Bank Leverage Cycles

Galo Nuño and Carlos Thomas

Banco de España

ESSIM, May 23 2012

Introduction

- The 2007-2009 financial crisis has spurred research on the role played by financial intermediaries in its origin and propagation
- An influential line of research has focused on the collapse of the 'shadow banking' sector:
  - no access to central bank liquidity or deposit insurance
  - debt with very short maturity (repo, ABCP, etc.) backed by securitized assets
  - losses in subprime-related assets + uncertainty about risk exposure $\rightarrow$ collapse of funding (rise in *margins*/*haircuts*) $\rightarrow$ sharp *deleveraging* of 'shadow' institutions
- Gorton & Metrick (2010), Brunnermeier (2009), Geanakoplos (2010), Krishnamurthy et al. (2012), etc.

The importance of bank leverage

- Sharp changes in intermediary leverage not particular to this financial crisis
- Large swings in leverage of some types of intermediaries since 1960s (Adrian & Shin, 2010, 2011b)
- By definition,

$$\text{assets} = \text{leverage} \times \text{equity capital.}$$

- Given equity, market-driven changes in leverage affect the financial sector's ability to finance the real economy

This paper

Goals:

- Empirical: document the cyclical comovement of leverage and assets of financial intermediaries and GDP in the United States
- Theoretical: build a general equilibrium model with financial intermediation and endogenous leverage, and assess its ability to match the data

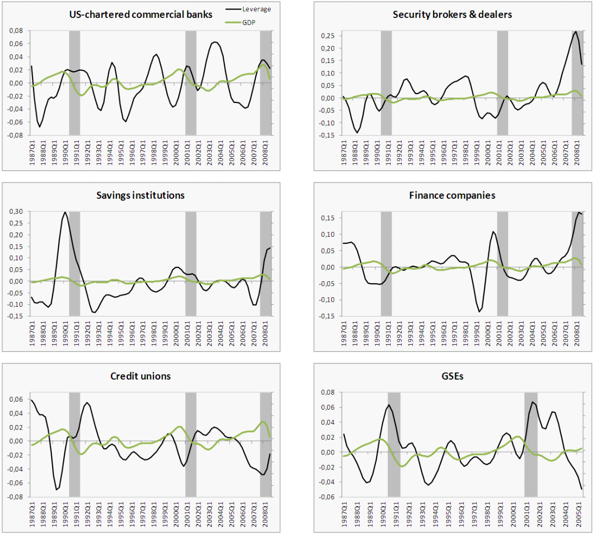
Contribution to the literature

- Most work on leverage cycles/margin spirals is qualitative, aimed at illustrating theoretical mechanisms (two/three periods, partial equilibrium)
  - Adrian and Shin (2011a), Brunnermeier and Pedersen (2009), Dang, Gorton & Holmström (2011), Geanakoplos (2010), etc.
  - We construct a fully dynamic, general equilibrium model than can be confronted with aggregate data
- DSGE models with financial intermediaries have thus far neglected the role of bank leverage:
  - Christiano, Motto & Rostagno (2010): no role for bank leverage, focus on *entrepreneurial* leverage
  - Gertler & Karadi (2011), Gertler & Kiyotaki (2011): leverage is endogenous, but its role in the propagation of shocks is left unexplained; focus on bank capital channel

Total assets and leverage of US financial intermediaries

Source: Flow of Funds; all series logged and BP(6,32)-filtered

Leverage and GDP



Source: Flow of Funds and BEA; all series logged and BP(6,32)-filtered

Business cycle statistics: US, 1984-2011

	Standard deviations (%)		
	Total assets	Leverage	GDP
			1.03
Regulated intermediaries			
US-chartered commercial banks	1.30	3.12	
Savings institutions	4.59	8.61	
Credit unions	2.34	2.75	
Unregulated intermediaries			
Security brokers and dealers	7.57	7.62	
Finance companies	3.05	5.34	
GSEs	3.85	2.90	

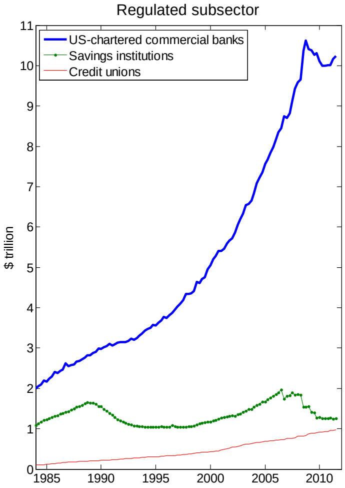
Source: Flow of Funds and BEA; total assets are divided by GDP deflator; all series logged and BP(6,32)-filtered

