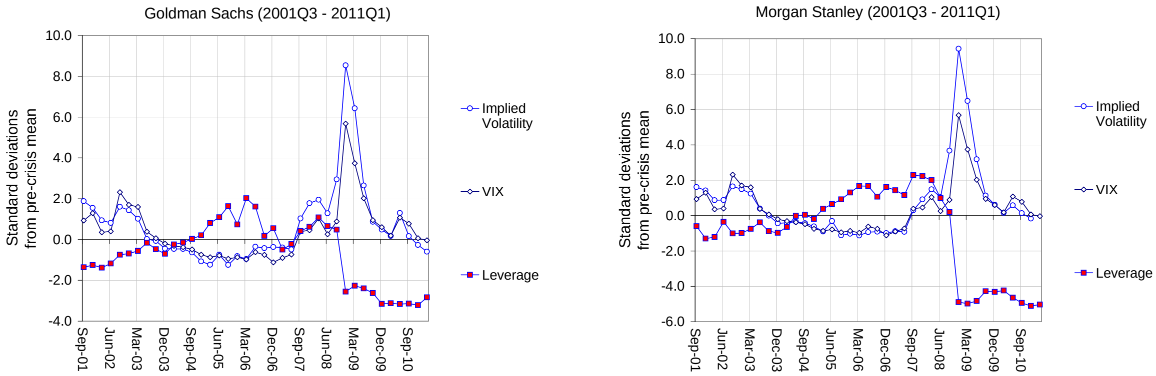


Figure 4. Plots of the VIX index, leverage of Goldman Sachs and Morgan Stanley and the implied volatility of their equity options. All series are measured as standard deviations from the mean during 2001Q3 - 2006Q4. (Source: SEC 10Q and CBOE)

Figure 4 plots the leverage of Goldman Sachs and Morgan Stanley through the crisis period. Leverage is measured in units of standard deviations from the mean during the period 2001Q3 - 2006Q4. Also plotted is the VIX index and the implied volatility embedded in the equity options of the two banks. All series are measured in standard deviations from the mean during 2001Q3 - 2006Q4. We see that leverage of both Goldman Sachs and Morgan Stanley increase in the period before the crisis, only to fall sharply with the onset of the 2008 crisis.

Adrian and Shin (2010, 2012) highlight the role of measured risks, and in particular the bank's Value-at-Risk (a quantile measure of potential losses) as a key determinant of the expansion or contraction of lending. They show that a good rule of thumb is that banks adjust lending in order to keep their probability of failure constant in the face of changing financial conditions. In periods of market stress, banks contract lending and shed risky exposures, while in tranquil conditions, banks expand lending.

In turn, the Value-at-Risk measures of individual banks move closely in step with fluctuations in measures of financial stress, most notably the VIX index, but also in spreads of individual bank credit default swaps (CDS) and the implied volatility of the banks' equity options. For this reason, the VIX index takes on particular significance in our empirical investigation which

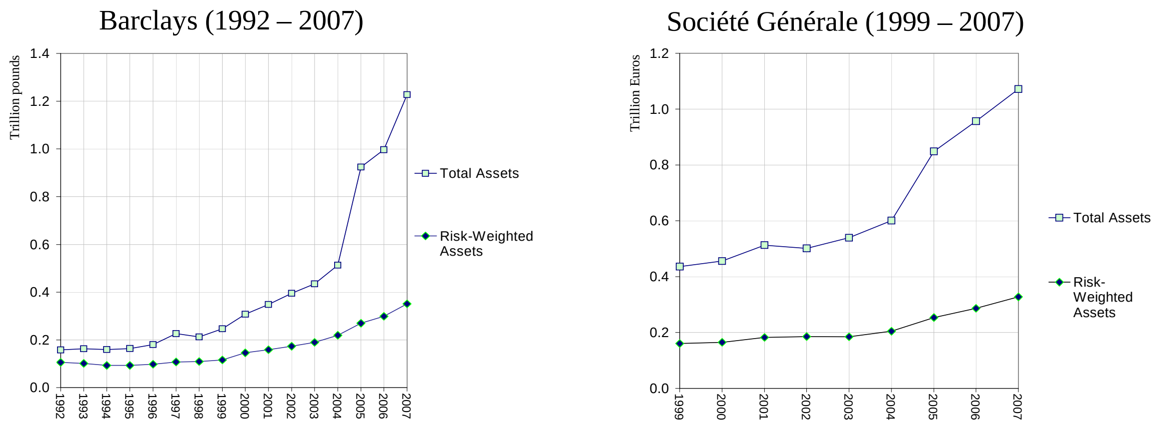


Figure 5. Total assets and risk-weighted assets of Barclays and Société Générale (Source: Bankscope)

follows.

A consequence of banks' model of balance sheet management is that leverage depends sensitively on the prevailing measured risks in the financial system. During tranquil times when measured risks are low, bank lending increases rapidly to use up the slack in lending capacity as suggested by the lower perceived risks. In effect, lending expands in tranquil times so that the bank's risk constraint binds *in spite of* the low measured risks. Borio and Disyatat (2011) have coined the term "excess elasticity" to describe the tendency of the banking system to expand when financial constraints are relaxed. Figure 5 illustrates such excess elasticity. It plots the total assets and risk-weighted assets of two typical European global banks - Barclays and Société Générale. Even as total assets were growing rapidly up to the eve of the crisis in 2007, the risk-weighted assets of the banks were growing moderately, reflecting the low levels of measured risks, and implying low levels of equity capital on the banks' balance sheets.

Our model of bank credit supply below is faithful to this empirical feature of bank balance sheet management, where asset increases are driven by lower credit risk and the corresponding increase in "balance sheet capacity". For risk-neutral profit maximizing banks, the balance sheet constraint binds all the time, so that in periods of low measured risks, balance sheets must

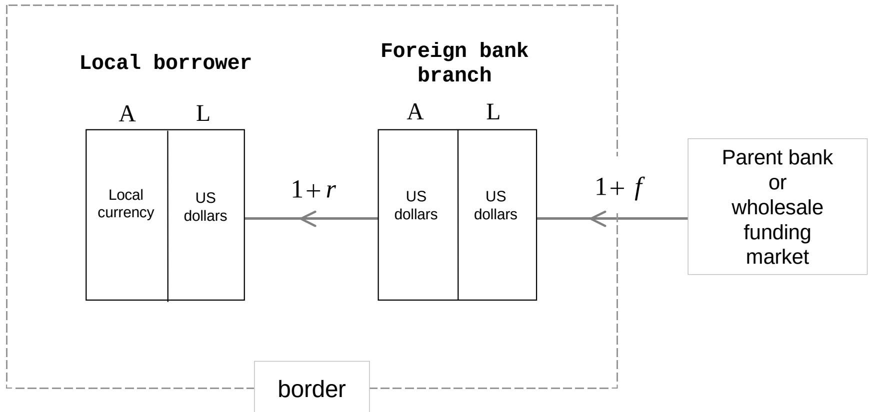


Figure 6. This figure depicts the lending relationships examined in the model. A foreign bank branch lends to local borrowers in dollars and finances its lending from the wholesale dollar funding market.

be large enough so that the risk constraint binds *in spite of* the low measured risks.[5]

3 Model

Our model is based on the relationships depicted in Figure 6. A foreign bank branch based in the capital flow-recipient economy lends to local borrowers in dollars and finances its lending either by borrowing from the wholesale dollar funding market, or by sourcing the funding from its parent. We describe each constituent of the model in more detail.

3.1 Local Borrowers

Local borrowers could be either household or corporate borrowers. For corporate borrowers, incurring liabilities in foreign currency is one way for exporting companies to hedge their future dollar export receivables. Even for non-exporters, borrowing in foreign currency is a means toward speculating on currency movements. For households, mortgage borrowing in foreign

[5]Adrian and Shin (2012) propose a micro-founded contracting model to explain the observed behavior. The model complements existing macro models of financial frictions where banks' lending constraint binds only in the downturn.

currency (Swiss francs and euros) was prevalent in Hungary and other coutnries in emerging Europe, often encouraged by subsidiaries of Western European banks that could fund themselves from their parents.

We model the local borrowers according to the Vasicek (2002) model of credit risk, which has served as the backbone of the Basel capital regulations (BCBS (2005)).

The value of the borrower's project in dollar terms at date 0 is denoted by V_0. Each borrower j has dollar-denominated debt with face value F, maturing at date T. The value of the borrower's project (in US dollar terms) at date T is denoted V_T, and is a lognormal random variable given by

$$V_T = V_0 \exp\left\{\left(\mu - \frac{s^2}{2}\right)T + s\sqrt{T}W_j\right\} \tag{1}$$

where W_j is a standard normal random variable. The borrower defaults when $V_T < F$.

The probability of default viewed from date 0 is

$$\begin{aligned}\text{Prob}\left(V_T < F\right) &= \text{Prob}\left(W_j < -\frac{\ln\left(V_0/F\right) + \left(\mu - \frac{s^2}{2}\right)T}{s\sqrt{T}}\right) &(2)\\ &= \Phi\left(-d_j\right) &(3)\end{aligned}$$

where $\Phi(.)$ is the c.d.f. of the standard normal and d is the *distance to default* in units of standard deviations of the standard normal W_j.

$$d = \frac{\ln\left(V_0/F\right) + \left(\mu - \frac{s^2}{2}\right)T}{s\sqrt{T}} \tag{4}$$

Denote by θ the value of the local currency in terms of dollars, so that an increase in θ corresponds to an appreciation of the domestic currency. The effect of currency appreciation is to shift the outcome density upward in Figure 7 so that the probability of default declines. We deal with currency appreciation in more detail below.

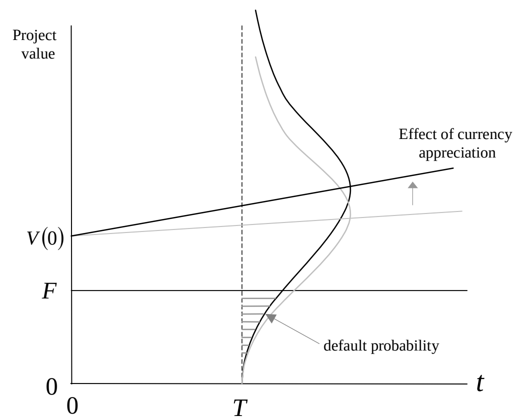


Figure 7. Project value V_T and notional debt F for local borrowers. The borrower defaults when V_T falls short of the notional debt F. The effect of a currency appreciation is to shift the outcome density upward, lowering the default probability.

