Cross-Border Banking and Global Liquidity

Valentina Bruno       Hyun Song Shin

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“Global Liquidity”

- Global factor associated with credit availability and compressed risk premiums
- Strong cross-border element
Global Liquidity: Two Phases

- **First Phase of Global Liquidity (2003 - 2008)**
  - Bank-driven
  - Key theme is leverage
  - Main actors: global banks intermediating US dollar credit
  - Global factor is leverage of global banks

- **Second Phase of Global Liquidity (2010 - )**
  - Bond market-driven
  - Key theme is search for yield
  - Main actors: Asset managers with global reach

This paper is about the First Phase
“Triple Coincidence”

• Boundary of national income area

• Boundary defining decision-making unit with coherent preferences
  – Consumption and savings decisions (e.g. “global savings glut”)
  – Portfolio choice decisions (e.g. preference for “safe assets”)

• Boundary defining currency area
  – Exchange rate as relative price level
Figure 1. Boundary for national income accounting defines “economic territory”
Figure 2. Boundary for national income accounting defines decision-making unit
Figure 3. Boundary for national income accounting defines exchange rates as relative prices across boundary.
Figure 4. Foreign currency claims and liabilities of BIS reporting banks (Source: BIS Locational statistics 5A)
Figure 5. 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 6. 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 7. 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 8. Cross-border bank lending in US Dollars
Where to draw the boundary?

The balance sheet chain is consistent with many variants with different placement of the border:

- The local bank can be within the border (say, branch of foreign-owned bank)

- The local bank can be in a neighbouring jurisdiction

- The asset side of the global bank could be in a regional financial centre (Hong Kong or Singapore, say)

- The liabilities side of the global bank could in the United States

- What of the European headquarters? Where does it fit in the picture?
US dollar depreciation and global lending boom

- Local currency appreciation strengthens borrower balance sheet
- Creates slack in lending capacity of local banks; creates slack in global bank lending capacity; local and global banks drive credit boom
- Higher interest rate differential vis-à-vis the dollar amplifies boom
Figure 9. Cross-border claims (loans and deposits) of BIS reporting banks on counterparties listed on right
(Source: BIS locational banking statistics Table 7A)
Figure 10. Cross-border claims (loans and deposits) of BIS reporting banks on counterparties listed on right (Source: BIS locational banking statistics Table 7A)
Figure 11. **Cross-border liabilities by type of counterparty.** Left panel shows cross-border debt liabilities by pairwise classification of borrower and lender. “Bank to bank” refers to cross-border claims of banks on other banks (BIS banking statistics table 7A minus 7B). “Bank to non-bank” refers to cross-border claims of banks on non-banks (BIS table 7B). Claims of non-banks are from BIS international debt security statistics, tables 11A and 11B). The right panel shows cross-border debt liabilities of developed countries according to BIS classification.
Figure 12. **Cross-border bank-to-bank liabilities.** Left panel shows cross-border bank-to-bank debt liabilities as percentage of GDP of the recipient economy. The right panel shows cross-border bank-to-bank debt liabilities as percentage of total private credit in recipient economy. Cross-border bank-to-bank liabilities are from the BIS banking statistics (table 7A minus 7B). GDP and private credit data are from the World Bank.
Timeline for borrower

Exchange rate $\theta_0$
Loan granted

Exchange rate $\theta_1$
Loan repaid

0

1
**Borrowers**

Many potential borrowers indexed by $j$; purchase asset for 1 dollar by borrowing at rate $r$

Effort cost $e_j$, distributed in the population according to $H(.)$

$\theta_t$ is exchange rate (increase in $\theta_t$ is *appreciation* of local currency). $\bar{\theta}_1$ is date 0 expected value of $\theta_1$

Dollar value of project at date 1 is

$$\theta_1 V_1 = \exp \left\{ \mu (\bar{\theta}_1) - \frac{s^2}{2} + s W_j \right\}$$  \hspace{1cm} (1)

$W_j$ is a standard normal, $\mu(\cdot)$ is increasing function of $\bar{\theta}_1$
Figure 13. The borrower defaults when $\theta_1 V_1$ falls short of the notional debt $1 + r$. The effect of a currency appreciation is to shift the outcome density upward, lowering the default probability.
Borrower $j$ with effort cost $e_j$ undertakes the project if

$$E \left( \max \{0, \theta_1 V_1 - (1 + r)\} \right) - e_j \geq 0$$  \hfill (2)

Denote by $e^* (r)$ the threshold effort cost level where (2) holds with equality when the loan rate is $r$.