Business cycle statistics: US, 1984-2011

	Correlation assets & leverage	Correlation with GDP	
		Total assets	Leverage
US-chartered commercial banks	0.21 (0.0518)	0.46 ** (0.0000)	−0.06 (0.5942)
Savings institutions	0.32 ** (0.0023)	0.73 ** (0.0000)	0.34 ** (0.0014)
Credit unions	0.70 ** (0.0000)	−0.36 ** (0.0007)	−0.57 ** (0.0000)
Security brokers and dealers	0.76 ** (0.0000)	0.47 ** (0.0000)	0.22 * (0.0444)
Finance companies	0.52 ** (0.0000)	0.41 ** (0.0001)	0.24 * (0.0252)
GSEs	0.32 ** (0.0048)	0.33 ** (0.0045)	−0.14 (0.2376)

Source: Flow of Funds and BEA; total assets are divided by GDP deflator; all series logged and BP(6,32)-filtered. P-values of test of no correlation reported in parenthesis. Asterisks denote statistical significance of non-zero correlation at 1% (**) and 5% (*) confidence level

Total assets of leveraged financial subsectors

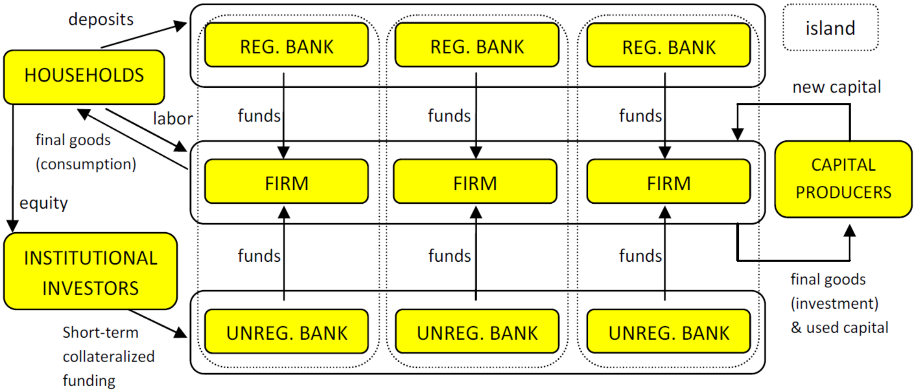


Note: All series from the US Flow of Funds.

Summary of empirical analysis

- Leverage and total assets are several times more volatile than GDP (all subsectors)
- Regulated intermediaries (mostly commercial banks): leverage is rather *a*cyclical with respect to total assets and GDP
- Unregulated intermediaries (mostly security broker/dealers & finance companies): leverage is strongly *pro*cyclical with respect to total assets, and marginally procyclical with respect to GDP

Model structure



Unregulated banks

- End of period $t-1$: unregulated bank in island j borrows B_{t-1}^{j} from institutional investors, commits to repay $\bar{B}_{t-1}^{j}$ in period t

Unregulated banks

- End of period $t-1$: unregulated bank in island j borrows B_{t-1}^{j} from institutional investors, commits to repay $\bar{B}_{t-1}^{j}$ in period t
- Bank purchases A_{t-1}^{j} state-contingent claims issued by island-j's firm, which are used as collateral

Unregulated banks

- End of period $t-1$: unregulated bank in island j borrows B_{t-1}^{j} from institutional investors, commits to repay $\bar{B}_{t-1}^{j}$ in period t
- Bank purchases A_{t-1}^{j} state-contingent claims issued by island-j's firm, which are used as collateral
- Beginning of t: bank collects gross return $R_t^A \omega^j$ on its assets, where

Unregulated banks

- End of period $t-1$: unregulated bank in island j borrows B^j_{t-1} from institutional investors, commits to repay $\bar{B}^j_{t-1}$ in period t
- Bank purchases A^j_{t-1} state-contingent claims issued by island-j's firm, which are used as collateral
- Beginning of t: bank collects gross return $R^A_t \omega^j$ on its assets, where
  - R^A_t: aggregate return on capital

Unregulated banks

- End of period $t-1$: unregulated bank in island j borrows B_{t-1}^{j} from institutional investors, commits to repay $\bar{B}_{t-1}^{j}$ in period t
- Bank purchases A_{t-1}^{j} state-contingent claims issued by island-j's firm, which are used as collateral
- Beginning of t: bank collects gross return $R_t^A \omega^j$ on its assets, where
  - R_t^A: aggregate return on capital
  - $\omega^j \geq 0$: island-specific return on capital $\sim$ iid $F\left(\omega^j; \sigma_{t-1}\right) \equiv F_{t-1}\left(\omega^j\right)$

Unregulated banks

- End of period $t-1$: unregulated bank in island j borrows B_{t-1}^{j} from institutional investors, commits to repay $\bar{B}_{t-1}^{j}$ in period t
- Bank purchases A_{t-1}^{j} state-contingent claims issued by island-j's firm, which are used as collateral
- Beginning of t: bank collects gross return $R_t^A \omega^j$ on its assets, where
  - R_t^A: aggregate return on capital
  - $\omega^j \geq 0$: island-specific return on capital $\sim$ iid $F\left(\omega^j; \sigma_{t-1}\right) \equiv F_{t-1}\left(\omega^j\right)$
- Dispersion of time-t island-specific shocks, σ_{t-1}, is known in $t-1$ and follows a stochastic process