3.2 Loan Portfolio of Banks

Banks provide dollar-denominated private credit (denoted C) to local borrowers at the rate $1+r$. We suppose that there is an infinitely elastic demand for dollar-denominated credit at the rate $1+r$, so that we may assume r to be fixed.

The private credit is funded by cross-border bank liabilities (denoted by L) drawn from wholesale markets or from the parent bank at the funding rate $1+f$. Both C and L are denominated in dollars.

Each bank has a well diversified loan portfolio consisting of loans to many borrowers. Credit risk follows the Vasicek (2002) model. We assume that the standard normal W_j defined in (2) can be written as the linear combination:

$$W_j = \sqrt{\rho} Y + \sqrt{1-\rho} X_j \tag{5}$$

where Y and $\{X_j\}$ are mutually independent standard normals. Y is the common risk factor while each X_j are the idiosyncratic component of credit risk for the particular borrower j. The parameter $\rho \in (0,1)$ determines the weight given to the common factor Y.

Then borrower j repays the loan when $Z_j \geq 0$, where Z_j is the random variable:

$$\begin{aligned} Z_j &= d_j + W_j \\ &= d_j + \sqrt{\rho}Y + \sqrt{1-\rho}X_j \end{aligned} \tag{6}$$

where d_j is the distance to default of borrower j. The probability of default by borrower j is $\Phi(-d_j)$. Let ε be the probability of default. Hence, borrower j repays the loan when $Z_j \geq 0$ where

$$Z_j = -\Phi^{-1}(\varepsilon) + \sqrt{\rho}Y + \sqrt{1-\rho}X_j \tag{7}$$

Private credit extended by the bank is C at interest rate r so that the notional value of assets (the amount due to the regional bank at date 1) is $(1+r)C$. Conditional on Y, defaults are independent. Taking the limit where the number of borrowers becomes large while keeping the notional assets fixed, the realized value of the bank's assets can be written as a deterministic function of Y, by the law of large numbers. The realized value of assets at date 1 is the random variable $w(Y)$ defined as:

$$\begin{aligned} w(Y) &\equiv (1+r)C \cdot \Pr(Z_j \geq 0|Y) \\ &= (1+r)C \cdot \Pr\left(\sqrt{\rho}Y + \sqrt{1-\rho}X_j \geq \Phi^{-1}(\varepsilon)|Y\right) \\ &= (1+r)C \cdot \Phi\left(\frac{Y\sqrt{\rho}-\Phi^{-1}(\varepsilon)}{\sqrt{1-\rho}}\right) \end{aligned} \tag{8}$$

Figure 8 plots the densities over asset realizations, and shows how the density shifts to changes in the default probability ε (left hand panel) or to changes in ρ (right hand panel). Higher values of ε imply a first degree stochastic dominance shift left for the asset realization density, while shifts in ρ imply a mean-preserving shift in the density around the mean realization $1-\varepsilon$.

From here on, we will assume that ε is a small number, and in particular, $\varepsilon < 0.5$. The

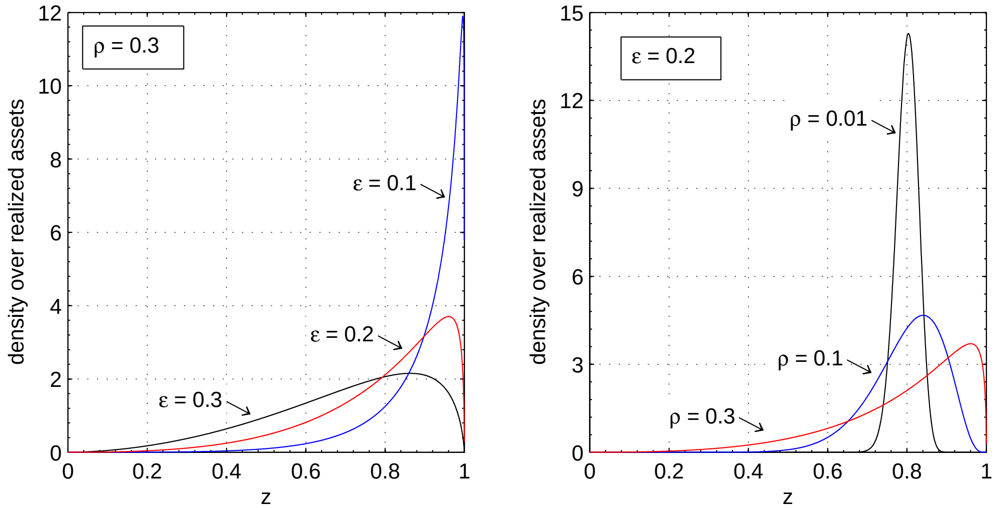


Figure 8. The two charts plot the densities over realized assets when $C(1+r) = 1$. The left hand charts plots the density over asset realizations of the bank when $\rho = 0.1$ and ε is varied from 0.1 to 0.3. The right hand chart plots the asset realization density when $\varepsilon = 0.2$ and ρ varies from 0.01 to 0.3.

c.d.f. of the realized value of the loan portfolio at the terminal date is given by

$$\begin{aligned} F(z) &= \Pr(w \leq z) \\ &= \Pr\left(Y \leq w^{-1}(z)\right) \\ &= \Phi\left(w^{-1}(z)\right) \\ &= \Phi\left(\frac{1}{\sqrt{\rho}}\left(\Phi^{-1}(\varepsilon) + \sqrt{1-\rho}\,\Phi^{-1}\left(\frac{z}{(1+r)C}\right)\right)\right) \end{aligned} \tag{9}$$

Assume that the regional bank follows the Value-at-Risk (VaR) rule of keeping enough equity to limit the insolvency probability to $\alpha > 0$. The bank is risk-neutral otherwise. The bank's objective is to maximize expected profit subject only to its Value-at-Risk constraint. The bank remains solvent as long as the realized value of $w(Y)$ is above its notional liabilities at date 1. Since the funding rate on liabilities is f, the notional liability of the bank at date 1 is $(1+f)L$. The bank grants private credit C so that its VaR constraint just binds.

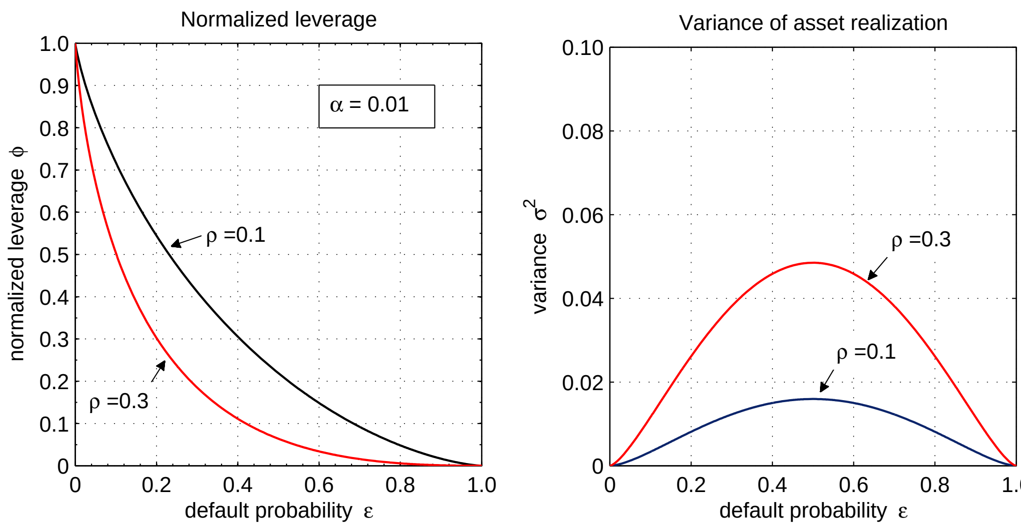


Figure 9. Left hand panel plots the normalized leverage ratio φ as a function of ε. The right hand panel plots the variance σ^2 as a function of epsilon for two values of ρ.

$$\Pr\left(w < (1+f)\,L\right) = \Phi\left(\frac{\Phi^{-1}(\varepsilon)+\sqrt{1-\rho}\,\Phi^{-1}\left(\frac{(1+f)L}{(1+r)C}\right)}{\sqrt{\rho}}\right) = \alpha \tag{10}$$

Re-arranging (10), we can write the ratio of notional liabilities to notional assets as follows.

$$\frac{\text{Notional liabilities}}{\text{Notional assets}} = \frac{(1+f)\,L}{(1+r)\,C} = \Phi\left(\frac{\sqrt{\rho}\Phi^{-1}(\alpha) - \Phi^{-1}(\varepsilon)}{\sqrt{1-\rho}}\right) \tag{11}$$

We will use the shorthand:

$$\varphi(\alpha,\varepsilon,\rho) \equiv \Phi\left(\frac{\sqrt{\rho}\Phi^{-1}(\alpha)-\Phi^{-1}(\varepsilon)}{\sqrt{1-\rho}}\right) \tag{12}$$

Clearly, $\varphi \in (0,1)$. Denote by σ^2 the variance of $w(Y)/C(1+r)$. In the appendix, we show[6] that the variance σ^2 is given by

$$\sigma^2 = \Phi_2\left(\Phi^{-1}(\varepsilon), \Phi^{-1}(\varepsilon); \rho\right) - \varepsilon^2 \tag{13}$$

[6]See Vasicek (2002), which states this and other results for the asset realization function $w(Y)$.

where $\Phi_2(\cdot, \cdot; \rho)$ is the cumulative bivariate standard normal with correlation ρ. The right hand panel of Figure 9 plots the variance σ^2 as a function of ε. The variance is maximized when $\varepsilon = 0.5$, and is increasing in ρ. The left hand panel of Figure 9 plots the ratio of notional liabilities to notional assets φ as a function of ε.

