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

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# Two Questions

- What configuration of exchange rates are consistent with rebalancing of global demand?

- To what extent will exchange rate appreciation stem capital inflows?
  - What are the financial stability implications of exchange rate appreciation?
  - What are the feedback effects between leverage and exchange rate appreciation?
  - How do the answers depend on stance of advanced economy monetary policy?

# A Popular Narrative

- *"Low interest rates maintained by advanced economy central banks are key drivers of*
  - *Cross-border capital flows to emerging economies*
  - *Credit booms and overheating for capital recipient economies*
  - *Overshooting of real exchange rates"*

- Are these claims true?

- What are the mechanisms?

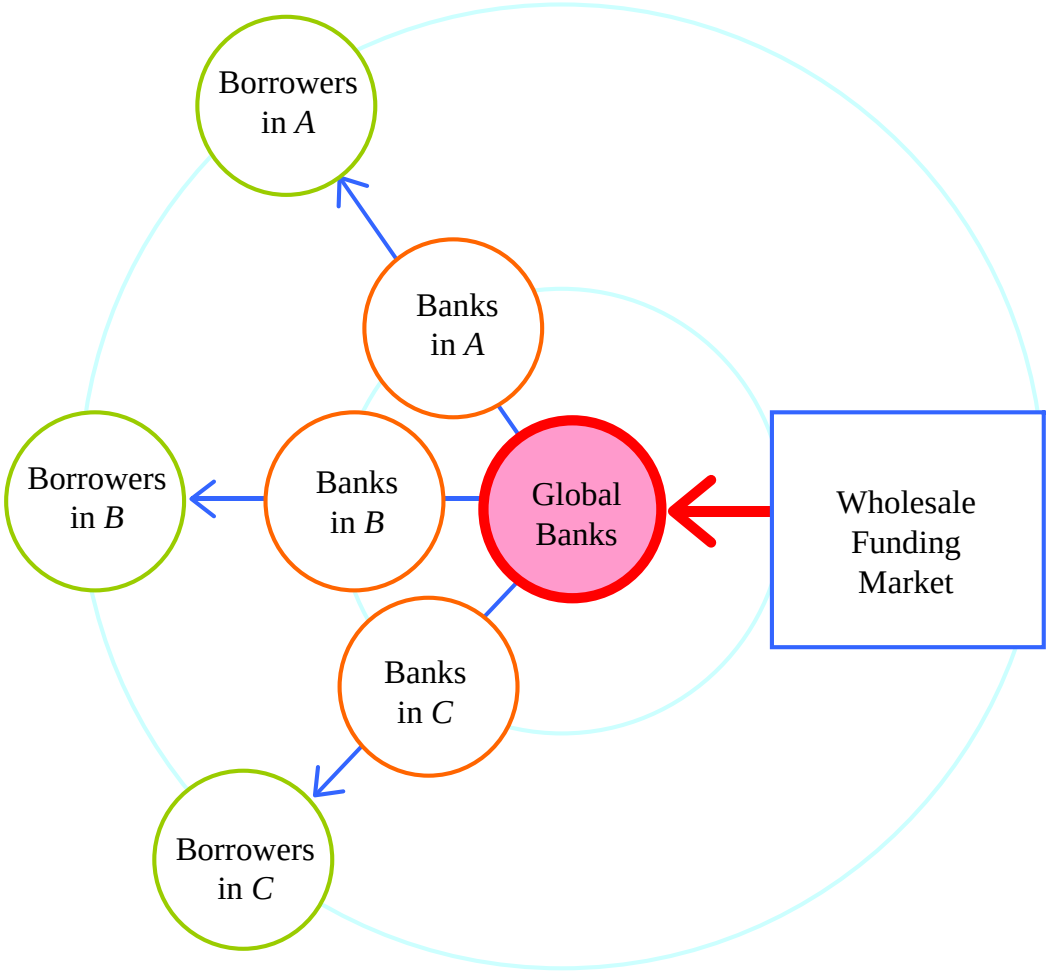



Figure 1. Topography of global liquidity

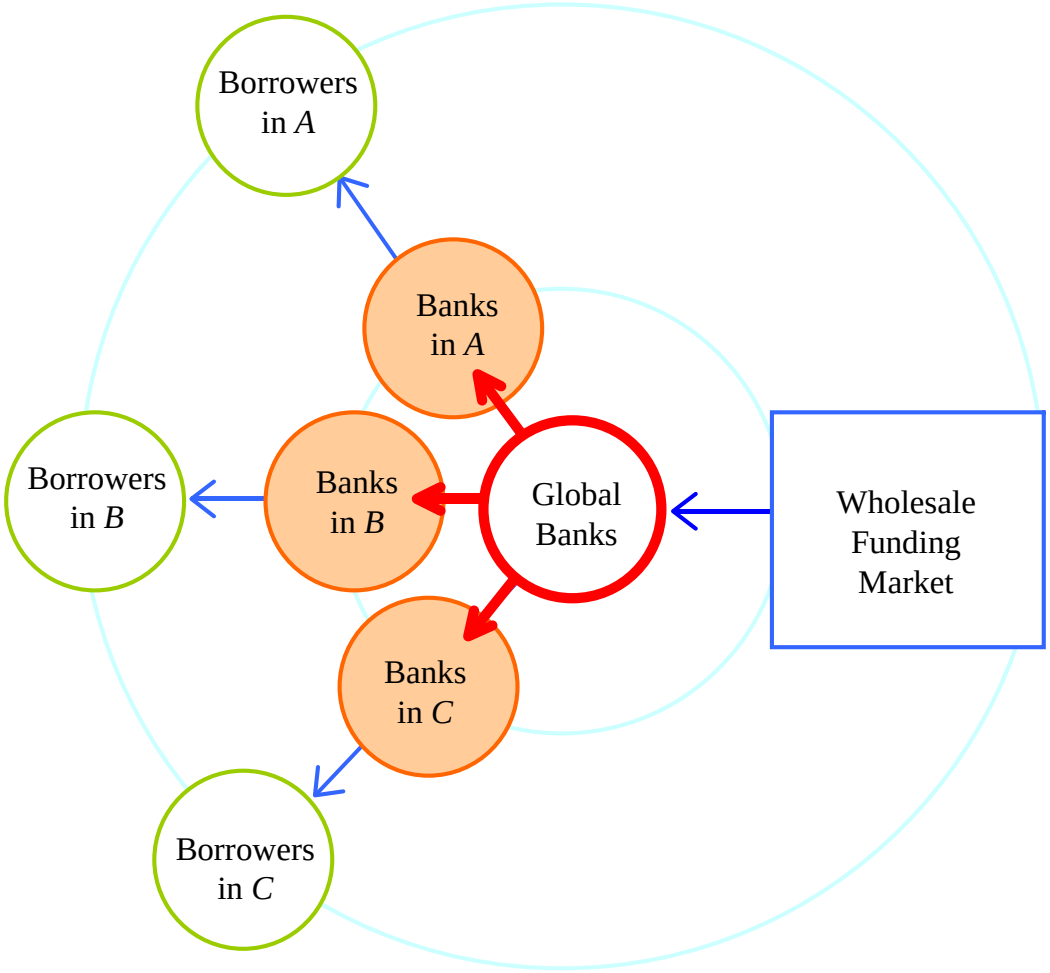



Figure 2. Topography of global liquidity

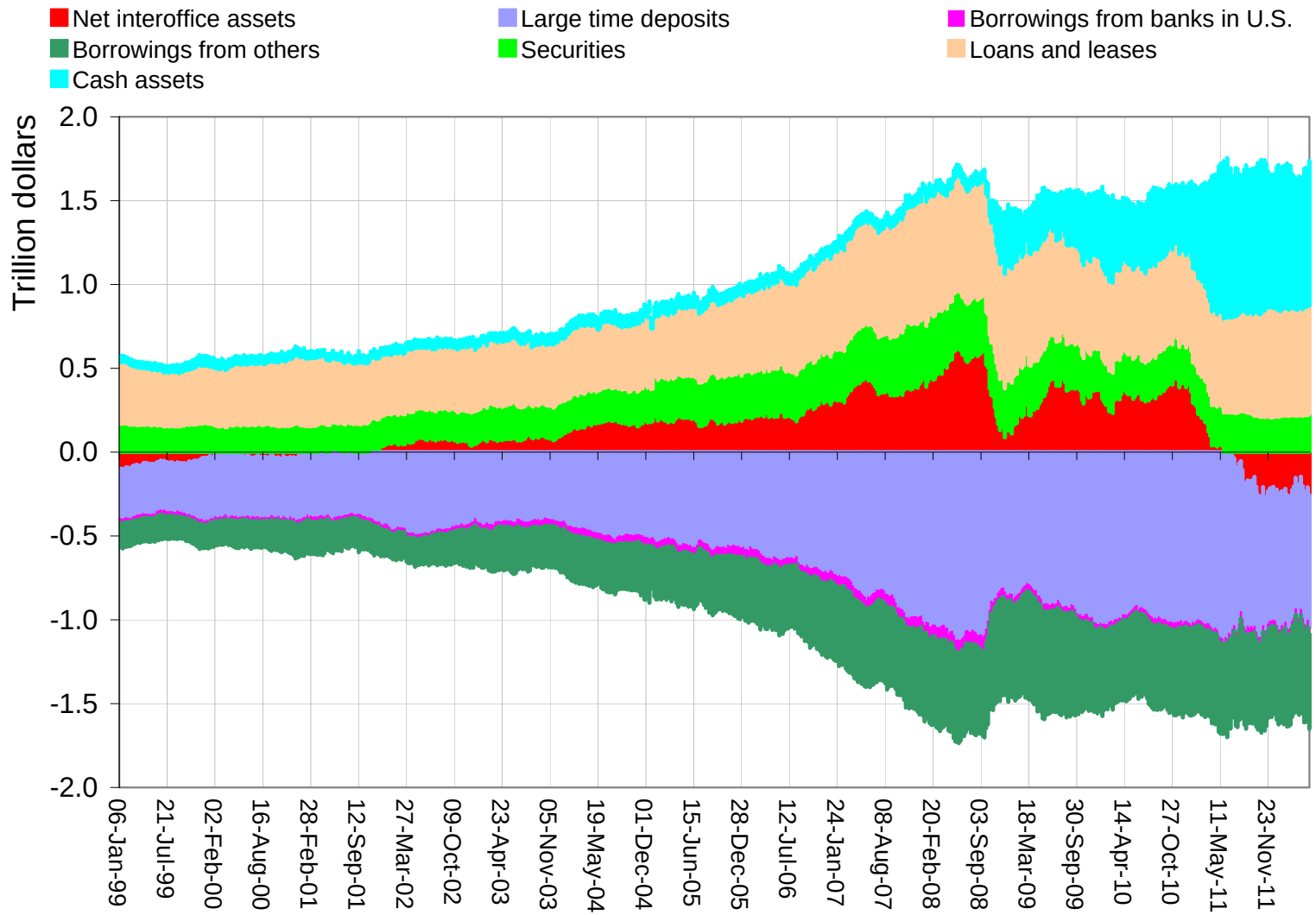



Figure 3. Assets and liabilities of foreign banks in the U.S. (Source: Federal Reserve H8 weekly series on assets and liabilities of foreign-related institutions)