Loan demand is

$$C_d (r) = H \left( e^* (r) \right)$$  \hfill (3)

- decreasing in borrowing rate $r$ and
- increasing in expected appreciation of local currency $\bar{\theta}_1$
Borrower defaults when $\theta_1 V_1 < 1 + r$. Probability of default viewed from date 0 is

$$\text{Prob} (\theta_1 V_1 < 1 + r) = \text{Prob} \left( W_j < -\frac{\ln(1/(1+r)) + \mu - s^2/2}{s} \right)$$

$$= \Phi (-d_j)$$

where $d_j$ is distance to default:

$$d_j = \frac{-\ln (1 + r) + \mu (\bar{\theta}_1) - s^2/2}{s}$$

Probability of default is falling in $\bar{\theta}_1$
Vasicek (2002):

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

Borrower \( j \) repays the loan when \( Z_j \geq 0 \), where \( Z_j \) is the random variable:

\[ Z_j = d_j + \sqrt{\rho Y} + \sqrt{1 - \rho X_j} \]
\[ = -\Phi^{-1}(\varepsilon) + \sqrt{\rho Y} + \sqrt{1 - \rho X_j} \]

Realized value of assets at date 1

\[ w(Y) \equiv (1 + r)C \cdot \Pr(Z_j \geq 0|Y) \]
\[ = (1 + r)C \cdot \Pr\left(\sqrt{\rho Y} + \sqrt{1 - \rho X_j} \geq \Phi^{-1}(\varepsilon)|Y\right) \]
\[ = (1 + r)C \cdot \Phi\left(\frac{Y \sqrt{\rho} - \Phi^{-1}(\varepsilon)}{\sqrt{1 - \rho}}\right) \]
Figure 14. 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.
Figure 15. **Three modes of leveraging up:** Mode 1 is through an equity buyback through a debt issue. Mode 2 is through a dividend financed by asset sale. Mode 3 is through increased borrowing to fund new assets. In each case the grey area indicates balance sheet component that is held fixed.
Figure 16. BNP Paribas: annual change in assets, equity and debt (1999-2010) (Source: Bankscope)
Societe Generale: annual changes in assets, equity and debt (1999 - 2010)

Figure 17. Société Générale: annual change in assets, equity and debt (1999-2010) (Source: Bankscope)
Credit Supply by Banks

- Book equity is given

- Credit supply is
  \[ \text{Equity} \times \text{Leverage} \]
  So theory of leverage is theory of credit supply

- \( \Rightarrow \) Credit supply (hence, capital flows, interbank runs) depend on risk conditions
Assets or Enterprise Value?

Enterprise value is defined as

\[
\text{Enterprise value} = \text{market capitalization} + \text{debt}
\]

- Enterprise value addresses \textit{how much a bank is worth}
- Total assets address \textit{how much a bank lends}

Here, we focus on total assets, as we are interested in cross-border lending
Determinants of Regional Bank Lending

Risk-neutral regional banks with fixed $E_R$

Choice variable is $C$ (equivalently, $L$ or leverage)

Banks maximize expected value of book equity:

\[
\text{Equity value} = \text{Asset value} - \text{Debt value}
\]
\[= \text{Asset value} - \text{Notional debt} + \text{Option value of default} \]

Contracting problem with moral hazard (Adrian and Shin (2014))

Leverage is constrained by creditors
Notation

Bank

\[
\begin{array}{ccc}
  & C & \\
1+r & E & 1+f \\
  & L & \\
\end{array}
\]
Moral Hazard Problem

- Good portfolio: probability of default $\varepsilon$ and correlation $\rho > 0$

- Bad portfolio: probability of default $\varepsilon + k$ ($k > 0$) correlation $\rho' > \rho$
  (higher option value of limited liability)

Good portfolio realized value:

$$w_G(Y) = (1 + r) C \cdot \Pr \left( \sqrt{\rho} Y + \sqrt{1 - \rho} X_j \geq \Phi^{-1}(\varepsilon) \mid Y \right)$$

$$= (1 + r) C \cdot \Phi \left( \frac{Y \sqrt{\rho} - \Phi^{-1}(\varepsilon)}{\sqrt{1 - \rho}} \right)$$