From (11) and the balance sheet identity $E + L = C$, we can solve for the bank's supply of private credit. When private credit supply is positive, we have

$$C = \frac{E}{1 - \frac{1+r}{1+f} \cdot \varphi} \tag{14}$$

Note that C is proportional to the bank's equity E, and so (14) also denotes the *aggregate* supply of private credit when E is the *aggregate* equity of the banking sector. The leverage of the bank (and the sector) is the ratio of assets to equity, and is

$$\text{Leverage } = \frac{1}{1 - \frac{1+r}{1+f} \cdot \varphi} \tag{15}$$

On the liabilities side of the balance sheet, the banks' demand for cross-border funding L can be solved from (11) and the balance sheet identity $E + L = C$.

$$L = \frac{E}{\frac{1+f}{1+r} \cdot \frac{1}{\varphi} - 1} \tag{16}$$

3.3 Risk-Taking Channel of Monetary Policy

We are now ready to examine the impact of monetary policy through changes in the bank funding cost f.

In conducting our comparative statics exercise, we assume that greater capital inflows through the banking sector (i.e. higher L) will put upward pressure on the exchange rate.

Assumption 1. θ is increasing in L.

We will take the bank funding rate f as given and conduct comparative statics analysis with respect to changes in f. A more sophisticated treatment of the funding rate f would have been

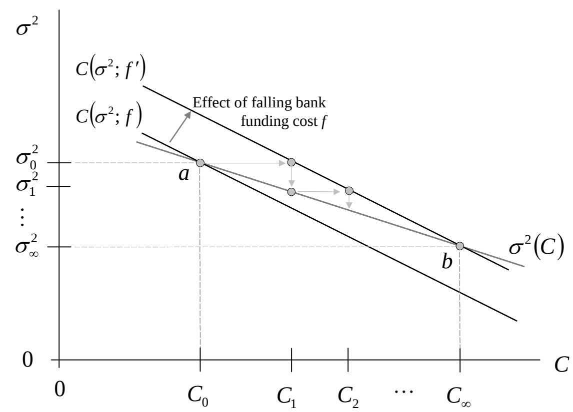


Figure 10. Impact of a decline in bank funding cost f consisting of the initial impact and the amplification effect.

to model the lending behavior of the global banks for whom f is the lending rate in wholesale funding markets. See Bruno and Shin (2011) for such an analysis.

Consider a fall in the funding cost f. The impact of this fall in funding cost can be decomposed into the *initial impact* and the *amplification effect*. Figure 10 illustrates the two effects. The initial impact of the cut in funding cost f is depicted by the rightward pointing arrow in Figure 10. There is an increase in lending from C_0 to C_1 following the solution for bank credit supply given by (14). However, the increase in lending is mirrored on the liabilities side by an increase in L, as given by (16). In other words, a lowering of bank funding cost results in the increased capital inflow through the banking sector, as given by a larger L.

Then, from Assumption 1, the increase in L results in an appreciation in the exchange rate θ. Denote by $G(z)$ the c.d.f. of the borrowers' project realization depicted in Figure 7, where the c.d.f. is given in local currency terms. Then, in US dollar terms, the project realization c.d.f. is given by

$$G\left(\frac{z}{\theta}\right) \tag{17}$$

Therefore, an appreciation of the currency (increase in θ) results in a first-degree stochastic shift of the outcome density as illustrated in Figure 7, resulting in a fall in the default probability. If we denote by ε' the default probability with currency appreciation and ε the default probability without currency appreciation, we have

$$\varepsilon' < \varepsilon < 0.5 \tag{18}$$

The decline in the default probability ε sets in motion the amplification mechanism where bank lending increases through an increase in φ, which implies even greater capital inflows through L, which then results in further declines in the default probability ε. Since the variance σ^2 of the asset realization is increasing in the default probability ε for $\varepsilon < 0.5$, we can state the amplification mechanism in terms of the mutually reinforcing effect of greater lending C financed with greater capital inflows L, which dampens the volatility of outcome, which in turn creates spare lending capacity of the banks.

The stepwise adjustment process depicted in Figure 10 illustrates the amplification mechanism. Greater risk-taking by banks results in dampened volatility, which in turn leads to even further risk-taking. The circular diagram we had at the outset of the paper (Figure 1) has its counterpart in Figure 10. The stepwise adjustment is in logical time, as in our model, as our model is a static one. However, the stepwise adjustment process is useful in thinking through the interaction effects.

Formally, we can write $C(\sigma^2; f)$ as the total lending by the banking sector as a function of σ^2, with the funding rate f as a parameter. In turn, the variance of asset realization σ^2 can be written as a function of total lending C, since C determines the banking sector liabilities L and hence the exchange rate θ. Thus, the equilibrium is given by the solution to the pair of equations:

$$\begin{cases} C = C(\sigma^2; f) \\ \sigma^2 = \sigma^2(C) \end{cases} \tag{19}$$

Both relationships are downward-sloping, so that a decline in the funding cost f can result in substantial shifts in total lending and volatility.

To gauge the comparative statics, begin with the expression for credit supply C given by (14). Taking the derivative of C with respect to the funding rate f, we have

$$\frac{dC}{df} = -\frac{C}{\frac{1+f}{1+r}\frac{1}{\varphi} - 1}\left[\frac{\varphi'(\varepsilon)}{\varphi}\frac{d\varepsilon}{dC} \cdot \frac{dC}{df} - \frac{1}{1+f}\right] \tag{20}$$

Solving for the elasticity in credit supply with respect to the gross funding rate $1+f$,

$$\frac{dC}{df}\frac{1+f}{C} = -\frac{1}{\frac{1+f}{1+r}\frac{1}{\varphi} - \left(1 + C \cdot \frac{\varphi'}{\varphi}\frac{d\varepsilon}{dC}\right)} \tag{21}$$

The term associated with the risk-taking channel is $d\varepsilon/dC$, which can be unpacked as follows:

$$\begin{aligned}\frac{d\varepsilon}{dC} &= \frac{d\varepsilon}{d\theta} \cdot \frac{d\theta}{dL} \cdot \frac{dL}{dC} \\ &= \frac{dG(z^*/\theta)}{d\theta} \cdot \frac{d\theta}{dL} \\ &= -\frac{z^*}{\theta^2} \cdot g\left(\frac{z^*}{\theta}\right) \cdot \frac{d\theta}{dL}\end{aligned} \tag{22}$$

where $g(.)$ is the density over project outcomes for the borrowers and z^* is the default threshold in domestic currency terms. Note that $dL/dC = 1$ from the balance sheet identity with fixed equity.

The amplification effect associated with a decline in bank funding rate f can be seen from (21). With feedback, the impact of a fall in bank funding cost is magnified by the decline in measured risks associated with currency appreciation.

It is worth noting that the amplification associated with the risk-taking channel is distinct from the more commonly discussed "carry trade" phenomenon that exploits interest rate differences across currencies. The risk-taking channel works through the feedback loop from greater

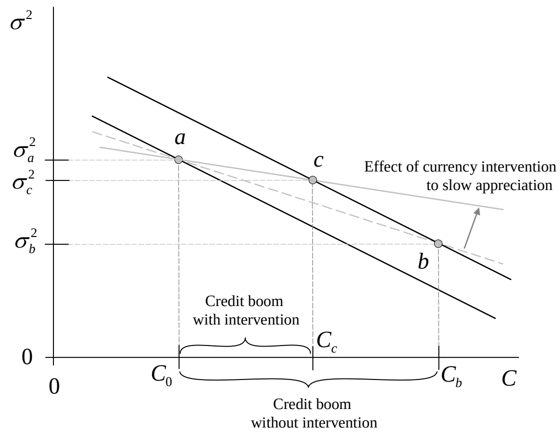


Figure 11. Effect of intervention to mitigate currency appreciation

risk-taking to the dampening of measured risks. It would have been possible to interpret θ as an asset price, rather than the exchange rate, and have the risk-taking channel take effect in a purely domestic context.

3.4 Effect of Currency Intervention

A key quantity that determines the magnitude of the amplification effect is the sensitivity of the exchange rate θ to capital inflows. A large appreciation of the exchange rate relative to the increase in L translates into a large decline in the probability of default ε, and hence a large decline in the measured risks of lending. As such, intervention in the currency market that can mitigate or slow the rate of currency appreciation may play a role in mitigating the effects of global liquidity driven by a fall in bank funding costs.

Figure 11 illustrates the effect of currency intervention. The economy starts at point a and experiences a decline in funding cost f. With no intervention, the economy shifts to point b, implying a large increase in lending financed by large capital inflows, and a commensurate decline in measured risks σ^2. However, when currency intervention limits the appreciation of the currency, the balance sheet effect for the borrowers is dampened, leading to a smaller credit boom, smaller capital inflows and only a moderate decrease in measured risks.

The effect illustrated in Figure 11 does not take account of the long run fundamentals for the economy. However, if there are suspicions that the sharp appreciation of the currency is driven by short-term distortions in global capital markets driven by excessive risk-taking by banks, then intervention to mitigate those distortions may be justified.

Intervention in the currency market is not the only way to “lean against the wind” of global liquidity. Direct macroprudential policy tools that either restrain lending (restrain C), or to impose a levy on foreign currency-denominated banking sector liabilities (restrain L) as is the policy in Korea, are alternatives to intervention in the currency market.

4 Empirical Analysis

We now move to an empirical analysis that examines whether (and to what extent) dollar funding costs determine banking sector cross-border capital flows. We consider a four-variable vector autoregression (VAR) examining the dynamic relationship between the VIX index of implied volatility on equity index options, the forward term premium between the 10 year and 3 month US treasury rates, the target Feds Funds rate of the Federal Reserve, and aggregate cross-border banking sector flows given by the growth in the total cross-order loans and deposits of the BIS reporting banks. Our focus is on the period before the crisis in order to examine the workings of the risk-taking channel on the up-swing of the global liquidity cycle. We use quarterly data from the last quarter of 1995 to the third quarter of 2007. The fourth quarter of 1995 is the first available quarter for the capital flows data that we use (BIS locational statistics, Table 7A) and the third quarter of 2007 was chosen to mark the beginning of the financial crisis. Our choice of sample period also helps to compare our results to those of Bekaert et al. (2010), who also used data up to the crisis.