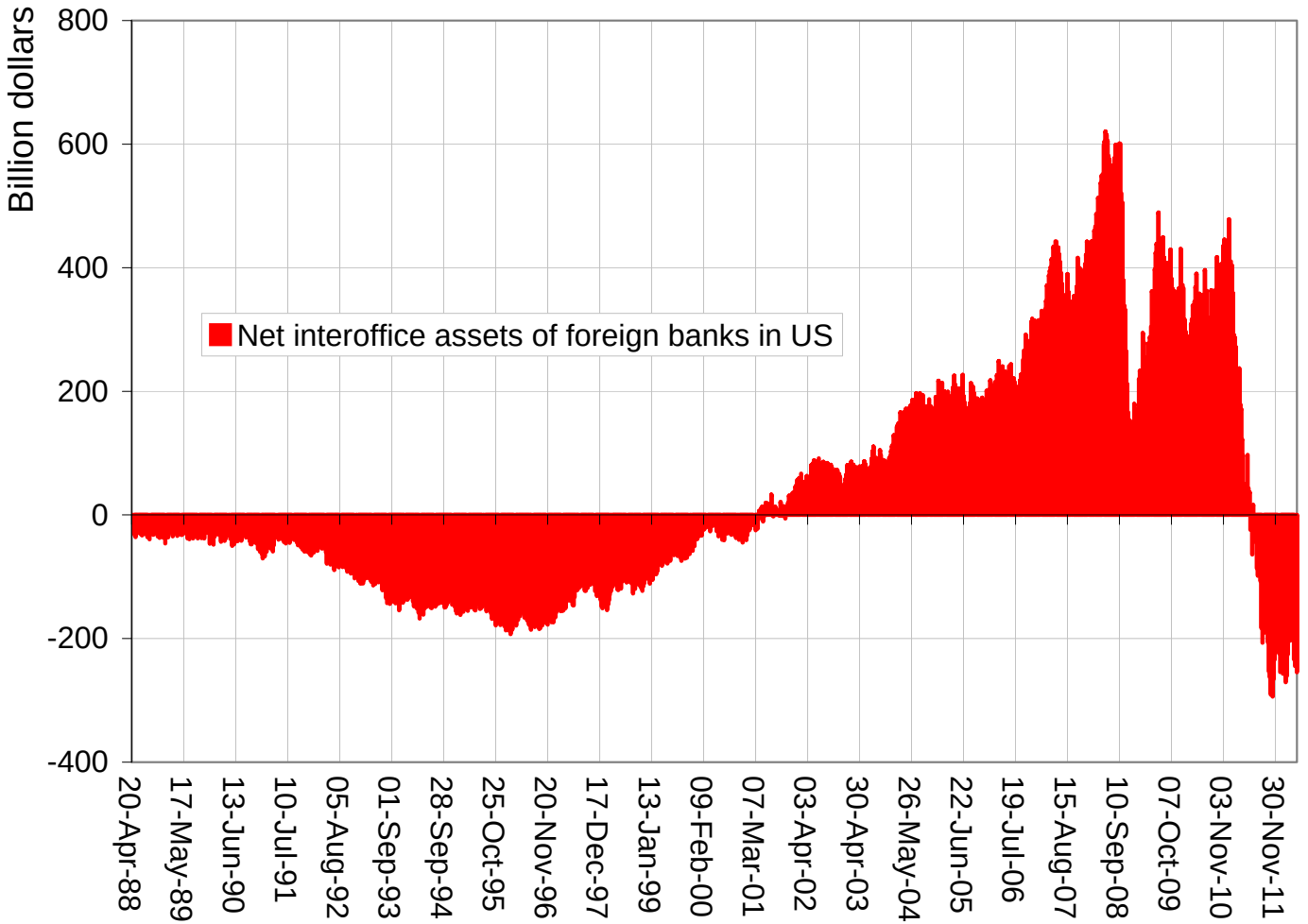



Figure 4. Net interoffice assets of foreign banks in U.S. given by negative of Federal Reserve weekly H8 series on "net due to related foreign offices of foreign-related institutions"

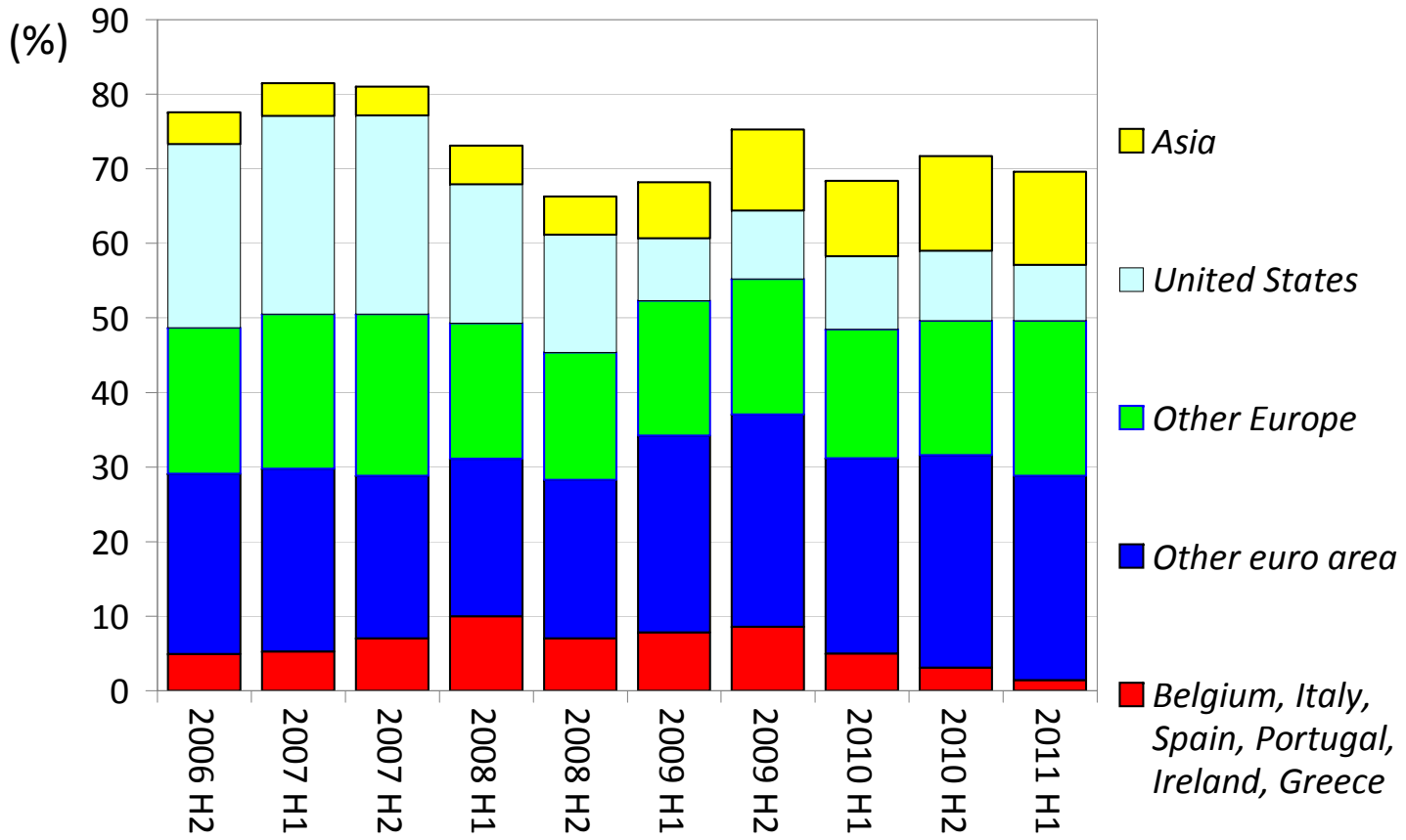



Figure 5. Amount owed by banks to US prime money market funds (% of total), based on top 10 prime MMFs, representing $755 bn of $1.66 trn total prime MMF assets (Source: IMF GFSR Sept 2011, data from Fitch).

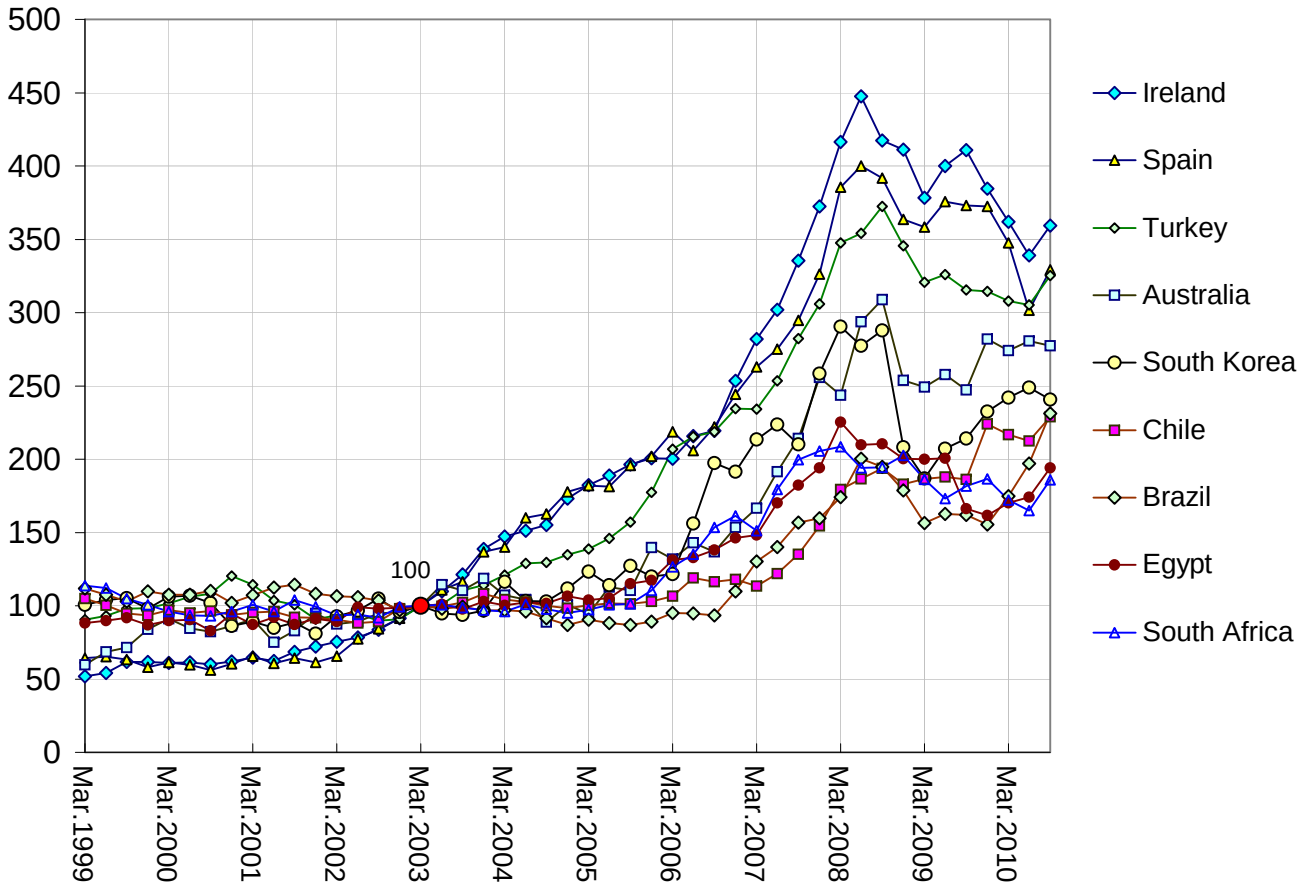



Figure 6. External claims (loans and deposits) of BIS reporting banks on counterparties listed on right (Source: BIS locational banking statistics Table 7A)