(4)
Normalized asset realization \( \hat{w}_G (Y) \equiv w_G (Y) / (1 + r) C \) has c.d.f.

\[
F_G (z) = \Pr(\hat{w}_G \leq z) \\
= \Pr(Y \leq \hat{w}_G^{-1} (z)) \\
= \Phi(\hat{w}_G^{-1} (z)) \\
= \Phi \left( \frac{\Phi^{-1}(\epsilon) + \sqrt{1 - \rho} \Phi^{-1}(z)}{\sqrt{\rho}} \right) \tag{5}
\]

Bad portfolio \( \hat{w}_B (Y) \equiv w_B (Y) / (1 + r) C \) has c.d.f.

\[
F_B (z) = \Phi \left( \frac{\Phi^{-1}(\epsilon + k) + \sqrt{1 - \rho'} \Phi^{-1}(z)}{\sqrt{\rho'}} \right) \tag{6}
\]
ϕ is notional debt ratio of the bank:

\[ \varphi = \frac{(1+f)L}{(1+r)C} \]  

- ϕ is the default point of the bank as a proportion of its notional assets
- strike price of the embedded put option arising from limited liability

Risk-neutral bank chooses ϕ to maximize:

\[ E(\hat{w}) - [\varphi - \pi(\varphi)] \]  

subject to incentive compatibility constraint

\[ E_G(\hat{w}) - [\varphi - \pi_G(\varphi)] \geq E_B(\hat{w}) - [\varphi - \pi_B(\varphi)] \]
or

\[ \Delta \pi (\varphi) \leq k \]  

(10)

Lemma 1. There is a unique \( \varphi \) that solves \( \Delta \pi (\varphi) = k \).
Digression on Options and Outcome Distribution

Outcome space is \( \{0, 1, 2, \ldots, Z\} \).

\( p(s) \) is price of Arrow-Debreu contingent claim at outcome \( s \)
Put option with strike price $z$ has price

$$p(z - 1) + 2p(z - 2) + 3p(z - 3) + \cdots + zp(0)$$

**First difference** in option prices is c.d.f.

$$\pi(z) - \pi(z - 1) = p(z - 1) + 2p(z - 2) + 3p(z - 3) + \cdots + zp(0)$$

$$-p(z - 2) - 2p(z - 3) - \cdots - (z - 1)p(0)$$

$$= p(z - 1) + p(z - 2) + p(z - 3) + \cdots + p(0)$$

**Second difference** in option prices is (state price) density

In general, state price density is *second derivative* of option price w.r.t. strike price (Breeden and Litzenberger (Journal of Finance, 1978)).
Given risk-neutrality, $\Delta \pi (\varphi) = \int_{0}^{\varphi} [F_B(s) - F_G(s)] ds$. Since $F_G(z)$ cuts $F_B(z)$ once from below, $\Delta \pi (\varphi)$ is single-peaked. In particular,

$$\lim_{\varphi \to 1} \Delta \pi (\varphi) = \int_{0}^{1} [F_B(s) - F_G(s)] ds$$

$$= \int_{0}^{1} [1 - F_G(s)] ds - \int_{0}^{1} [1 - F_B(s)] ds$$

$$= \int_{0}^{1} sF_G(s) ds - \int_{0}^{1} sF_B(s) ds = k \quad (11)$$

so that $\Delta \pi (\varphi)$ approaches $k$ from above as $\varphi \to 1$. Since $\varphi < 1$ for any bank with positive notional equity, we have a unique solution to $\Delta \pi (\varphi) = k$. 


Default Probability of Regional Banks

Under incentive compatibility constraint, probability of default by the bank is

\[ \alpha = F_G(\varphi) \]

so that

\[ \alpha = \Phi \left( \frac{\Phi^{-1}(\varepsilon) + \sqrt{1 - \rho \Phi^{-1}(\varphi)}}{\sqrt{\rho}} \right) \]  \hspace{1cm} (12)

Since \( \varphi \) is uniquely solved by Lemma 1, and \( \varepsilon \) and \( \rho \) are parameters of the contracting problem, \( \alpha \) is also uniquely defined.