The Fed Funds rate is computed for the end of the quarter as the target Fed Fund rate minus the CPI inflation rate ($FEFU$). The Fed Funds target rates are obtained from the St. Louis Fed website (FRED) and the Consumer Price Indexes are from the Bureau of Labor statistics website. We use the end of the quarter Chicago Board Options Exchange (CBOE) Volatility

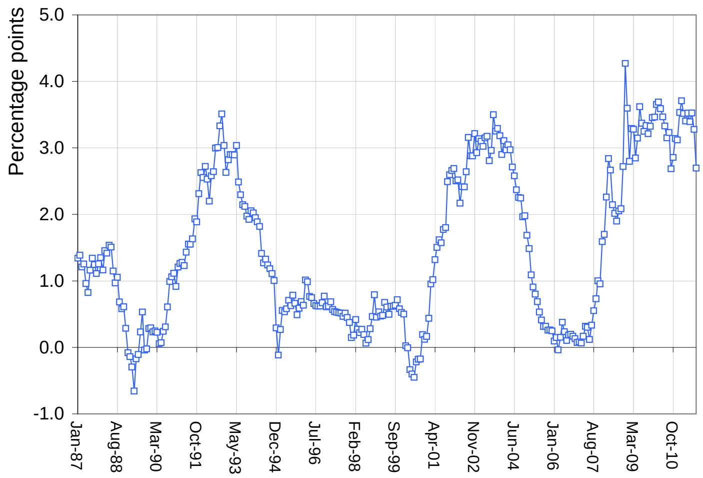


Figure 12. Twelve month forward term premium between 10 year and 3 month US Treasury rates. The series is computed following the methodology of Gurkaynak, Sack, and Wright (2006)

Index (VIX) for the implied annualized volatility in the S&P500 stock index options. We work with the log of VIX. We use the 12 months forward rate for the US Treasury 10 year - 3 month spread computed by Gurkaynak, Sack, and Wright (2006), and updated using their methodology. This series is plotted in Figure 12.

Our measure of aggregate banking sector capital flows is the log difference of the external loans and deposits of BIS reporting banks (denoted as $LOANS$) obtained from the BIS locational statistics data (Table 7A). The key organizational criteria of the BIS locational statistics data are the country of residence of the reporting banks and their counterparties as well as the recording of all positions on a gross basis, including those with respect to their own affiliates. This methodology is consistent with the principles underlying the compilation of national accounts and balance of payments, thus making the locational statistics appropriate for measuring capital flows in a given period. Table 1 provides summary statistics of our variables.

Some insight into the relationship between monetary policy and the risk-taking channel can be illustrated by examining the cross-correlations between the forward term premium and the

Table 1. **Summary Statistics** This table summarizes our key variables in terms of their number of observations, mean, standard deviation, minimum and maximum.

Variable	Obs	Mean	Std. Dev.	Min	Max
VIX	47	20.52	6.85	11.39	40.95
FTP	47	1.11	1.11	-0.34	3.29
FEFU	47	1.46	1.76	-2.02	4.13
LOANS	47	2.51%	3.33%	-6.49%	9.87%

VIX index. Table 2 provides the cross-correlogram between VIX and FTP, which plots the cross-correlation between the log of the VIX and the 12 month forward term premium i quarters ahead (columns on the left) and for the cross-correlation between the 12 month forward term premium and the log of the VIX i quarters ahead (columns on the right). The length of horizontal bars indicate level of significance for the cross-correlations.

The message from Table 2 is that monetary policy both *reacts to* but also *has an impact on* the volatility in the capital markets. The left side of Table 2 shows that today's VIX is highly correlated with current and future forward term premiums, indicating that the market expects the yield curve to steepen. We will verify shortly that the term premium increases through a decline in the target Fed Funds rate through an easing of monetary policy. In other words, any spike in the VIX gives rise to expectations of easing of monetary policy.

The columns on the right hand side of Table 2 indicate that such easing of monetary policy eventually has the effect of quelling market turbulence. That is, we see that the cross-correlation between the forward term premium today and the future values of the VIX are negative and highly significant. The maximum impact comes around 9 quarters later.

Taken together, the initial evidence in Table 2 suggests an intimate link between monetary policy and market volatility. Monetary policy both reacts to volatility, but it also has an impact on the volatility, by soothing market distress. These correlograms are analogous to those of Bekaert et al. (2010) who examined the relationship between the Fed Funds rate and the VIX, who also find that monetary policy both reacts to, but also has an impact on volatility.

Table 2. **Cross-correlogram of VIX and FTP.** The length of horizontal lines indicate level of significance for the cross-correlation between the log of the VIX and the 12 month forward term premium i quarters ahead (left columns) and for the cross-correlation between the 12 month forward term premium and the log of the VIX i quarters ahead (right columns).

VIX, FTP $(+i)$			FTP, VIX $(+i)$		
	i			i	
——	0	0.4132		0	0.0284
——	1	0.4540		1	-0.0928
——	2	0.4720	-	2	-0.1925
——	3	0.4556	–	3	-0.3004
——	4	0.4115	——	4	-0.4361
——	5	0.3838	——-	5	-0.5481
–	6	0.3555	———	6	-0.628
–	7	0.2814	———	7	-0.7339
–	8	0.2617	————	8	-0.7716
-	9	0.2163	————	9	-0.7767
-	10	0.2226	———	10	-0.7176
-	11	0.1842	———	11	-0.6544
-	12	0.1648	——-	12	-0.5752
-	13	0.1934	——-	13	-0.5007
-	14	0.2019	——	14	-0.4117
-	15	0.2019	–	15	-0.3436
-	16	0.1973	–	16	-0.2631
-	17	0.1657	-	17	-0.1944
-	18	0.1643		18	-0.1190
	19	0.098		19	-0.0409

4.1 Identification

In order to explore the dynamic relationships in our sample, we conduct an empirical investigation using a vector autoregression (VAR). We examine vector autoregressions involving the four series *LOANS, FEFU, VIX and FTP,* where *LOANS* is the external claims of BIS reporting banks, *FEFU* is the real Fed Funds target rate, *VIX* is the VIX volatility index, and *FTP* is the 12 months forward term premium. We consider the structural VAR $A(L)y_t = \varepsilon_t$, where $A(L)$ is a matrix of polynomial in the lag operator L, y_t is the data vector and ε_t is a vector of orhogonalized distrurbances.

Formal lag selection procedures (the Akaike information criterion (AIC), the Hannan and Quinn information criterion (HQIC) and the Bayesian information criterion (BIC)) suggest one or three lags. However, the Lagrange multiplier test for autocorrelation in the residuals of the VAR shows that only the model with two lags eliminates all serial correlation in the residuals. We therefore choose two lags. For a stable VAR model we want the eigenvalues to be less than one and the formal test confirms that all the eigenvalues lie inside the unit circle. The choice of only two lags is also motivated by the need for a parsimonius system given our relatively small sample of quarterly observations (47 quarters). Longer lags may also create instability in the impulse-response functions.

We obtain structural identification by imposing a Cholesky decomposition of the estimate of the variance-covariance matrix. We impose the Cholesky restrictions by applying the following exclusion restrictions on contemporaneous responses in the matrix A to fit a just-identified model:

$$A = \begin{bmatrix} a_{11} & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix}$$

Of our four variables, two are market prices - VIX and the forward term premium - which adjust instantaneously to news. As such, they should be modeled as depending on the contemporaneous values of the two slower-moving series - the Fed Funds target rate and the capital flows in the previous quarter given by the *LOANS* variable. Thus, we order *FTP* and *VIX* below *LOANS* and *FEFU.* The ranking between *LOANS* and *FEFU,* is motivated by the fact that *LOANS* reflect capital flows over the previous quarter, so that it can be seen as being the most sluggish of our four series. The Fed Funds target rate will have been chosen some time before the end of the quarter, and so we rank *FEFU* as being second.

However, the choice in ranking between the two price variables - *FTP* and *VIX* - is more difficult, as both are market prices that adjust instantaneously. For this reason, we run two separate VAR analyses, where we examine both orderings of *FTP* and *VIX.* Thus, our two analyses of structural VAR runs are as follows:

- The first structural VAR has the ordering *LOANS, FEFU, VIX, FTP* and the impulse responses are presented in Figure 13.
- Our second structural VAR has the ordering *LOANS, FEFU, FTP, VIX* and the impulse responses are presented in Figure 14.

We compute bootstrapped confidence intervals based on 1000 replications. Given our relative small number of quarterly observations, we make the small-sample adjustment when estimating the variance-covariance matrix of the disturbances.

4.2 Evidence from Structural VAR

Figures 13 and 14 give our main empirical findings through the orthogonalized impulse-response functions (IRFs) of the variables included in the SVAR, along with 90 percent confidence bands. Each box of the tables gives the impulse responses over 20 quarters to a one-standard-deviation variable shock identified in the first column. The responding variables are listed in the first row. Figure 13 shows the results relative to the order (*LOANS*, *FEFU*, *VIX*, *FTP*) whereas Figure 14 refers to the order (*LOANS*, *FEFU*, *FTP, VIX*).