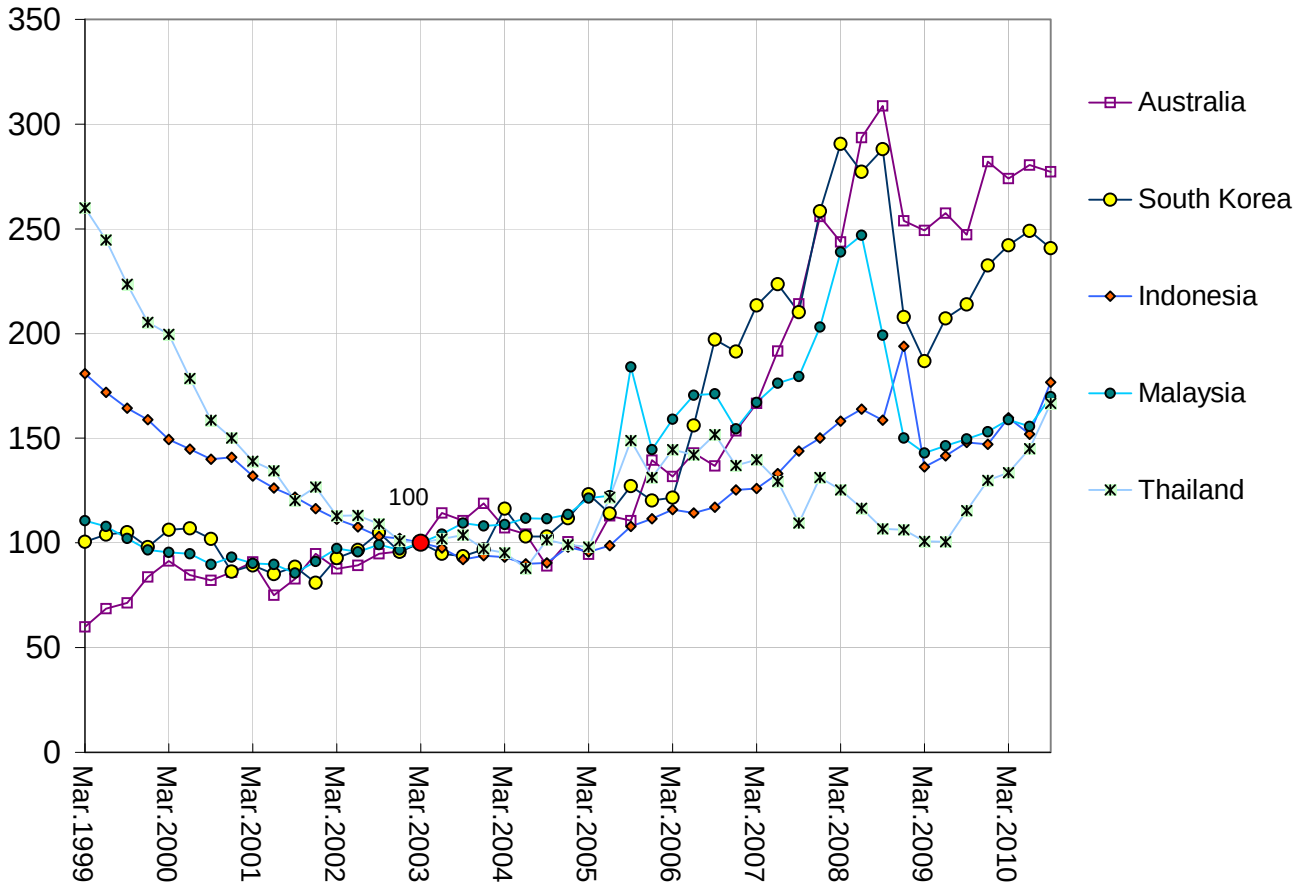
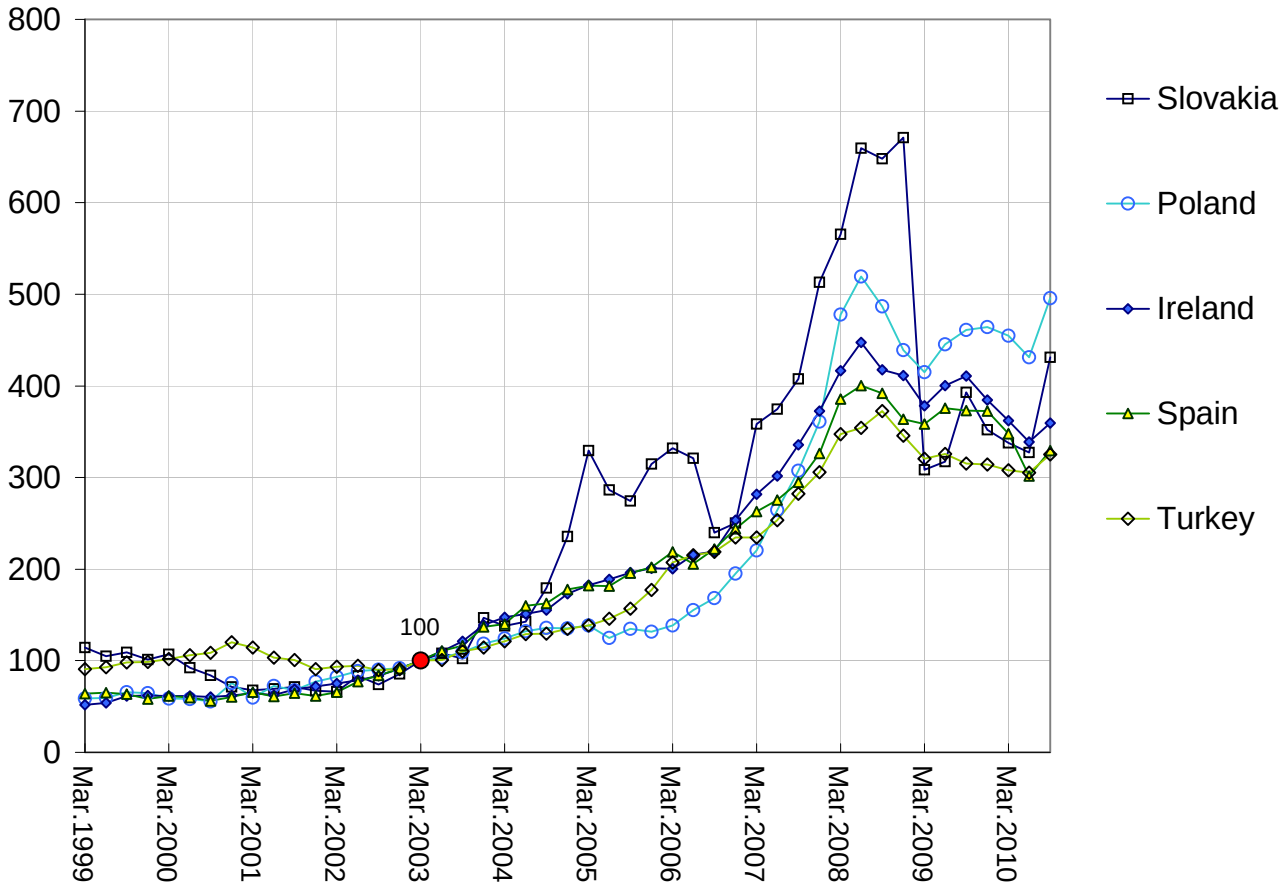



Figure 7. External claims (loans and deposits) of BIS reporting banks on counterparties listed on right (Source: BIS locational banking statistics Table 7A)

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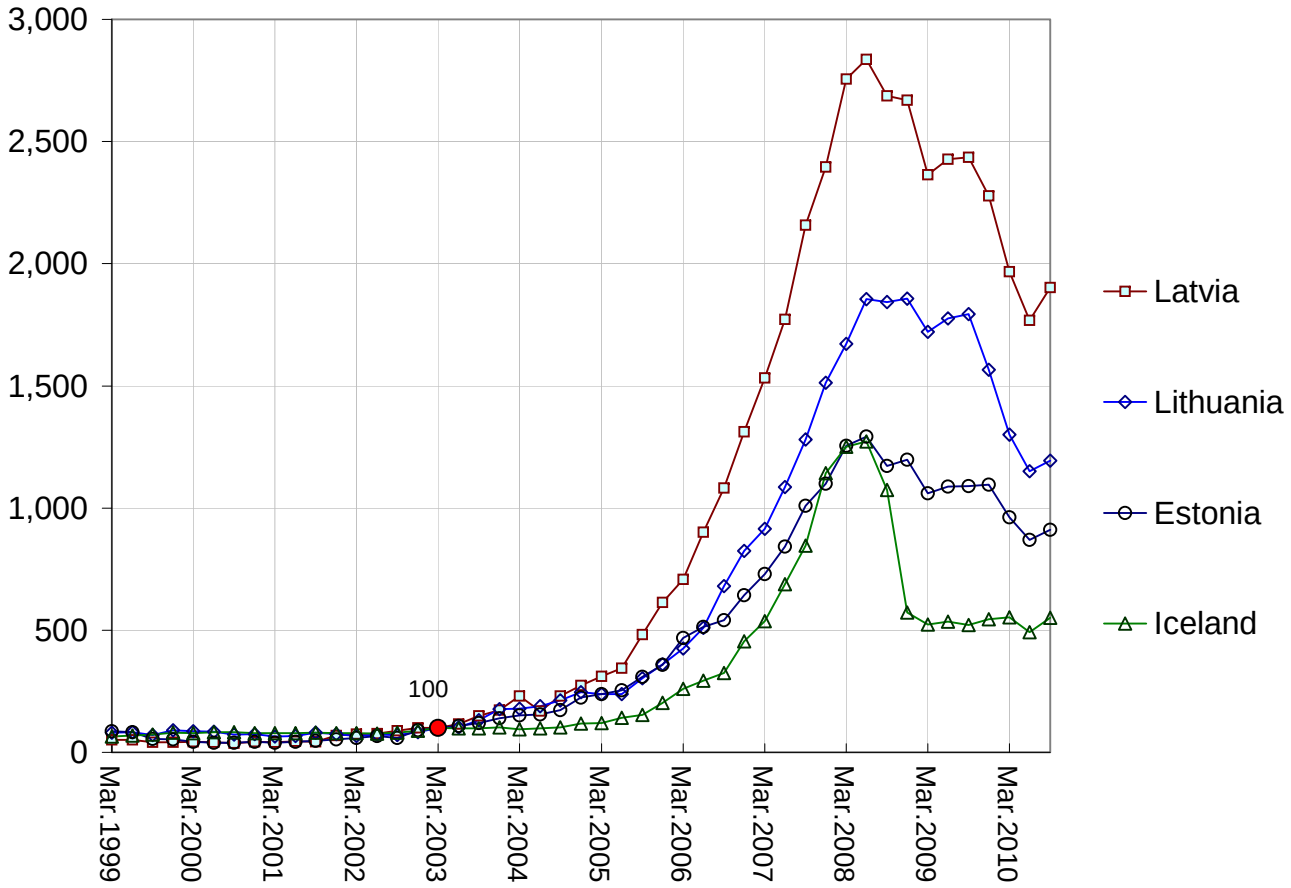



Figure 9. External claims (loans and deposits) of BIS reporting banks on counterparties listed on right (Source: BIS locational banking statistics Table 7A)

# Risk-Taking Channel

Borio and Zhu (2008)

- Pivotal role of banking sector
  - Short-term interest rates and term premium
- Leverage cycle
  - Expansion phase driven by low measured risks
  - Measured risks are dampened during expansions
  - "Excess elasticity" (Borio and Disyatat (2011))
- Global liquidity
  - US dollar wholesale bank funding market
  - European global banks