From the point of view of global banks, the regional banks are borrowers with default probability \( \alpha \), and same apparatus can be applied once more
Double-decker model of Global Liquidity

Figure 18. Regional and global bank balance sheets
Figure 19. Topography of global liquidity
Figure 20. Topography of global liquidity
Diversified loan portfolio from region $k$

Regional bank in $k$

Diversified loan portfolio *across* regional banks

Borrower $j$ in region $k$

Regions

Figure 21. Global and regional banks
Global, Regional and Idiosyncratic Risk Factors

\[ Z_{kj} \equiv -\Phi^{-1}(\varepsilon) + \sqrt{\rho}Y_k + \sqrt{1 - \rho}X_{kj} \]  \hspace{1cm} (13)

\[ Y_k = \sqrt{\beta G} + \sqrt{1 - \beta}R_k \]  \hspace{1cm} (14)

Global bank has a fully-diversified portfolio across regions. Regional bank \( k \) defaults when \( \hat{w}_G(Y_k) < \varphi \), or

\[ Y_k < \hat{w}^{-1}(\varphi) = \frac{\Phi^{-1}(\varepsilon) + \sqrt{1 - \rho}\Phi^{-1}(\varphi)}{\sqrt{\rho}} \]

\[ = \Phi^{-1}(\alpha) \]  \hspace{1cm} (15)

Equivalently, regional bank \( k \) defaults when \( \xi_k < 0 \), where \( \xi_k \) is the random
variable:

\[ \xi_k \equiv -\Phi^{-1}(\alpha) + Y_k \]
\[ = -\Phi^{-1}(\alpha) + \sqrt{\beta}G + \sqrt{1 - \beta}R_k \tag{16} \]

Global bank asset realization is deterministic function of global risk factor \( G \) only

\[ w(G) = (1 + f) L \cdot \Pr(\xi_k \geq 0 | G) \]
\[ = (1 + f) L \cdot \Pr (R_k \geq \frac{\Phi^{-1}(\alpha) - G\sqrt{\beta}}{\sqrt{1 - \beta}} | G) \]
\[ = (1 + f) L \cdot \Phi \left( \frac{G \sqrt{\beta} - \Phi^{-1}(\alpha)}{\sqrt{1 - \beta}} \right) \tag{17} \]
Normalized asset realization is $\hat{w}(G) = w(G) / (1 + f)L$ with c.d.f.

$$F(z) = \Phi(\hat{w}^{-1}(z))$$

$$= \Phi\left(\sqrt{1 - \beta} \Phi^{-1}(z) + \Phi^{-1}(\alpha)\right)$$ \hspace{1cm} (18)

**Global bank contracting problem.**

- Good portfolio has loans with default probability $\alpha$ but $\beta = 0$
- Bad portfolio probability of default $\alpha + h$, with $h > 0$, and $\beta' > 0$.

$$w_B(G) = (1 + f)L \cdot \Phi\left(\frac{G \sqrt{\beta'} - \Phi^{-1}(\alpha + h)}{\sqrt{1 - \beta'}}\right)$$ \hspace{1cm} (19)
Normalized \( \hat{w}_B (G) \equiv \frac{w_B (G)}{(1 + f) L} \) with c.d.f.

\[
F_B (z) = \Phi \left( \frac{\Phi^{-1}(\alpha+h) + \sqrt{1-\beta} \Phi^{-1}(z)}{\sqrt{\beta}} \right)
\]  

(20)

Outcome distribution of the good portfolio is

\[
F_G (z) = \begin{cases} 
0 & \text{if } z < 1 - \alpha \\
1 & \text{if } z \geq 1 - \alpha 
\end{cases}
\]  

(21)

Notional debt ratio \( \psi = \frac{(1 + i) M}{(1 + f) L} \).

Bank maximizes

\[
E (\hat{w}) - [\psi - \pi (\psi)]
\]  

(22)
subject to incentive compatibility constraint

\[ E_G(\hat{w}) - [\psi - \pi_G(\psi)] \geq E_B(\hat{w}) - [\psi - \pi_B(\psi)] \]  

(23)

or

\[ \Delta \pi(\psi) \leq h \]  

(24)

Lemma 2. There is a unique \( \psi \) that solves \( \Delta \pi(\psi) = h \), where \( \psi < 1 - \alpha \).