In Figure 13 we first note that the impulse response functions of *FEFU* (impulse) to *VIX* (response) confirm the evidence found in Bekaert et al. (2010) that a contractionary monetary

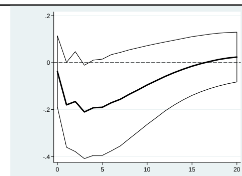
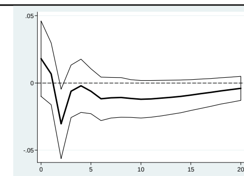
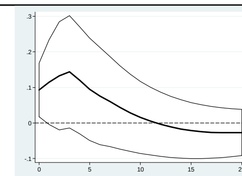
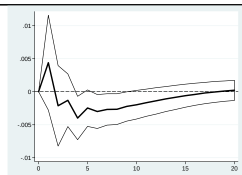
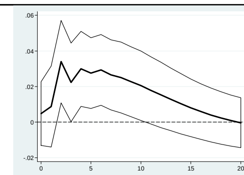
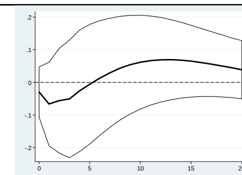
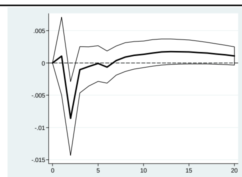
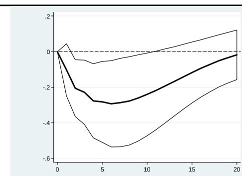
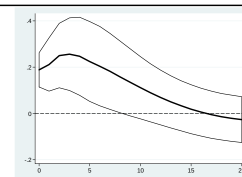
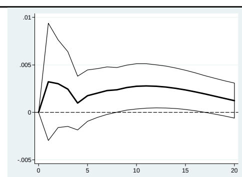
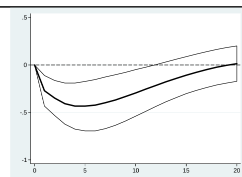
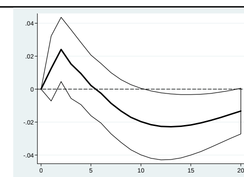
Structural VAR	Cholesky ordering 1	2	3	4
Impact of (↓)	On LOANS	On Fed Funds	On VIX	On FTP
LOANS				
Fed Funds				
VIX				
FTP				

Figure 13. **Impulse response functions in Structual VAR.** This figure presents estimated structural impulse-response functions for the four variable structual VAR (LOANS, FEFU, VIX, FTP) and 90 percent bootstrapped confidence intervals for the model with two lags, based on 1000 replications.

policy shock leads to an increase in the *VIX* after 2 quarters and remains significant until quarter 10.[7] A positive shock to the Fed Funds rate also decreases banking sector capital flows by a maximum of 0.4% in quarter 4, although the impact is only marginally significant in quarter 4 and between quarters 6 and 9.

A positive shock to *VIX* has a significant impact on *FTP*, *FEFU*, and *LOANS*. In particular, the shock to volatility increases the forward term premium for up to 8 quarters, with a maximum impact of 25 basis points in the third quarter. In other words, a shock to *VIX* leads to expectations of a steeper yield curve 12 months ahead. When we examine the impact of the FTP shock to the target Fed Funds rate, we see that the steepening of the yield curve is achieved primarily through the lowering of the target Fed Funds rate. In this way, the increase in market distress leads immediately to expectations of a more accommodative monetary policy. The effect can be seen in the increase in the forward term premium, as well as a cut in the Fed Funds rate from quarter 2 to quarter 10, with maximum of 29 basis points after 6 quarters. The impact on the cross-border banking sector capital flows happens after 2 quarters and dissipates quickly afterwards. In periods of heightened market stress, banks contract lending by almost 1 percent at a quarterly rate, which is a sizeable contraction relative to the average growth of lending of 2.5% every quarter.

As for the 12 month forward premium (*FTP*), the impact on the *VIX* is positive and significant in quarter 2 and then it becomes negative and significant after 11 quarters. The impact on the real Fed Funds target rate follows a similar pattern of the *VIX* impulse, with a significant negative impact from quarter 1 to quarter 11 and with a maximum of 43 basis points in quarter 5. The impact on *LOANS* is positive (0.3% maximum) and significant between quarters 8 to 17. Finally, when *LOANS* is the impulse variable, we observe a feedback effect on *VIX* in quarter 2 and on *FEFU* in quarter 3.

The above results are confirmed in Figure 14, where the ordering of the VIX and forward term premium are reversed. We see that the main themes in Figure 13 are preserved in this

[7] Bekaert et al. (2010) find that the impact of the real rate on risk-adversion becomes significant after 4 months and remains significant till month 34.

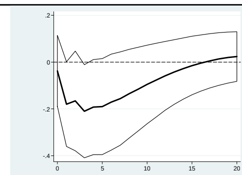
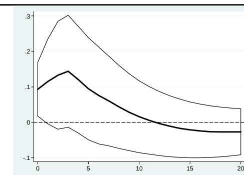
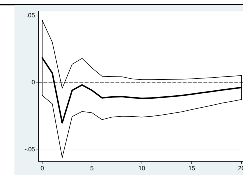
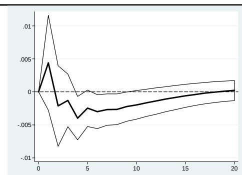
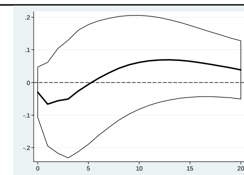
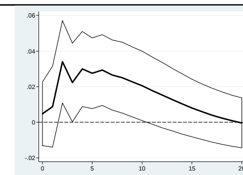
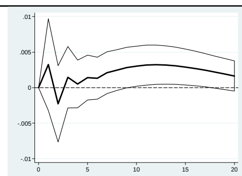
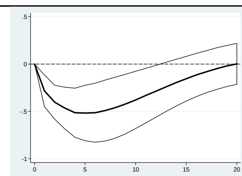
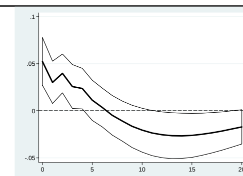
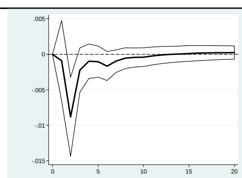
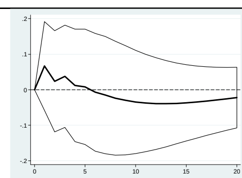
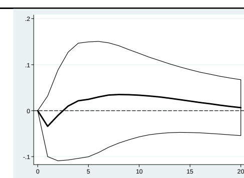
Structural VAR	Cholesky ordering 1	2	3	4
Impact of (↓)	On LOANS	On Fed Funds	On FTP	On VIX
LOANS				
Fed Funds				
FTP				
VIX				

Figure 14. **Impulse response functions in Structual VAR.** This figure presents estimated structural impulse-response functions for the four variable structual VAR (LOANS, FEFU, FTP, VIX) and 90 percent bootstrapped confidence intervals for the model with two lags, based on 1000 replications.

run of the VAR both in the relevant significant quarters and magnitude of the economic impact. The one exception is the impulse response functions of *VIX* (impulse) on *FEFU* (response) and on *FTP* (response) which are no longer significant. The Cholesky's decomposition seems to be sensitive to the ordering of *VIX* and *FTP* variables only for these specific impulse response functions. Taken together, we can summarize our findings in Figures 13 and 14 as follows.

- The widening of the 12 month forward term premium is followed by cuts in the Fed Funds rate after one quarter and lasting over several months
- The cross-border claims of the BIS-reporting banks respond sensitively to shocks to the forward term spread, the VIX, and Fed Funds rate. In this sense, global liquidity and US monetary policy is intimately linked.
- The economic magnitude of the impact is larger when the VIX is the impulse, which suggests that the VIX is the primary channel of transmission.

5 Concluding Remarks

The evidence in our paper suggests that the driving force behind banking sector capital flows is the leverage cycle of the global banks. Furthermore, credit growth in the recipient economy is explained, in part, by the fluctuations in global liquidity that follow the leverage cycle of the global banks. Our findings reinforce the argument in Borio and Disyatat (2011) on the importance of *gross* capital flows between countries in determing financial conditions, rather than *net* flows. Gross flows, and in particular measures of banking sector liabilities should be an important source of information for risk premiums and hence financial sector vulnerability.[8] We conclude with some remarks on measuring global liquidity.

The distinction between core and non-core bank liabilities depends on the particular economy and the context of financial development. For advanced economies with developed debt markets, non-core liabilities will include non-deposit funding that is raised in the wholesale bank funding

[8]See Shin and Shin (2010) and Hahm, Shin and Shin (2011) for empirical analyses of this issue.

market, such as repos or financial commercial paper. We may conjecture that core liabilities, such as retail deposits, are more stable (or "sticky") than non-core liabilities.

For financial systems at an early stage of development or where the banking sector is restricted by regulation from having access to the global banking system, the distinction between core and non-core liabilities will fall within M2, depending on who holds the claim. When the domestic banking sector is mostly closed, it may be more meaningful to decompose M2 itself into its core and non-core components. The non-core component of deposits then may includes the deposits of non-financial companies who end up recycling funding within the economy and hence become integrated into the intermediary sector itself. China and India are two examples where this distinction between core and non-core liabilities may be usefully employed.

The detailed classifications will need to build on further analytical study of the attributes of various funding aggregates of the intermediary sector. For countries with open capital markets, international capital flows into the banking sector will be key indicators of financial vulnerability. For countries with relatively closed financial systems, where domestic banks do not have ready access to funding provided by the global banking system, a better approach would be to adapt existing conventional monetary aggregates to address financial stability concerns. The distinction between household retail deposits and corporate deposits in the banking sector could play an important role in this regard.

Appendix

In this appendix, we present the derivation of the variance of the normalized asset realization $\hat{w}(Y) \equiv w(Y)/(1+r)C$ in Vasicek (2002). Let $k = \Phi^{-1}(\varepsilon)$ and $X_1, X_2, \cdots, X_n$ be i.i.d. standard normal.

$$\begin{aligned}
E\left[\hat{w}^n\right] &= E\left[\left(\Phi\left(\tfrac{Y\sqrt{\rho}-k}{\sqrt{1-\rho}}\right)\right)^n\right] \\
&= E\left[\prod_{i=1}^n \Pr\left[\sqrt{\rho}Y + \sqrt{1-\rho}X_i > k \middle| Y\right]\right] \\
&= E\left[\Pr\left[\sqrt{\rho}Y + \sqrt{1-\rho}X_1 > k, \ldots, \sqrt{\rho}Y + \sqrt{1-\rho}X_n > k \middle| Y\right]\right] \\
&= \Pr\left[\sqrt{\rho}Y + \sqrt{1-\rho}X_1 > k, \ldots, \sqrt{\rho}Y + \sqrt{1-\rho}X_n > k\right] \\
&= \Pr\left[Z_1 > k, \ldots, Z_n > k\right]
\end{aligned}$$

where $(Z_1, \ldots, Z_n)$ is multivariate standard normal with correlation ρ. Hence

$$E\left[\hat{w}\right] = 1 - \varepsilon$$

and

$$\begin{aligned}
\operatorname{var}\left[\hat{w}\right] &= \operatorname{var}\left[1 - \hat{w}\right] \\
&= \Pr\left[1 - Z_1 \le k, 1 - Z_2 \le k\right] - \varepsilon^2 \\
&= \Phi_2\left(k, k; \rho\right) - \varepsilon^2 \\
&= \Phi_2\left(\Phi^{-1}(\varepsilon), \Phi^{-1}(\varepsilon); \rho\right) - \varepsilon^2
\end{aligned}$$

where $\Phi_2(\cdot, \cdot; \rho)$ cumulative bivariate standard normal with correlation ρ.