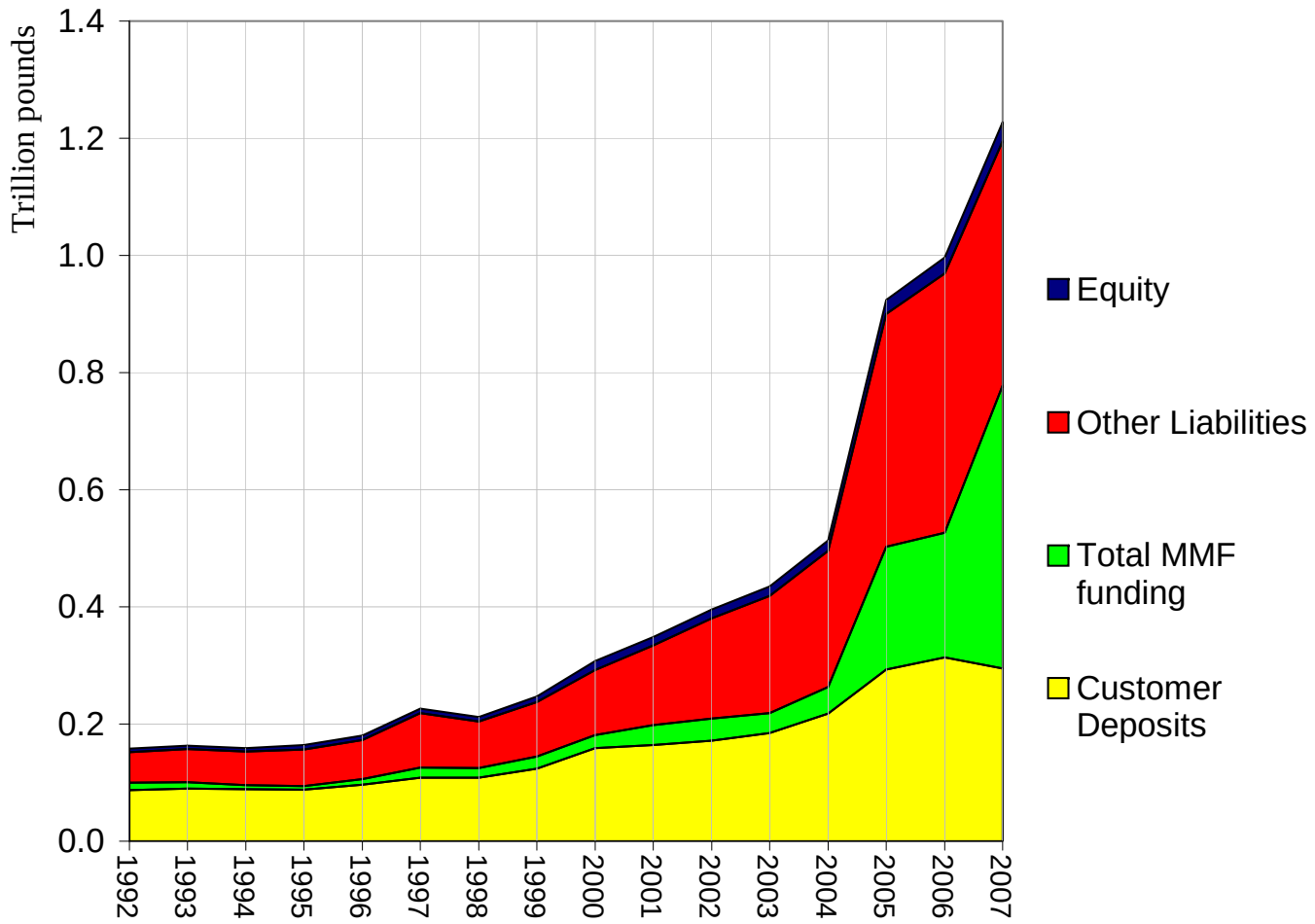



Figure 10. Total Liabilities of Barclays (1992 - 2007) (Source: Bankscope)

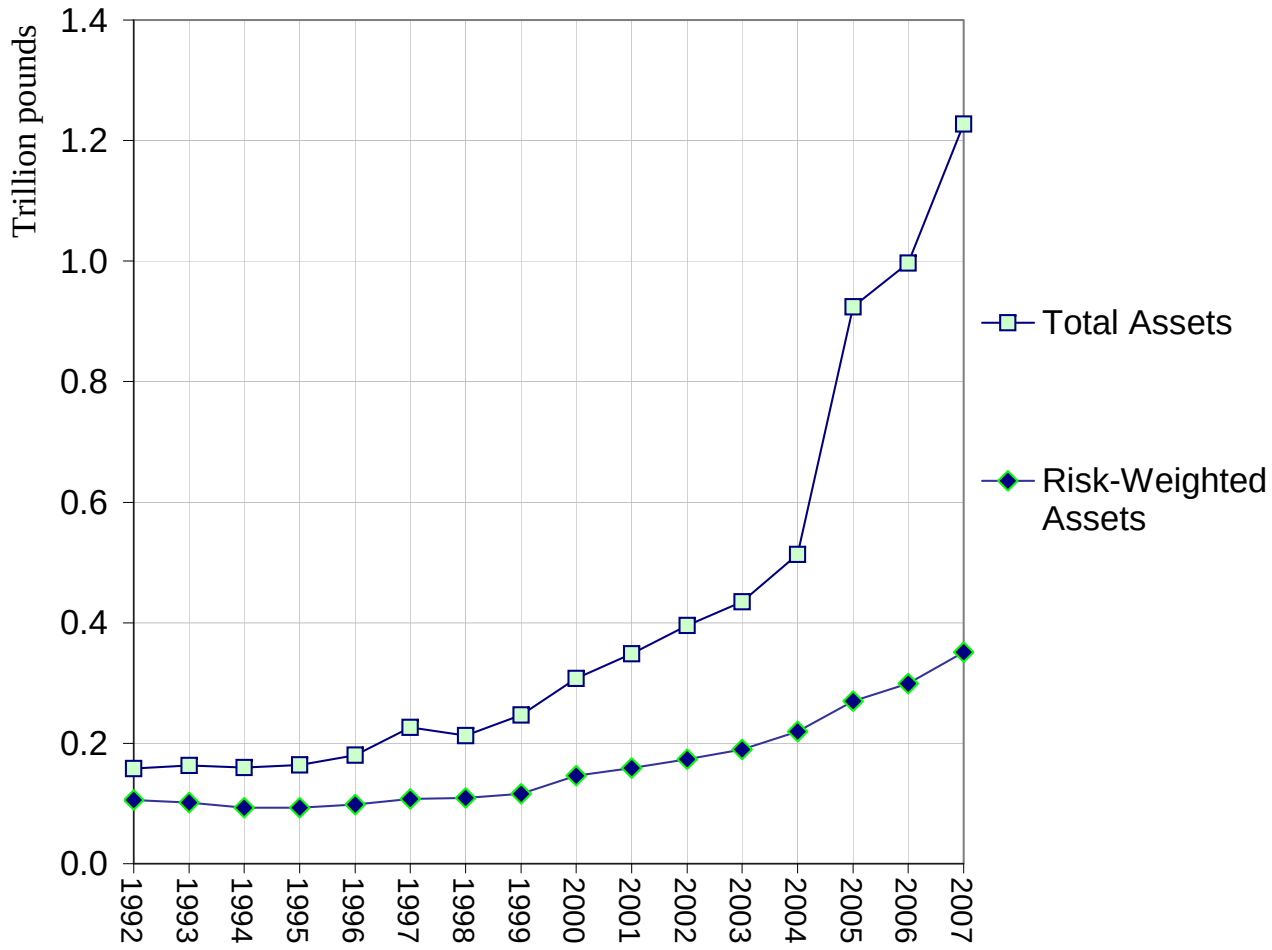



Figure 11. Barclays, risk-weighted assets and total assets (Source: Bankscope)

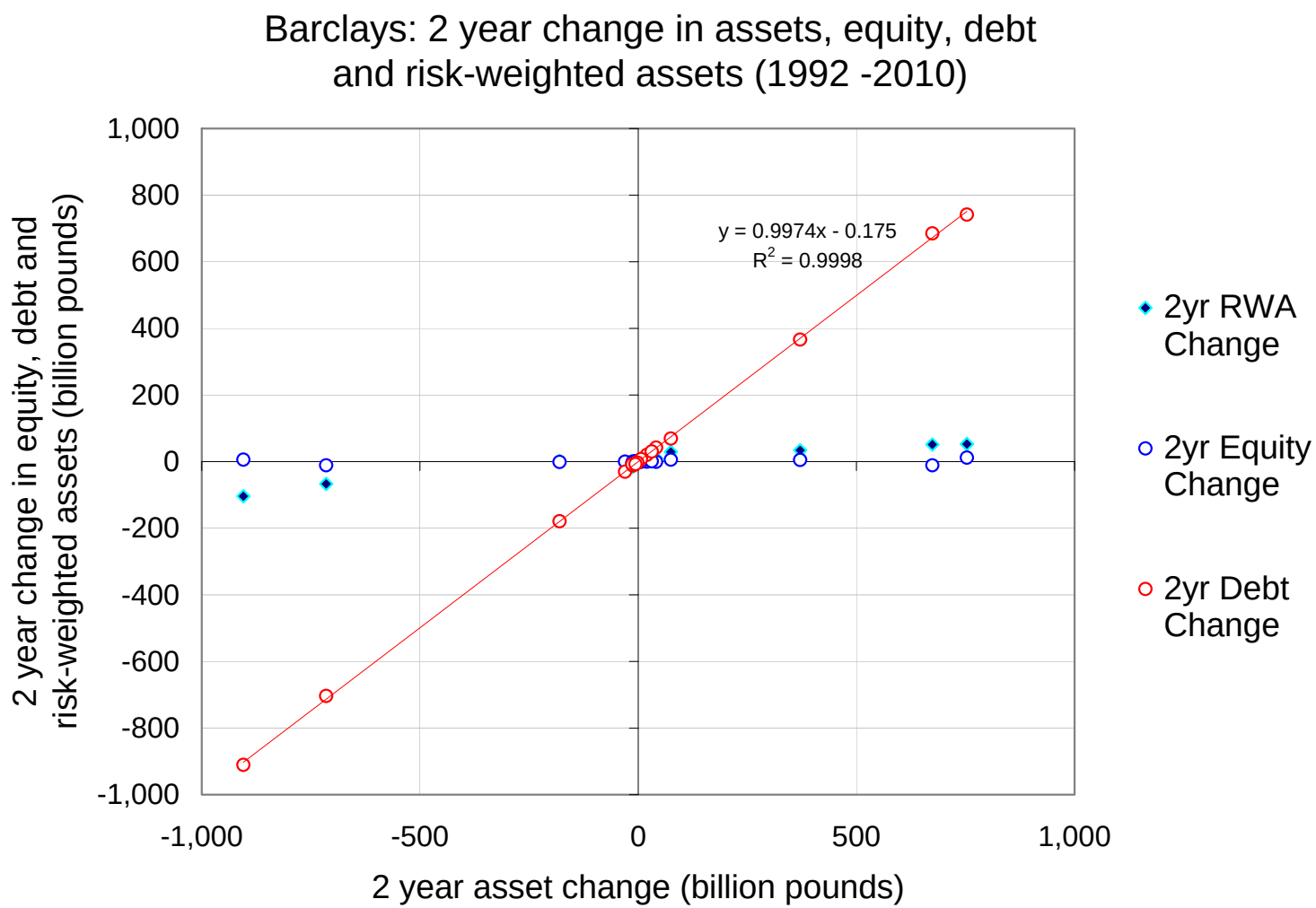



Figure 12. Barclays: 2 year change in assets, equity and debt (1992-2010) (Source: Bankscope)