(debt issued by global bank is risk-free)
Closed Form Solution

Market clearing for $L$

$$\frac{E_R}{1 + \frac{r}{1 + f} \cdot \frac{1}{\varphi} - 1} = \frac{E_G}{1 - \frac{1 + f}{1 + i} \psi}$$

Private credit

$$C = \frac{E_G + E_R}{1 - \frac{1 + r}{1 + i} \varphi \psi}$$

Total private credit

$$= \frac{\text{Aggregate bank capital (regional + global)}}{1 - \text{spread} \times \text{regional leverage} \times \text{global leverage}}$$
Equilibrium stock of cross-border lending $L$

$$L = \frac{E_G + E_R \cdot \frac{1+r}{1+i} \varphi \psi}{1 - \frac{1+r}{1+i} \varphi \psi}$$

Total cross-border lending $= \frac{\text{Global and weighted regional bank capital}}{1 - \text{spread} \times \text{regional leverage} \times \text{global leverage}}$
Figure 22. Credit supply curve of local bank. Equilibrium in loan market is obtained by crossing supply and demand for loans. Equilibrium loan amount is increasing in expected appreciation $\bar{\theta}_1/\theta_0$. But lending rate $r^*$ could go either way.
Figure 23. Model is closed by determining date 0 exchange rate $\theta_0$. Fix $\bar{\theta}_1$. The banks supply $L$ dollars in spot market, while non-banks demand $D$ dollars in spot market. $\theta_0$ clears the spot market at date 0.
Comparative Statics

Global factors $E_G$ and $\psi$

\[
\Delta L \approx \frac{\partial L}{\partial E_G} \Delta E_G + \frac{\partial L}{\partial \psi} \Delta \psi \\
= \frac{1}{1 - \varphi \psi} \Delta E_G + \left( \frac{(1 - \varphi \psi) E_R \varphi - (E_G + E_R \varphi \psi)(-\varphi)}{(1 - \varphi \psi)^2} \right) \Delta \psi \\
= \frac{1}{1 - \varphi \psi} \Delta E_G + C \frac{\varphi}{1 - \varphi \psi} \Delta \psi
\]

Banking sector capital flows (i) increase with $\Delta E_G$ (ii) increase with bank leverage (iii) increase in change in bank leverage
Proposition 1. The model has a unique solution. Total credit in the regions is

\[ C = \frac{E_G + E_R}{1 - \frac{1+r}{1+i} \varphi \psi} \]  

(25)

and total cross-border lending is

\[ L = \frac{E_G + E_R \cdot \frac{1+r}{1+i} \varphi \psi}{1 - \frac{1+r}{1+i} \varphi \psi} \]  

(26)

where \( i \) is the risk-free US dollar interest rate.

(Geanakoplos (2009) and Fostel and Geanakoplos (2012): default does not happen precisely because the contract addresses the possibility of default)
Figure 24. **Risk capacity of global banking system.** This figure shows the impact of increased default risk from $\varepsilon$ to $\varepsilon'$ on the leverage of global and regional banks.
Corollary 1. *US dollar appreciation is associated with deleveraging somewhere in the global banking system*

Corollary 2. *Greater fundamental risk is associated with deleveraging somewhere in the global banking system*

Corollary 3. *Cross-border lending is increasing in global banks’ leverage, growth in global banks’ leverage, and growth in global banks’ equity.*

Corollary 4. *Cross-border lending is increasing in local banks’ leverage, growth in local banks’ leverage, and growth of local banks’ equity.*

Corollary 5. *Cross-border lending is increasing in the spread between local lending rate $r$ and money market rate $i$. 
Empirical Counterparts

Figure 25. Leverage of US Securities broker dealer sector (Source: Federal Reserve Flow of Funds)
Figure 26. Cross-border claims (loans and deposits) of BIS reporting banks on counterparties listed on right (Source: BIS locational banking statistics Table 7A)
Sample

Sample of 46 countries with largest foreign bank penetration (Claessens, van Horen, Gurcanlar and Mercado (2008))

Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, Cyprus, Czech Republic, Denmark, Egypt, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Indonesia, Ireland, Israel, Italy, Japan, Latvia, Lithuania, Malaysia, Malta, Mexico, Netherlands, Norway, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, South Korea, Spain, Sweden, Switzerland, Thailand, Turkey, Ukraine, United Kingdom and Uruguay.
### Summary Statistics

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Figure 27. Scatter chart of broker-dealer leverage and lagged log VIX
# Cross-Border Banking and Global Liquidity

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* *** indicates statistical significance at the 1% level.
Figure 28. 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.
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Robustness Analysis

- Crisis period dummy
  - Effect is larger during crisis period
  - But also at work during non-crisis periods

- Developing country dummy
  - No difference between developing and developed economies
  - Europe effect?