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Discussion of Valentina Bruno and Hyun Song Shin, "Capital Flows and the Risk-Taking Channel of Monetary Policy" *

Lars E.O. Svensson[1]

Valentina Bruno and Hyun Song Shin (2012) have contributed a very interesting and thought-provoking paper to this conference. They set up a model of an advanced economy (AE) where a parent bank lends in dollars to a local branch in an emerging economy (EE). The local branch then lends in dollars to EE borrowers. They show that a lower interest rate in the AE, all else equal, leads to an increased capital flow into the EE. The increased capital inflow in turn leads to an appreciation of the EE's currency, which improves the balance sheets of EE borrowers and leads to an amplified capital inflow. They also provide some empirical analysis with a VAR-model that indicates that a lower federal funds rate stimulates cross-border capital flows.

In my discussion, I first want to make the point that their model only has real interest rates and a real exchange rate. It does not have nominal policy rates that are distinct from the real interest rate and it does not distinguish between nominal and real variables. In particular, it does not contain any nominal frictions that make monetary policy meaningful, and it does not take into account that monetary policy can only temporarily make the actual short real interest rate deviate from the time-varying neutral (or "natural") short real rate, which is determined by other things than monetary policy, for instance, global imbalances, fiscal policy, and shocks to saving and investment. Thus, in spite of its title, their paper is arguably not about monetary policy but about real interest rates and capital flows between the AE and EE.

In my discussion, I will first compare with the standard open-economy macro analysis of cross-country interest-rate differentials, capital flows, and exchange-rate movements. Then I will comment on the EE borrowers' balance sheets, say something about optimal risk-taking and interest-rate differentials, and raise some issues about regulation and macroprudential policy in the model. Finally, I will suggest that the issues discussed in the paper also apply for cross-border capital flows between advanced economies with different interest rates and briefly refer to the situation in Sweden which has higher short interest rates than the euro area and the U.S.

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The standard open-economy macro analysis: UIP

Consider the standard open-economy macro analysis of the effects of a fall in the AE currency interest rate for a given EE currency interest rate. A lower AE interest rate then increases the interest-rate differential between the EE and AE and leads to an incipient capital inflow, which under flexible exchange rates in turn leads to an immediate EE currency appreciation and expectations of a future EE currency depreciation. If the appreciation is sufficient to result in an expected future depreciation that balances the increased interest-rate differential, the expected rate of return for an AE investor is the same for an investment in AE currency (dollar) and an investment in EE currency. That is, uncovered interest parity (UIP) holds. Then the incipient capital inflow does not materialize into any actual capital inflow, or at least the capital inflow stops after some initial inflows.

What is the appropriate monetary policy response in the EE in this situation? The appreciation dampens export and tradable production and stimulates nontradable production, and it reduces the inflation of imported goods. If policy was appropriate initially and then the negative effect on tradable production and inflation dominates, a lower policy rate that stimulates the EE and somewhat reduces the appreciation is called for.

In practice, it seems that EE monetary authorities in such a situation with lower AE interest rates often do not want to accept the initial appreciation of the currency and instead intervene in the foreign-exchange market or impose some capital controls to resist the appreciation. That is, the monetary authority tries to prevent the equilibrium exchange-rate response that is consistent with UIP. Then AE investors may expect that the central bank will eventually fail to prevent the appreciation, thus making investment in the EE doubly attractive for AE investors. They can profit both from the higher interest-rate differential and from an eventual appreciation. The capital inflow may increase further. Thus, preventing the equilibrium appreciation of the currency may make the capital-flow problem worse.

The balance sheets of EE borrowers

In the Bruno-Shin model, the appreciation of the EE currency is assumed to improve the balance sheets of EE borrowers, since the dollar value of their assets increases relative to the dollar value of their debt. However, if these borrowers are EE exporters, their export and their dollar profits will be hurt by the appreciation, since their dollar costs of production in the EE rise. This effect is missing in the Bruno-Shin model. On the other hand, if the borrowers are producing nontradable goods and services, their production and profits may benefit from the appreciation. This shows that one needs to assess the full general equilibrium effects on the borrowers' balance sheets in order to know whether they on average will improve or deteriorate.

The risk-taking channel and optimal risk-taking

Whether an increased interest-rate differential between the EE and the AE leads to increased risk-taking by the local branch in the EE is not completely obvious. It clearly depends on whether the increased interest-rate differential is moderated by increased expected currency depreciation or not. Under the assumption that the increased interest-rate differential is not fully moderated by the expected depreciation, the increased interest-rate differential means that the expected rate of return from borrowing in the AE currency (dollar) and investing in the EE increases. Whether that leads to more or less risk-taking then depends on the precise form of preferences between the expected rates of return and the risk of the AE bank and the local branch.

Figure 1 shows a stylized example of this, using the standard capital asset-pricing model (CAPM) for the local EE branch of the AE parent bank. The expected dollar rate of return is measured along the vertical axis and the risk, defined as the standard deviation of the dollar rate of return, is measured along the horizontal axis. The concave curve through point B is the efficient frontier of local-branch risky investment opportunities without any dollar borrowing from the AE bank. We can think of these local investment opportunities as the lending of the local branch to local firms, using some capital that the local branch initially has received from the AE bank. If the local branch can borrow from the AE bank at the safe dollar interest rate f, corresponding to point A, point B on the efficient frontier shows the expected rate of return and the risk of the optimal combination of local investment projects without any dollar borrowing. The investment-opportunity line for the local branch with dollar borrowing is then the segment of the solid line from point A through B that starts from point B and extends through and beyond point C. By borrowing at the rate f, the local branch can increase its leverage and invest in more local projects (in the optimal combination of projects corresponding to point B). In this way the local branch can reach the combinations of expected rate of return and risk on the investment-opportunity line north-east of point B.

The relevant preferences over expected rates of return and risk (the preferences of the shareholders of the AE bank that controls the local branch) are given by the convex indifference curves shown. Higher expected rates of return and less risk are preferred, so indifference curves have a positive slope. The optimal investment/borrowing choice is given by point C, the most preferred point on the investment-opportunity line, which will be a tangency point between the investment-opportunity line and the highest reachable indifference curve. The optimal risk-taking is given by the horizontal coordinate of point C, the horizontal distance between point C and the vertical axis. The leverage of the local branch, that is, its total assets over its capital, is given by the length of the segment AC divided by the length of the segment AB. The price of risk, the marginal increase in the expected rate of return from a marginal increase in the risk, is given by the slope of the investment-opportunity line.

Suppose now that the dollar interest rate falls to f ', corresponding to point A' in figure 2. The expected rate of return and risk for the new optimal combination of local investment projects is then given by point B', and the new investment-opportunity line with dollar borrowing is the segment of the line from point A' through B' that starts from point B' and extends through and beyond point C'. The new optimal investment/borrowing choice is given by point C', the new tangency point between the new investment-opportunity line and the new highest reachable indifference curve. Whether the new optimal investment/borrowing choice involves more or less risk-taking than the previous choice depends on whether the point C' is to the right or left of point C. This in turn depends on the precise nature of the preferences between expected rates of return and risk.

Since the new investment-opportunity line is steeper, the price of risk has increased, and a marginal increase in the risk brings a larger increase in the expected rate of return. Therefore, a pure "substitution" effect would tend to increase risk-taking. On the other hand, the new optimal investment/borrowing choice corresponds to a higher indifference curve, resulting in an "income" effect that may increase or decrease risk-taking. For the special case of quadratic preferences, the "expansion curves" representing the income effect are vertical lines, in which case there is no income effect on risk-taking. Then, the substitution effect dominates. But quadratic preferences are a special case. Thus, it is not completely obvious whether a fall in the dollar interest rate always leads to more risk-taking by the local branch.

Furthermore, in figure 2, the risk-taking by the local branch is privately optimal, given the AE bank's shareholders' preferences over the expected rate of return and the risk. Whether the risk-taking is *socially* optimal or not depends on whether there is some underlying systematic distortion of the local branch's investment/borrowing choice, causing too much or too little risk-taking relative to what is socially optimal.

The Bruno-Shin paper does not specify what the market failure, externality, or distortion is that may cause actual risk-taking to be too high or too low. There are references to "measured" risk, but there is no discussion of what the "true" risk might be.
Generally, is there too much or too little risk-taking today, after the 2008-2009 financial crisis and during the new euro-area crisis? Whereas there was in many cases obviously too much risk-taking before the 2008-2009 crisis, now there may in many cases be excessive risk aversion and too little risk-taking.

Regulation and macroprudential policy

In the Bruno-Shin model, the local branch's behavior is given by a binding Value-at-Risk restriction. The consequences of regulation and macroprudential policy according to Basel III are not considered. In the model considered, it would be interesting and highly relevant to see what the consequences are of a Basel-III regulation with binding minimum capital requirements, a minimum net stable funding ration (NSFR), and so on. My guess is that the results may be quite different.

Not only emerging economies? What about Sweden?

The analysis in the Bruno-Shin paper is of an EE for which the interest-rate differential to an AE increases when the interest rate in the AE falls. Then capital flows into the EE increase, with possible increased risks to financial stability. However, the analysis also seems to apply to an AE where the interest rate increases relative to the rate in other AEs. Sweden is arguably such a case.

The Swedish policy rate and the overnight rate are high, currently (in July 2012) 1.5 %. This is against the dissent of my colleague on the Riksbank Executive Board Karolina Ekholm and I – both of us would prefer a lower policy rate since current and forecasted inflation is below target and current and forecasted unemployment is above any reasonable estimate of a long-run sustainable unemployment rate (see Svensson (2012) and the attributed minutes from the July 2012 policy meeting, Sveriges Riksbank (2012b)).