# Credit Supply Model

- Vasicek credit risk model (backbone of Basel II)
- Turn on its head as *credit supply model*
  - Given sticky equity, **credit supply is determined by risk-taking decision**

$$C = \frac{E}{1 - \frac{1+r}{1+f}\varphi}, \qquad \varphi \in (0,1)$$

$\varphi$ is ratio of **notional debt** to **notional assets**

# Amplification Channel

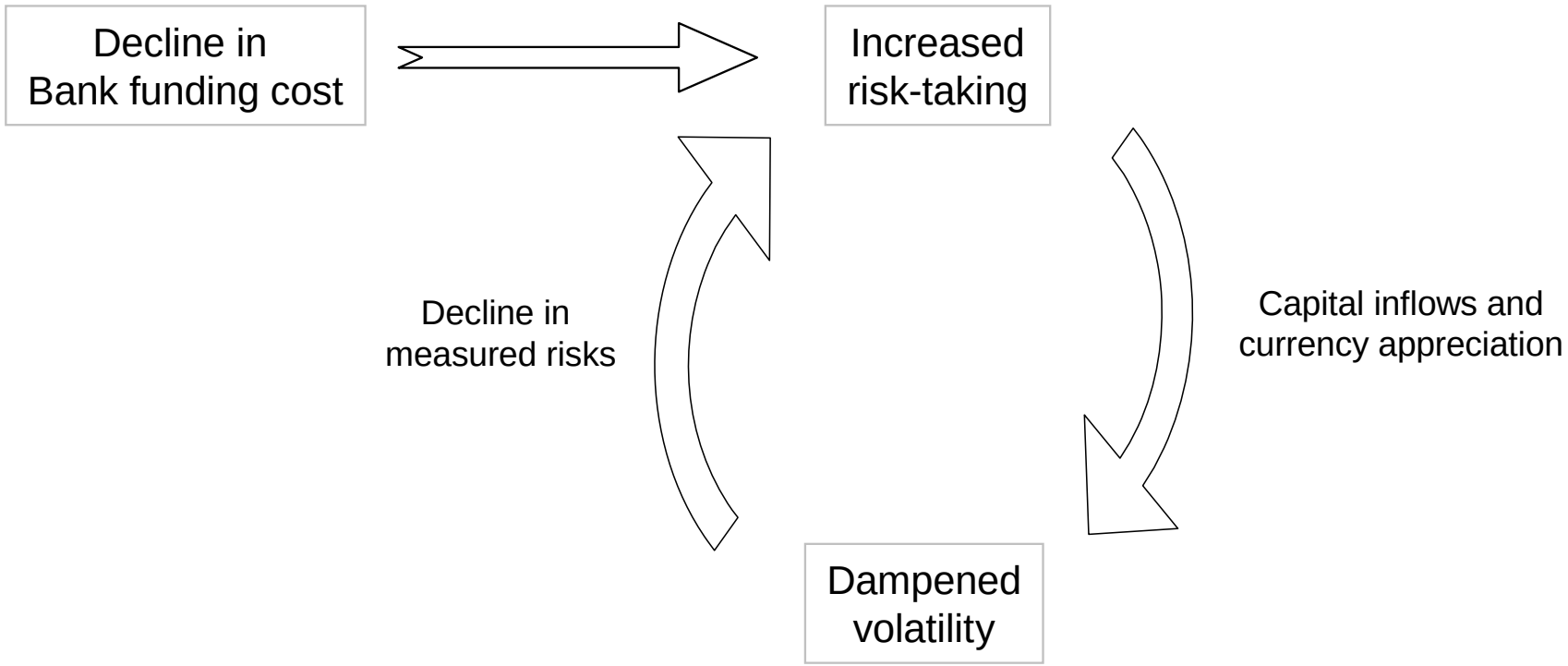



Figure 13. Risk-taking channel of monetary policy in the cross-border context

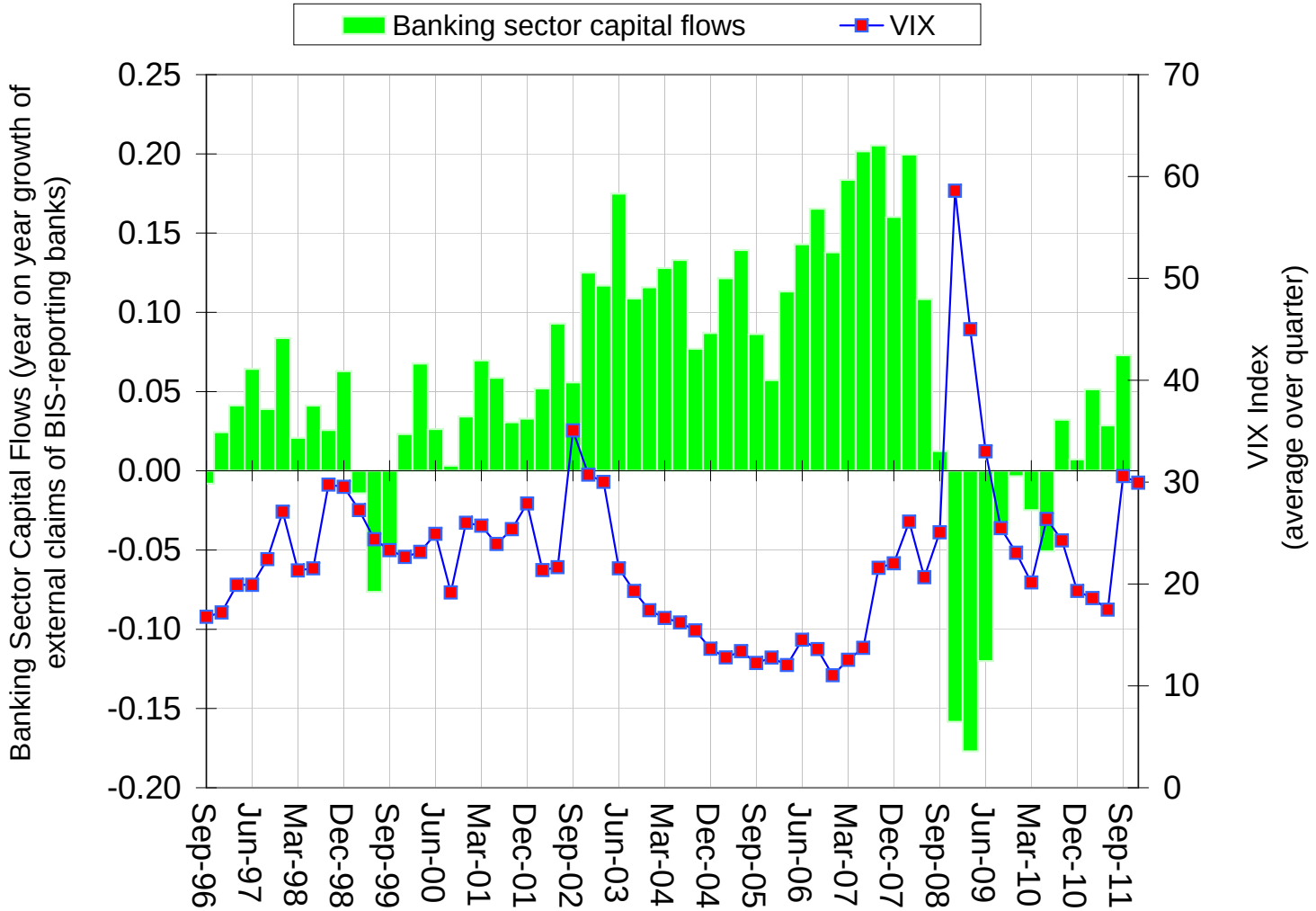



Figure 14. This figure plots cross-border banking sector capital flows as year-on-year growth in external claims of BIS-reporting banks (Table 7A). The VIX series is the quarterly average of CBOE VIX index.

# Model Sketch

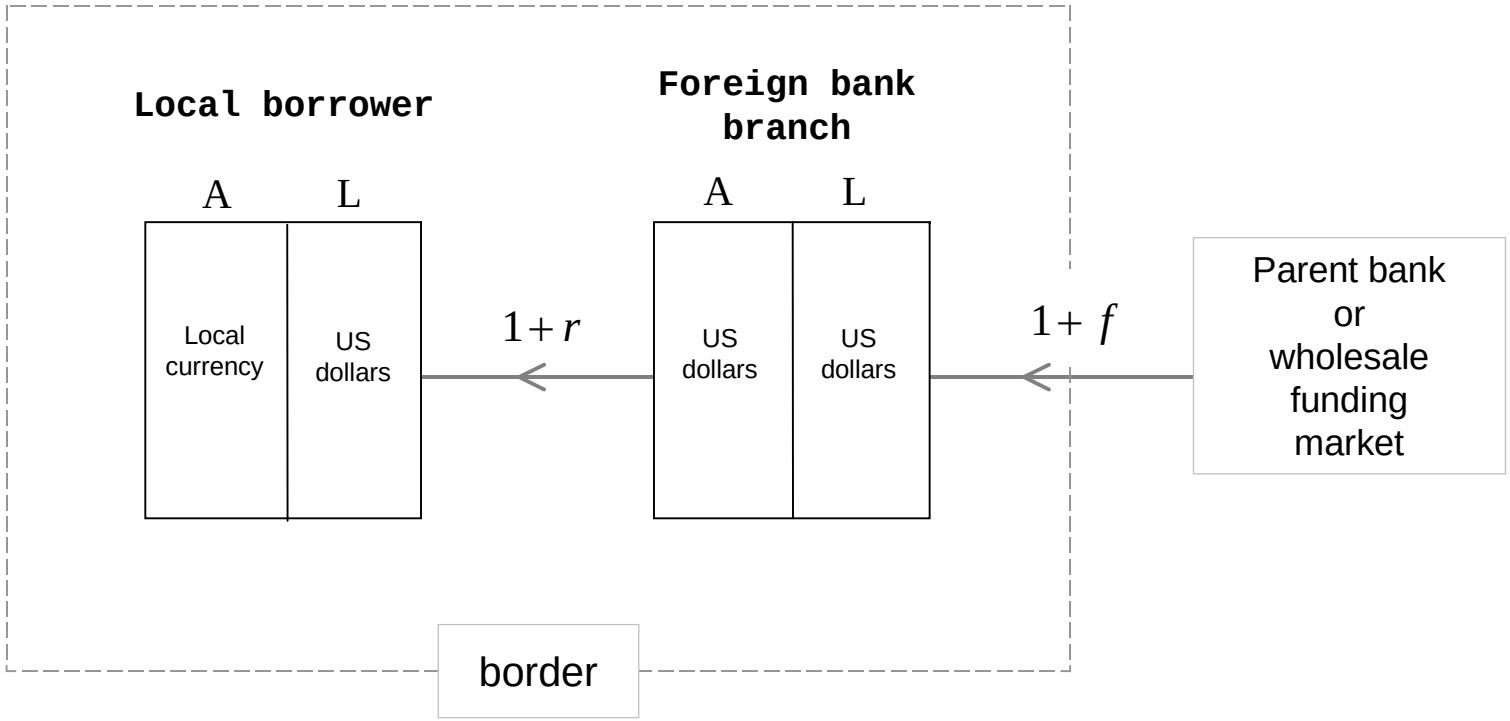
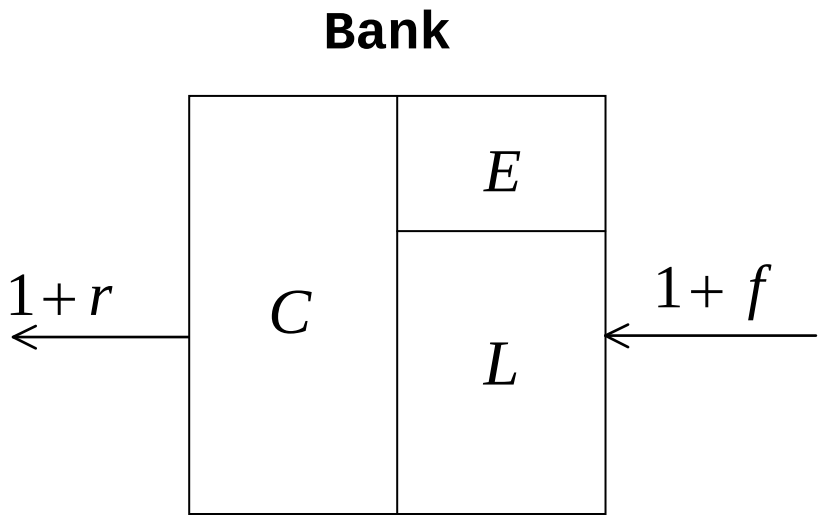



Figure 15. This figure depicts the lending relationships examined in the model. A foreign bank branch lends to local borrowers in dollars and finances its lending from the wholesale dollar funding market.

# Credit Supply

Notation for balance sheet of bank



# Borrowers

$F$ is debt with dollar face value $F$, maturing at date $T$.

Value of the borrower's project (in local currency) at date $T$ is

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

$W_j$ is a standard normal

Borrower defaults when

$$\theta_T V_T < F$$

$\theta_T$ is value of local currency against dollars

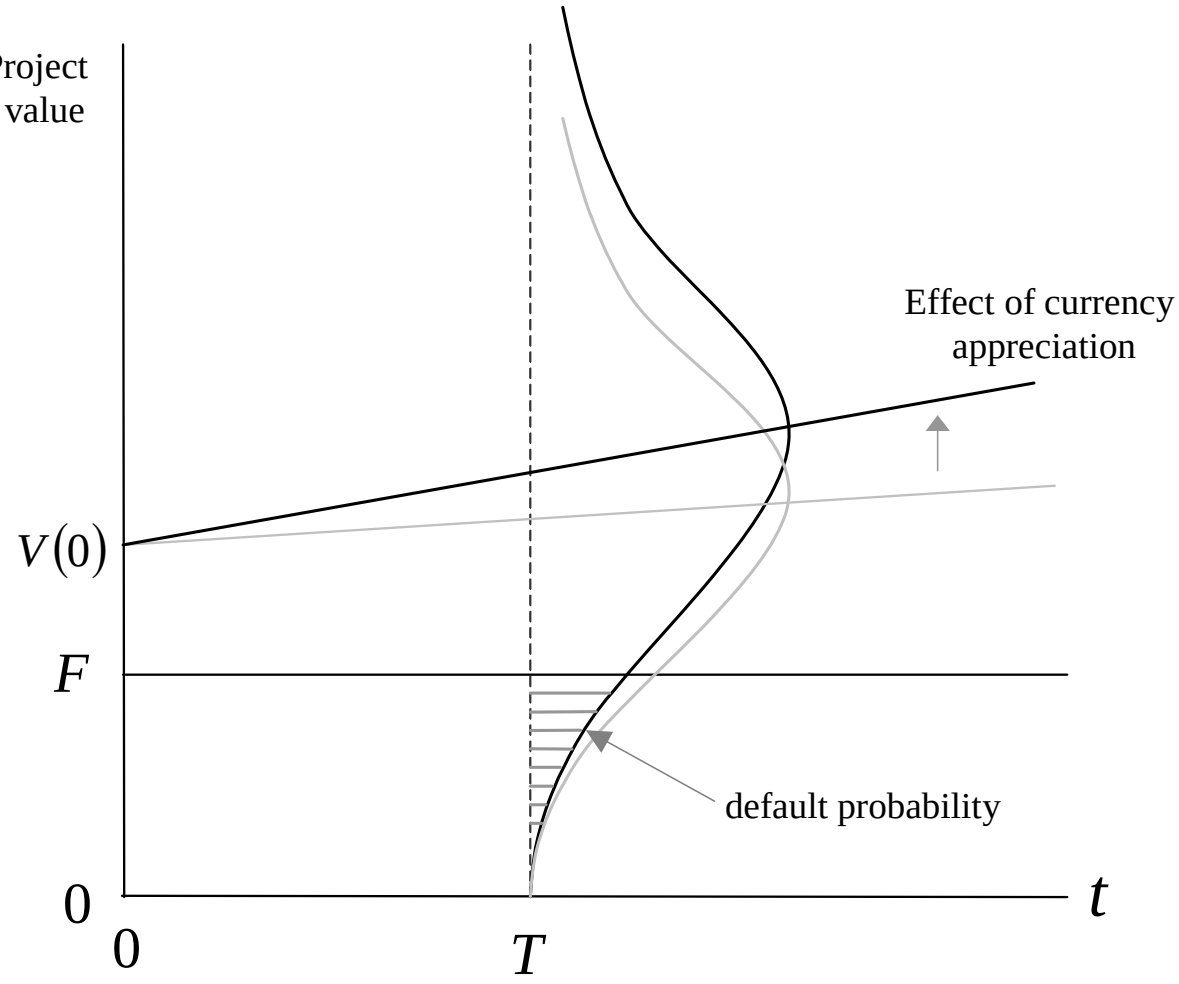



Figure 16. Project value $V_T$ and notional debt $F$ for local borrowers. The borrower defaults when $V_T$ falls short of the notional debt $F$. The effect of a currency appreciation is to shift the outcome density upward, lowering the default probability.

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

$d$ is the *distance to default*

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

# Loan Portfolio of Banks

Each bank has a well diversified loan portfolio consisting of loans to many borrowers.

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

where $Y$ and $\{X_j\}$ are mutually independent standard normals.

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

$$\begin{aligned} Z_j &= d_j + W_j \\ &= d_j + \sqrt{\rho} Y + \sqrt{1-\rho} X_j \\ &= -\Phi^{-1}(\varepsilon) + \sqrt{\rho} Y + \sqrt{1-\rho} X_j \end{aligned}$$

## Realized value of assets at date 1

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

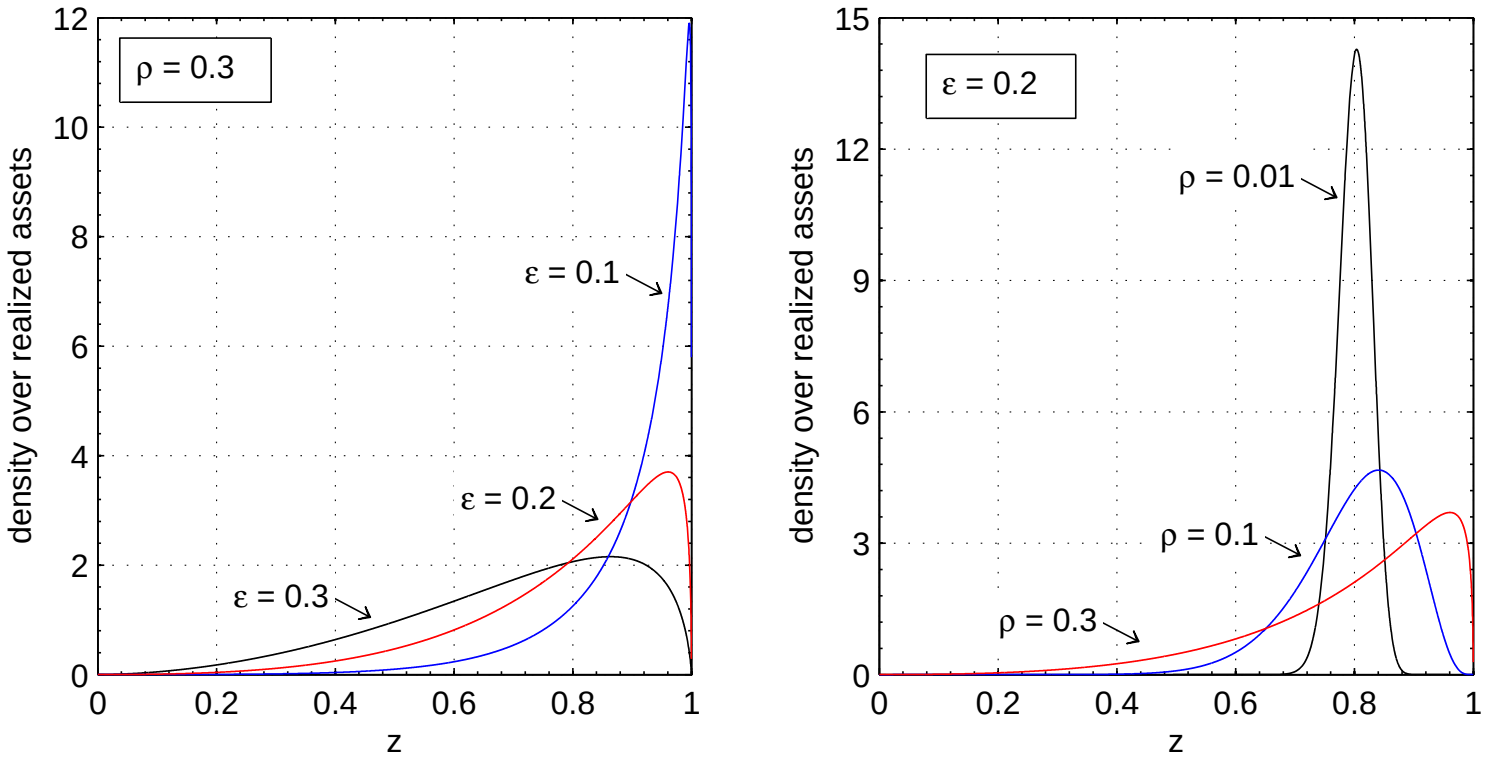



Figure 17. The two charts plot the densities over realized assets when $C(1+r)=1$. The left hand charts plots the density over asset realizations of the bank when $\rho = 0.1$ and $\varepsilon$ is varied from 0.1 to 0.3. The right hand chart plots the asset realization density when $\varepsilon = 0.2$ and $\rho$ varies from 0.01 to 0.3.

## c.d.f. of $w$

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

Value-at-Risk (VaR) rule with insolvency probability to $\alpha > 0$ when notional liability is $(1+f)\,L$.

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

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

where

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

# Supply of Credit

Credit supply $C$ and demand for funding $L$ is obtained from (1) and balance sheet identity $C = E + L$

$$C = \frac{E}{1 - \frac{1+r}{1+f} \cdot \varphi}, \qquad L = \frac{E}{\frac{1+f}{1+r} \cdot \frac{1}{\varphi} - 1}$$

Aggregation holds due to proportionality

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

# Amplification Channel

- Suppose $\theta_T$ is increasing in $L$ (capital inflows exert upward pressure on exchange rate)