In contrast, the Eonia rate in the euro area and the federal funds rate in the U.S. are much lower. The substantial interest-rate differential makes carry trade and capital flows into Sweden – borrowing at euro or dollar short rates and investing at krona short rates – quite attractive. This offers increased opportunities for foreign funding to Swedish banks. However, as is emphasised in the Riksbank's (2012a) Financial Stability Report, this entails risks as foreign investors may suddenly stop lending. When the Swedish policy rate is raised in relation to foreign rates it becomes even more attractive for foreign investors to fund Swedish banks and even easier for Swedish banks to increase their foreign funding. This is an example of a situation where raising the policy rate will if anything increase rather than decrease the risks to financial stability.

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Commentary on Capital Flows and the Risk-Taking Channel of Monetary Policy

John B. Taylor [1]

Valentina Bruno and Hyun Song Shin (2012) present an elegant microeconomic model which shows that low policy interest rates at major central banks can increase risk-taking in other countries. They also show that exchange rate changes in the absence of actions by central banks in these other countries magnify that increase in risk-taking. They then back up their model with empirical findings linking policy rates in the United States to various measures of risk taking.

In my view their findings raise important issues related to the conduct of monetary policy in our increasingly globalized financial system. Their findings also raise questions about the causes of the recent financial crisis with general implications for international economic policy going forward. I focus on these policy issues here.

1. Interest Rates and Risk Taking in the Bruno-Shin Model

The Bruno-Shin paper derives a link between the dollar interest rate and the flow of dollar credit abroad. Their starting point is the assumption some foreign firms abroad want to borrow in dollars to finance some their projects even though the returns on these projects are denominated in local currency. In their model, they posit that these projects are inherently risky. Thus loans made to the firms by banks to fund these projects are subject to default risk in the event that the project earns less than the loan, including interest payments.

Banks lending to the firm take account of this default risk by using a "Value at Risk" (VAR) approach. Accordingly, banks increase the size of the loans on the project up to the point where the amount that must be paid back (including interest) results in a probability of insolvency of the bank that just equals a set value α. The amount to be paid back is $(1+f)L$ where f is the interest rate and L represents the size of the loans. The higher is $(1+f)L$ the higher is the default risk. Thus α depends on $(1+f)L$. For a given value of α, the lower is f, the higher is L. In other words, a reduction in the federal funds rate increases lending and encourages more risk taking on the part of these firms.

But this is just the first round effect. In an international setting this initial effect can be magnified by other changes. Bruno and Shin (2012) assume that the exchange rate θ varies inversely with L. Thus when f is reduced and L rises, it causes an appreciation of the exchange rate. The appreciation reduces the likelihood of default because local currency then converts into more dollars to pay back the loan. This enables the banks to lend more. Thus L increases further, but this in turn causes θ to rise further. In other words there is an iterative feedback process with successive increases in L and θ responding to the initial change in the funding rate f. Since the process converges there is a well-defined solution, but the eventual impact is larger than the initial impact implying in a magnification or multiplier effect.

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[1] Stanford University

While the magnitudes of initial effect and the multiplier are uncertain, Bruno and Shin provide estimates of the overall effect on risk taking by estimating time series models. They find interest rate effects on risk taking as measured by the VIX, which are similar to the results of Bekaert, Hoerova, and Duca (2010). Thus the overall conclusion of the theory and the empirics is that a lower federal funds rate causes more lending and more risk taking abroad. This is the risk-taking channel of monetary policy.

Other Exchange rate Channels

Note that one of the end results of Bruno-Shin model is that a lower federal funds rate puts pressure on other countries' currencies to appreciate. This is also implied by open economy macro models with rational expectations and capital mobility where arbitrage forces tend to keep the rate of return in different currencies equal. Thus, a cut in the federal funds rate will cause a depreciation of the dollar by an amount that causes an expected appreciation of the dollar compensating for the lower dollar interest rate. The appreciation effect on other currencies exists in most empirical monetary models, as indicated by model data base constructed by Volker Wieland (2009).

2. Monetary Policy Responses

Now let me consider monetary policy.[2] There are three impacts to consider: currency intervention, interest rate policy, and capital controls. In my view relying on capital controls—even in these cases—runs counter to important international opening of markets that will eventually improve the workings of the world economy and raise economic growth. But here I focus on currency intervention and interest rate policy.

Currency Intervention and the Impact on Gross Flow

Currency intervention is one possible reaction of other central banks to the lower interest rate abroad. The central bank in the receiving country will likely intervene in the exchange market to prevent the appreciation of the currency. One motivation is to limit the risk-taking caused by the lower dollar funding rate. But there are other reasons, which have been emphasized in the literature, including the impact of the appreciated currency on the domestic economy and on the often politically powerful export businesses.

The intervention causes an accumulation of international reserves—mostly in the form of dollars. These dollar reserves must be invested somewhere and a logical place is in the United States in, for example, mortgage backed securities, which drives long term interest rates down. Thus, the gross outflow of loans is matched at least in part by a gross inflow of funds from central banks and sovereign wealth funds into securities. It is important to note that these flows occur without any change in the current account. That too much focus on the current account can take attention away from these gross flows has long been a concern to me as I pointed out when I served as in the U.S. Treasury from 2001-2005.[3]

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[2] Here I draw on research presented at conferences at American Enterprise Institute in November 2004 (Taylor (2004), at the NBER conference on international monetary policy in Girona, Spain in July 2007 (Taylor (2007a)), and at the June 2010 Norges Bank conference "On the Use of Simple Rules as Guidelines for Policy Decisions." (Taylor 2010)

[3] For example, in Taylor (2004), I stated that "it is important to put the current account in the perspective of the total amount of financial flows crossing U.S. borders in large, open and flexible markets." In his recent Ely at the American Economic Association Obstfeld (2012) provides an excellent treatment of the importance of gross flows.

One example of this phenomenon, pointed out by Borio and Disyatat (2011) and Beckworth and Crowe (2012), is how the low federal funds rate in the U.S in 2003-2005 may have led to such gross inflows of funds. This is in contrast to the view of Bernanke (2010) who argued that the low federal funds rate was not the reason for the boom in the housing market as I had found in Taylor (2007b). Rather Bernanke argued that the low long term rates were due to a savings glut by which the current account surpluses around the world caused the increased demand of U.S. mortgage securities. This is the sense in which the Bruno and Shin paper is “related to the debate on whether monetary policy was “too loose” in the run-up to the crisis” as the authors point out.

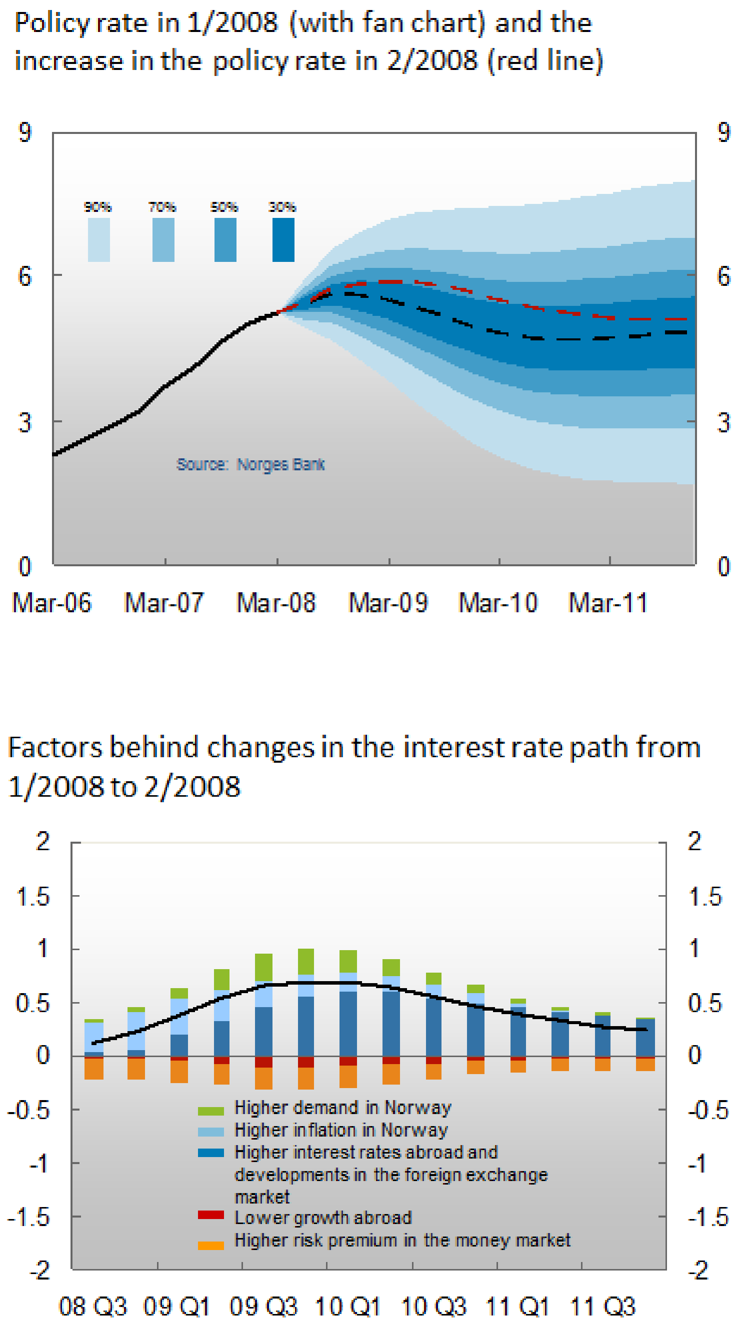
Interest rate Response

Another important reaction to the lower federal funds rate is that central banks in other countries will lower their interest rate relative to what it would otherwise be. The motivation is similar to the exchange market intervention: to keep the exchange rate from appreciating. There is indeed considerable evidence of this effect. First consider an example which I draw from the Norges Bank. See Røisland (2010) and OECD Survey (2010).

In Figure 1, I use two charts which show a decision by the Norges Bank to raise the policy interest rate. The top chart shows the increase from the black dashed line to the red dashed line. The lower chart shows that the main reason is the higher interest rates abroad. In Figure 2, I show two similar charts corresponding to a cut in interest rates from the black dashed line to the red dashed line. Again the main source is the decline in interest rates abroad as shown in the lower chart.