- Fall in funding cost $f$ has
  - *initial impact*
  - *amplification effect*

- Lending depends on measured risks; and risks are dampened by lending

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

Both downward-sloping

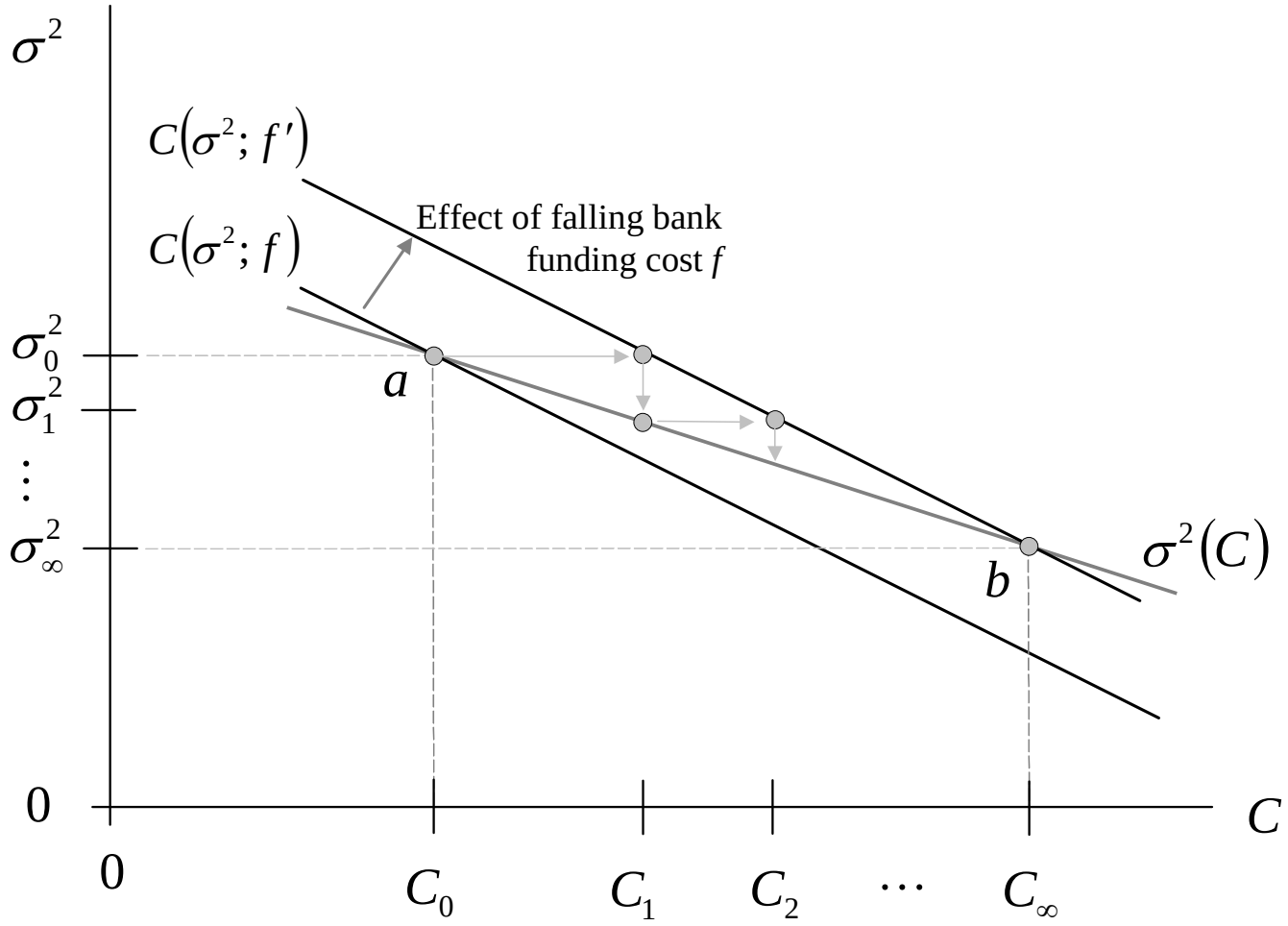



Figure 18. Impact of a decline in bank funding cost $f$ consisting of the initial impact and the amplification effect.

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

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

$g\left(.\right)$ is density of project outcomes

$z^*$ is default threshold in domestic currency

# Effect of Currency Intervention

Intervention can dampen amplification channel

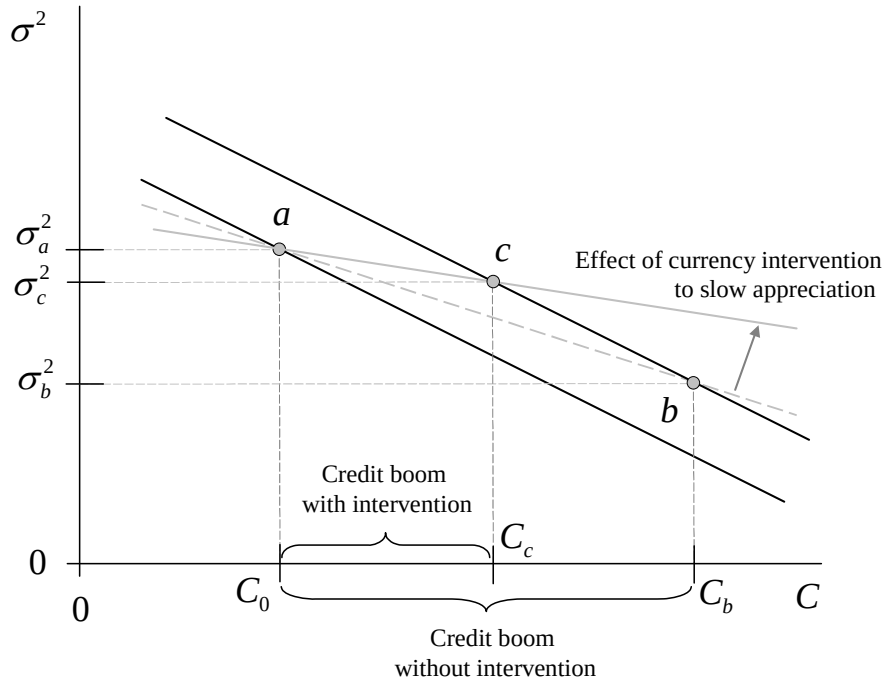



Figure 19. Effect of intervention to mitigate currency appreciation

# Closed-Form Solution for Cross-Border Banking Exposures

Bruno and Shin (2011)

$$\text{Total cross-border lending} = \frac{\text{Global and weighted regional bank capital}}{1 - \text{spread} \times \text{regional leverage} \times \text{global leverage}}$$

Leverage is normalized to lie between zero and one.

Spread is between lending rate to non-bank borrowers in recipient country and borrowing rate of global banks

| Panel regression: dependent variable is growth of BIS-reporting banks' lending in recipient country | | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| $\Delta$Interoffice | 0.0096*** | | | | 0.0097*** | 0.0082*** |
| | [0.000] | | | | [0.000] | [0.004] |
| VIX | | -0.0579*** | -0.0670*** | | -0.0417*** | -0.0383*** |
| | | [0.000] | [0.000] | | [0.000] | [0.000] |
| $\Delta$VIX | | | -0.0243*** | | -0.0264*** | -0.0210*** |
| | | | [0.000] | | [0.000] | [0.005] |
| RER | | | | | -0.0815*** | -0.0831*** |
| | | | | | [0.000] | [0.000] |
| $\Delta$equity | | | | 0.0280*** | 0.2638** | 0.2981** |
| | | | | [0.001] | [0.025] | [0.018] |
| $\Delta$equity*VIX | | | | | -0.0967** | -0.1096*** |
| | | | | | [0.013] | [0.009] |
| $\Delta$M2 | | | | | 0.0239 | 0.0251 |
| | | | | | [0.232] | [0.252] |
| GDP growth | | | | | 0.2766*** | 0.3208*** |
| | | | | | [0.000] | [0.000] |
| Debt to GDP | | | | | -0.0894*** | -0.0810** |
| | | | | | [0.005] | [0.013] |
| RLR | | | | | | 0.005 |
| | | | | | | [0.909] |
| Constant | 0.0242*** | 0.2012*** | 0.2287*** | 0.0204*** | 0.3136*** | 0.3045*** |
| | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] |
| Observations | 3,185 | 3,185 | 3,185 | 2,744 | 2,468 | 2,228 |
| R-squared | 0.006 | 0.039 | 0.043 | 0.003 | 0.118 | 0.122 |
| # countries | 49 | 49 | 49 | 49 | 48 | 47 |

| Panel regression: dependent variable is growth of BIS-reporting banks' lending in recipient country | | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| $\Delta$Interoffice | 0.0096*** | | | | 0.0097*** | 0.0082*** |
| | [0.000] | | | | [0.000] | [0.004] |
| VIX | | -0.0579*** | -0.0670*** | | -0.0417*** | -0.0383*** |
| | | [0.000] | [0.000] | | [0.000] | [0.000] |
| $\Delta$VIX | | | -0.0243*** | | -0.0264*** | -0.0210*** |
| | | | [0.000] | | [0.000] | [0.005] |
| RER | | | | | -0.0815*** | -0.0831*** |
| | | | | | [0.000] | [0.000] |
| $\Delta$equity | | | | 0.0280*** | 0.2638** | 0.2981** |
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|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| $\Delta$Interoffice | 0.0096*** | | | | 0.0097*** | 0.0082*** |
| | [0.000] | | | | [0.000] | [0.004] |
| VIX | | -0.0579*** | -0.0670*** | | -0.0417*** | -0.0383*** |
| | | [0.000] | [0.000] | | [0.000] | [0.000] |
| $\Delta$VIX | | | -0.0243*** | | -0.0264*** | -0.0210*** |
| | | | [0.000] | | [0.000] | [0.005] |
| RER | | | | | -0.0815*** | -0.0831*** |
| | | | | | [0.000] | [0.000] |
| $\Delta$equity | | | | 0.0280*** | 0.2638** | 0.2981** |
| | | | | [0.001] | [0.025] | [0.018] |
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| Debt to GDP | | | | | -0.0894*** | -0.0810** |
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| | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] |
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| R-squared | 0.006 | 0.039 | 0.043 | 0.003 | 0.118 | 0.122 |
| # countries | 49 | 49 | 49 | 49 | 48 | 47 |

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| $\Delta$Interoffice | 0.0104*** | 0.0076*** | 0.0074*** | 0.0074*** | 0.0075*** | 0.0076*** |
| | [0.000] | [0.002] | [0.003] | [0.003] | [0.002] | [0.002] |
| $\Delta$Interoffice*Korea | | | 0.0107*** | 0.0195*** | | |
| | | | [0.000] | [0.000] | | |
| $\Delta$Interoffice*Korea*Post 2010 | | | | -0.0314*** | | |
| | | | | [0.000] | | |
| VIX | -0.0629*** | -0.0498*** | -0.0498*** | -0.0499*** | -0.0485*** | -0.0485*** |
| | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] |
| VIX *Korea | | | | | -0.0621*** | -0.0631*** |
| | | | | | [0.000] | [0.000] |
| VIX *Korea*Post 2010 | | | | | | 0.0026* |
| | | | | | | [0.071] |
| $\Delta$VIX | -0.0214*** | -0.0211*** | -0.0212*** | -0.0211*** | -0.0212*** | -0.0212*** |
| | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] |
| RER | -0.0481*** | -0.0549*** | -0.0547*** | -0.0547*** | -0.0539*** | -0.0539*** |
| | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] |
| $\Delta$Money stock | | 0.7617*** | 0.7618*** | 0.7620*** | 0.7628*** | 0.7627*** |
| | | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] |
| GDP Growth | | 0.3008*** | 0.3002*** | 0.3001*** | 0.3013*** | 0.3012*** |
| | | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] |
| Debt to GDP | | -0.0806** | -0.0805** | -0.0806** | -0.0813** | -0.0814** |
| | | [0.015] | [0.015] | [0.015] | [0.014] | [0.014] |
| Constant | 0.2962*** | 0.2729*** | 0.2728*** | 0.2731*** | 0.2720*** | 0.2720*** |
| | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] |
| Observations | 3,120 | 2,892 | 2,892 | 2,892 | 2,892 | 2,892 |
| R-squared | 0.057 | 0.146 | 0.146 | 0.146 | 0.147 | 0.147 |
| Number of countries | 48 | 48 | 48 | 48 | 48 | 48 |

# Time Series Analysis

Four-variable vector autoregression (VAR)

- VIX index of implied volatility on equity index options
- Forward term premium between the 10 year and 3 month US treasury rates (Gurkaynak, Sack, and Wright (2006))
- Feds Funds target rate
- Cross-border banking sector flows (BIS locational statistics, Table 7A)

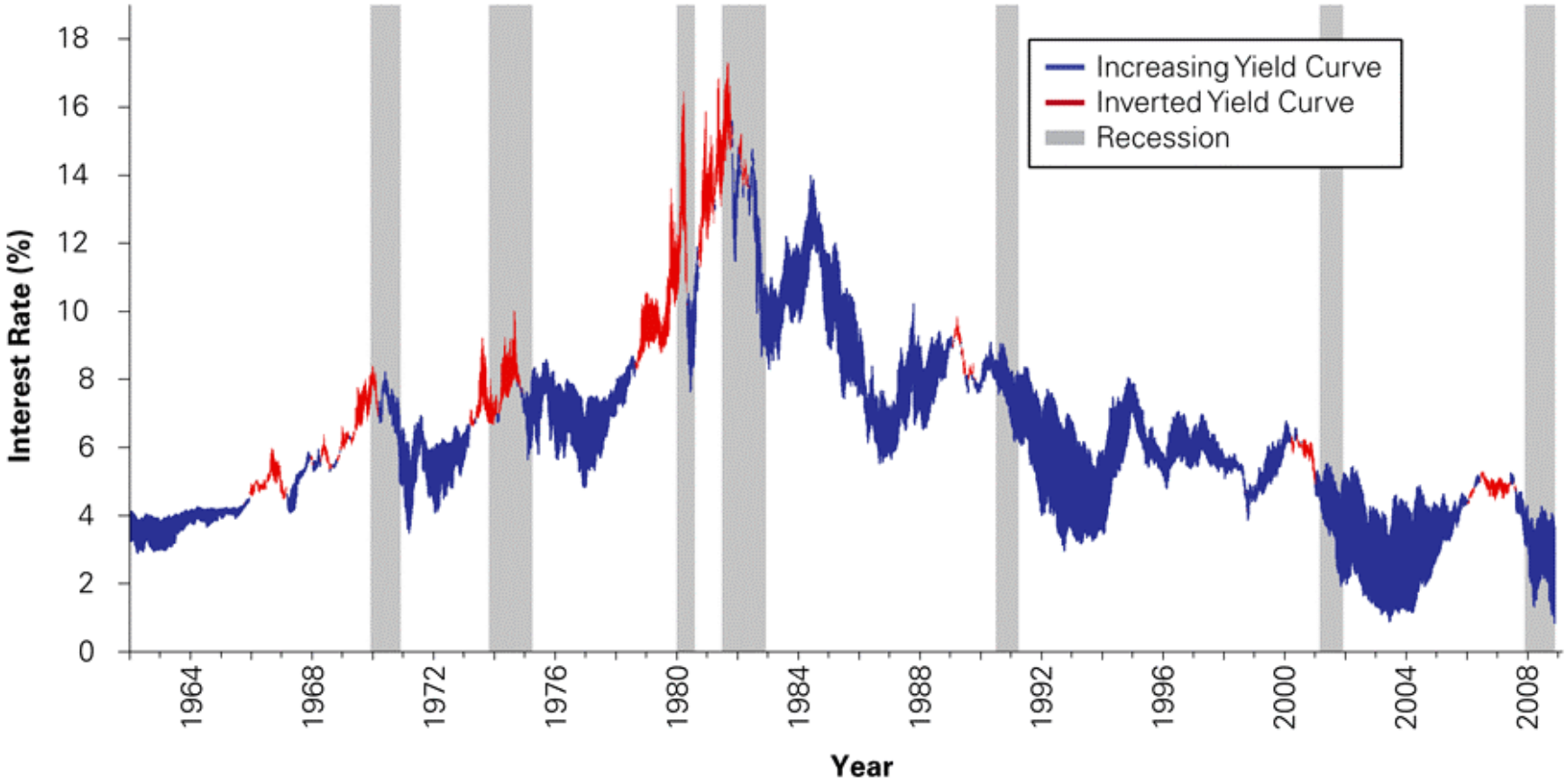



Figure 20. Term premium beween 10 year and 3 month US Treasury rates (Source: Berk and DeMarzo (2010))

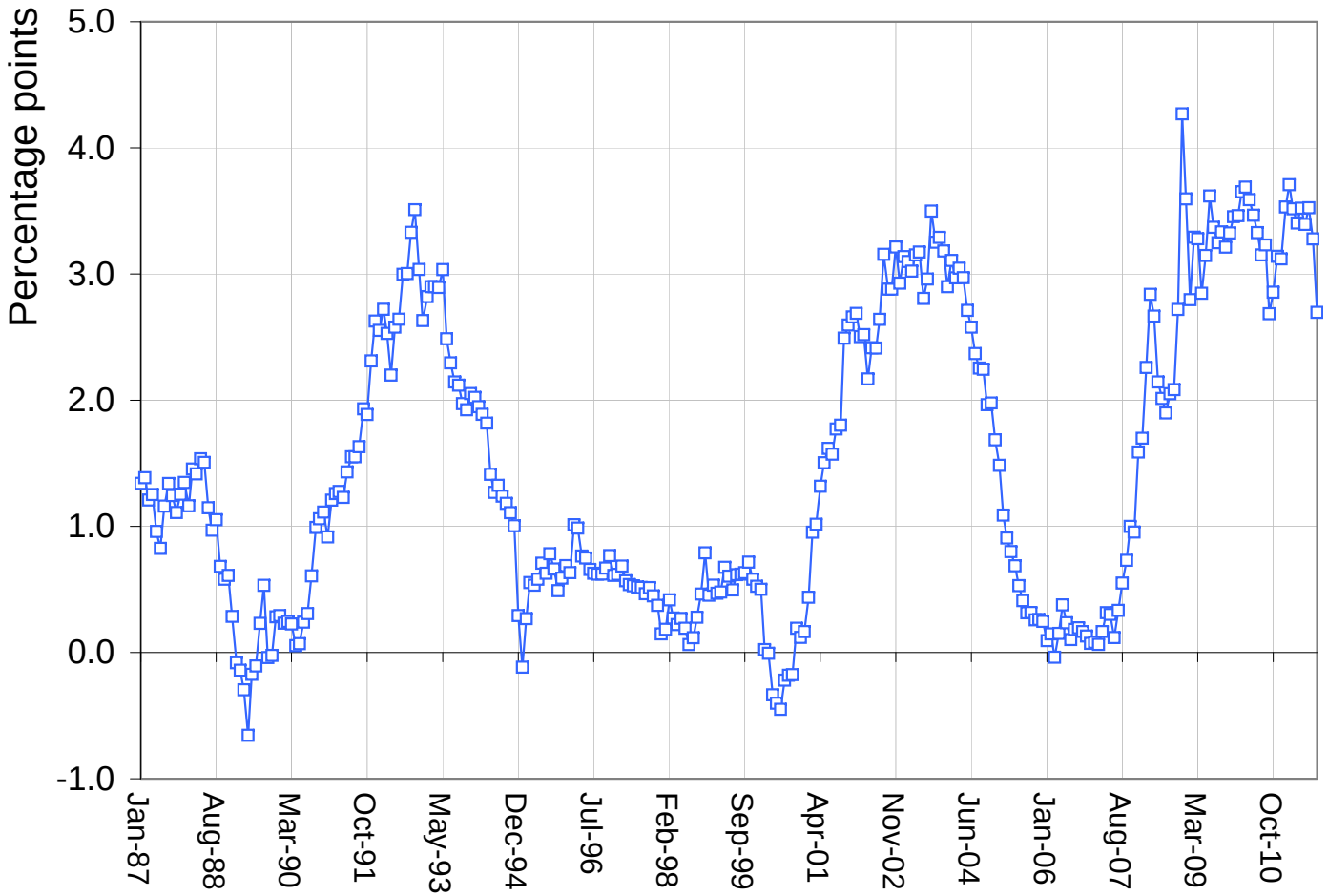



Figure 21. Twelve month forward term premium between 10 year and 3 month US Treasury rates. The series is computed following the methodology of Gurkaynak, Sack, and Wright (2006)

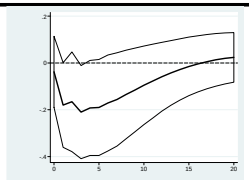
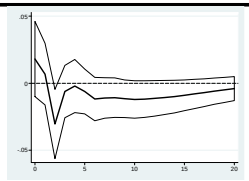
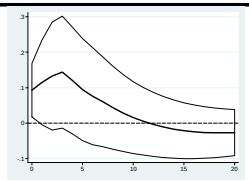
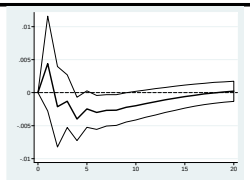
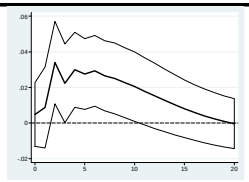
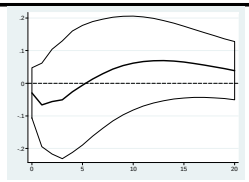
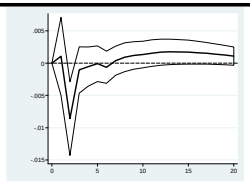
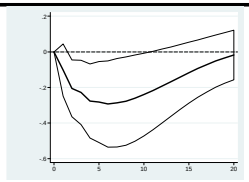
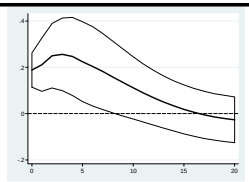
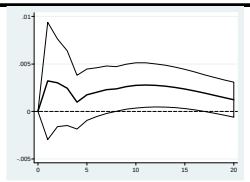
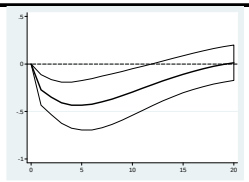
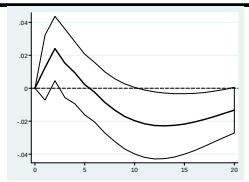
| Structural VAR | Cholesky ordering 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Impact of ($\downarrow$) | On LOANS | On Fed Funds | On VIX | On FTP |
| LOANS | |  |  |  |
| Fed Funds |  | |  |  |
| VIX |  |  | |  |
| FTP |  |  |  | |

Figure 22. **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.

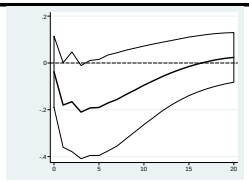
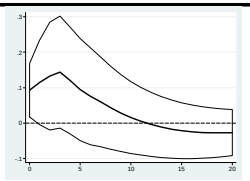
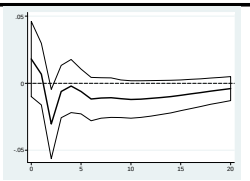
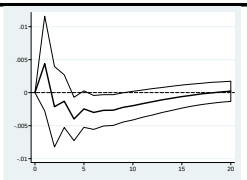
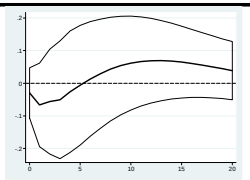
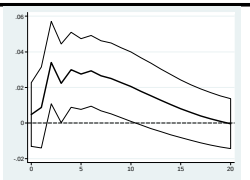
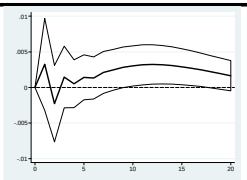
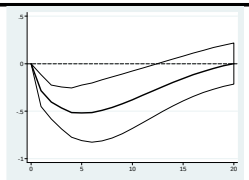
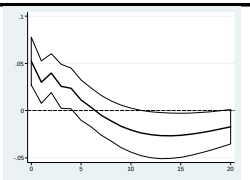
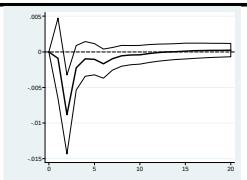
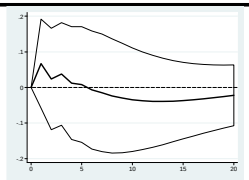
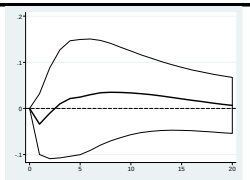
| Structural VAR | Cholesky ordering 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Impact of ($\downarrow$) | On LOANS | On Fed Funds | On FTP | On VIX |
| LOANS | |  |  |  |
| Fed Funds |  | |  |  |
| FTP |  |  | |  |
| VIX |  |  |  | |

Figure 23. **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.

# Tentative Conclusions

- US monetary policy has spillover effects through
  - Activity of global banks
  - Interplay between **risk-taking** and **measured risks**
  - **Global liquidity** is a meaningful concept
- Domestic credit conditions depend on global liquidity conditions
- Need to broaden discussions about exchange rates and global rebalancing in multilateral forums (e.g. G20) beyond current account and net capital flows
  - Importance of banking sector flows
  - September 2012 report of the *Committee on International Economic Policy and Reform*