Figure 1.

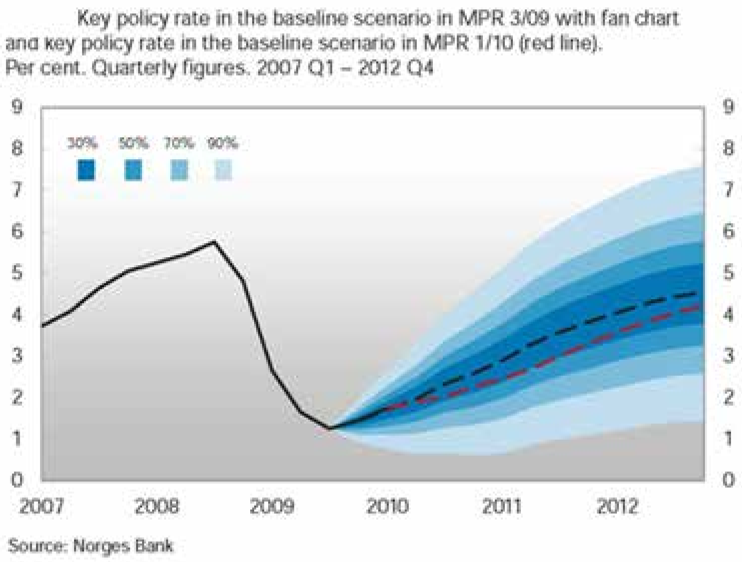
How an Increase in Policy Rates is Influenced by Other Central Banks.

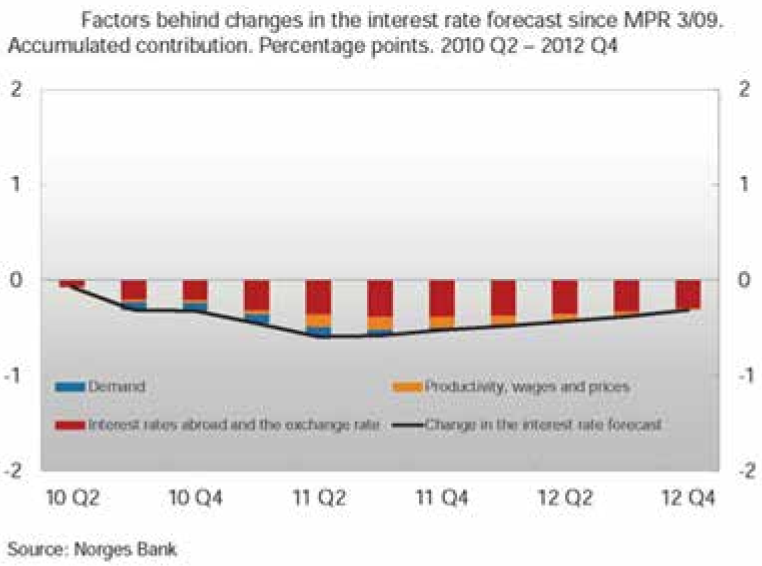


Note: the top chart shows the increase in the interest rate by the Norges Bank in early 2008 and the bottom chart shows that the major contributor to the decision was the increase in interest rates abroad.

Figure 2

How a Decrease in Policy Rates is Influenced by Other Central Banks



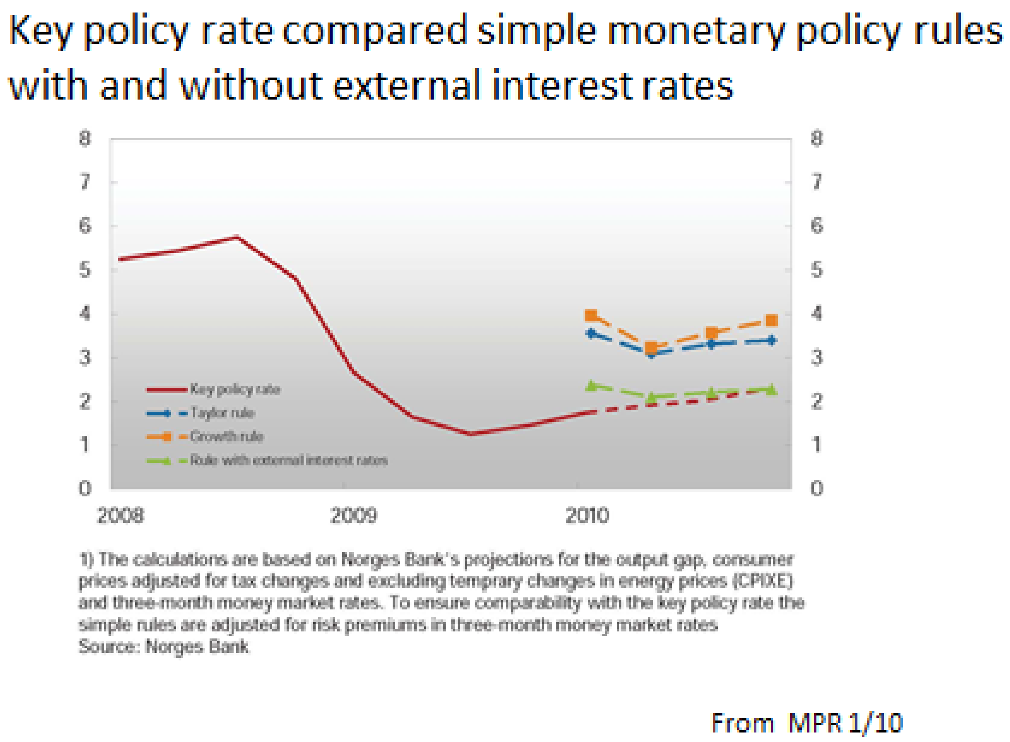


Note: the top chart shows the decrease in the interest rate by the Norges Bank in 2010 and the bottom chart shows that the major contributor to the decision was the decrease in interest rates abroad

Yet another way to see the influence of central bank decision in other countries is to look at the reaction function (policy rule) of the Norges Bank. Figure 3 shows the interest rate setting along with several policy rules. The rule with external interest rates comes much closer to describing the actions than the policy rules without external interest rates.

Figure 3

Policy rule with external interest rates more closely describes policy rates



There is also econometric evidence. Using panel data from 12 central banks (Australia, Canada, South Korea, the United Kingdom, Norway, New Zealand, Denmark, Israel, Brazil, the Eurozone, China, and Indonesia), Colin Gray (2012) estimated policy rate reaction functions where the federal funds rate or other measures of foreign interest rates entered on the right hand side. He found that the average reaction coefficient on the foreign rate was large and significant and as high as .75. In Taylor (2007a) I estimated reaction coefficients and found that the ECB coefficient on the federal funds rate averaged.21 during 2001-2006.

These close policy connections suggest the need for more research and discussion of the international aspects of monetary policy. To illustrate the kind of issues that are involved, consider a very simple two country framework with policy spillovers. Let *i* be the interest rate in one country—perhaps the United States—and *i** be the interest rate in the other country, or the rest of the world. Let *z* and *z** symbolize domestic factors (a weighted average of inflation and real GDP, for example). Then the policy rules can be written

$$i = z + \alpha i^*$$
$$i^* = z^* + \alpha^* i$$

Observe that central banks follow each other to some degree with α and α^* both positive and less than or equal to one. Solving these equations in terms of *z* and *z** gives:

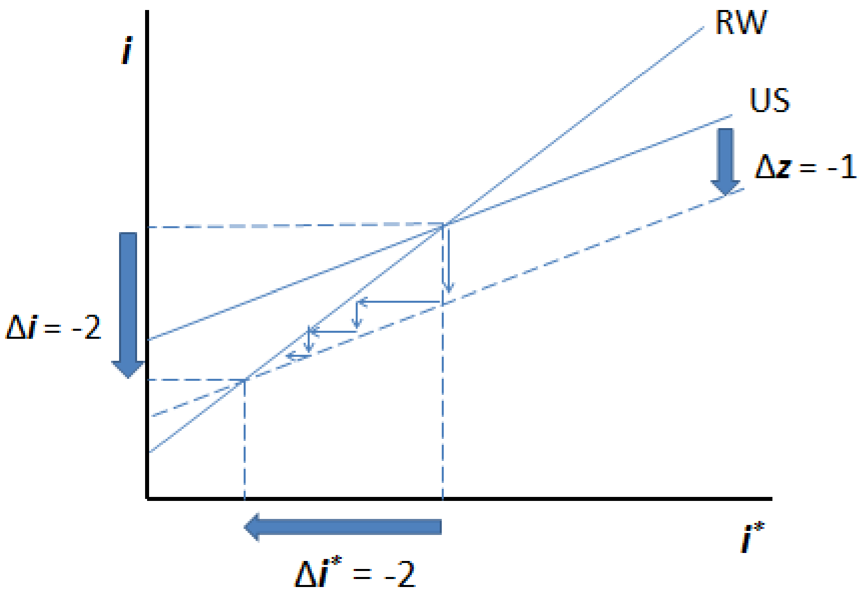
$$i = \frac{1}{1-\alpha\alpha^*}(z + \alpha z^*)$$

$$i^* = \frac{1}{1-\alpha\alpha^*}(z + \alpha^* z^*)$$

Note that there is a multiplier effect which is caused by the banks reacting to each other. Figure 4 illustrates this. It graphs the two equations with *i* on the vertical axis and *i** on the horizontal axis in the case there α = .5 and α^* = 1. If the Federal Reserve cuts its interest rate by 1 percent for example, the equilibrium is a 2 percent rate cut once other central banks and the Fed in turn react.

Figure 4

Equilibrium when central banks react to other central banks' interest rates



Conclusion

The paper by Bruno and Shin makes an important contribution to the literature on the impact of central bank decision on risk taking abroad. The paper also has important implications for the spillover of monetary policy between countries and thereby for international policy coordination as I have emphasized in this commentary. Very low policy rates in major central banks can create pressures on emerging market central banks to hold rates lower than they would be otherwise or to intervene in currency markets. This can lead to poor economic performance, which can feedback to the major countries. In my view this implies that "monetary rebalancing" should be a subject for research and international discussion as much as "current account rebalancing."

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