Risky bank debt

- Unregulated bank repays debt only if

$$R_t^A \omega^j A_{t-1}^j \geq \bar{B}_{t-1}^j \Leftrightarrow \omega^j \geq \frac{\bar{B}_{t-1}^j}{R_t^A A_{t-1}^j} \equiv \bar{\omega}^j.$$

Risky bank debt

- Unregulated bank repays debt only if

$$R_t^A \omega^j A_{t-1}^j \geq \bar{B}_{t-1}^j \Leftrightarrow \omega^j \geq \frac{\bar{B}_{t-1}^j}{R_t^A A_{t-1}^j} \equiv \bar{\omega}^j.$$

- If $\omega^j < \bar{\omega}^j$, bank defaults and institutional investors receives return on collateral, $R_t^A \omega^j A_{t-1}^j$.

Risky bank debt

- Unregulated bank repays debt only if

$$R_t^A \omega^j A_{t-1}^j \geq \bar{B}_{t-1}^j \Leftrightarrow \omega^j \geq \frac{\bar{B}_{t-1}^j}{R_t^A A_{t-1}^j} \equiv \bar{\omega}^j.$$

- If $\omega^j < \bar{\omega}^j$, bank defaults and institutional investors receives return on collateral, $R_t^A \omega^j A_{t-1}^j$.
- If $\omega^j \geq \bar{\omega}^j$, net earnings, $R_t^A \omega^j A_{t-1}^j - \bar{B}_{t-1}^j$, are distributed as dividends (Π_t^j) or retained as net worth (N_t^j). Non-negativity constraint on dividends: $\Pi_t^j \geq 0$ (Gertler & Kiyotaki, 2010).

Risky bank debt

- Unregulated bank repays debt only if

$$R_t^A \omega^j A_{t-1}^j \geq \bar{B}_{t-1}^j \Leftrightarrow \omega^j \geq \frac{\bar{B}_{t-1}^j}{R_t^A A_{t-1}^j} \equiv \bar{\omega}^j.$$

- If $\omega^j < \bar{\omega}^j$, bank defaults and institutional investors receives return on collateral, $R_t^A \omega^j A_{t-1}^j$.
- If $\omega^j \geq \bar{\omega}^j$, net earnings, $R_t^A \omega^j A_{t-1}^j - \bar{B}_{t-1}^j$, are distributed as dividends (Π_t^j) or retained as net worth (N_t^j). Non-negativity constraint on dividends: $\Pi_t^j \geq 0$ (Gertler & Kiyotaki, 2010).
- Bank uses net worth and borrowed funds to finance new asset purchases,

$$A_t^j = B_t^j + N_t^j.$$

Participation constraint

- Institutional investors have access to a riskless return R_t.
- For them to be willing to finance the bank, the following *participation constraint* must hold

$$
\begin{aligned}
& E_t \Lambda_{t,t+1} \left\{ R^A_{t+1} A^j_t \int^{\bar{\omega}^j_{t+1}} \omega dF_t(\omega) + \bar{B}^j_t \left[1 - F_t\left(\bar{\omega}^j_{t+1}\right) \right] \right\} \\
\geq \quad & E_t \Lambda_{t,t+1} R_t B_t = B_t = A^j_t - N^j_t,
\end{aligned}
$$

$\Lambda_{t,t+1} \equiv \beta u'(C_{t+1}) / u'(C_t)$: stochastic discount factor

Incentive compatibility constraint

- Banks are subject to a *moral hazard* problem *à la* Adrian & Shin (2011)
- They can invest in either of two firm segments: 'standard' and 'substandard'
- Both differ only in the distribution of island-specific returns: $F_t(\omega)$ and $\tilde{F}_t(\omega)$
- Substandard segment has higher *downside* risk in the FOSD sense,

$$\tilde{F}_t(\omega) > F_t(\omega)$$

for all $\omega \Rightarrow$ lower mean return,

$$\int \omega d\tilde{F}_t(\omega) \equiv \tilde{E}(\omega) < E(\omega) = 1.$$

Incentive compatibility constraint (2)

- To induce the bank to invest efficiently, investors impose an *incentive compatibility* (IC) constraint,

$$
\begin{aligned}
& E_t \Lambda_{t,t+1} \int_{\bar{\omega}^j_{t+1}} \left\{ \theta V^j_{t+1} + (1-\theta) \left[R^k_{t+1} A^j_t \omega - \bar{B}^j_t \right] \right\} dF_t(\omega) \\
\geq \quad & E_t \Lambda_{t,t+1} \int_{\bar{\omega}^j_{t+1}} \left\{ \theta V^j_{t+1} + (1-\theta) \left[R^k_{t+1} A^j_t \omega - \bar{B}^j_t \right] \right\} d\tilde{F}_t(\omega),
\end{aligned}
$$

  where

  - $1-\theta$: exogenous bank exit probability (Gertler & Karadi, 2011)
  - V^j_{t+1}: continuation value of non-defaulting, non-exiting bank j

Incentive compatibility constraint (3)

- Bank's net return proportional to value of *call option* on island risk,

$$\int_{\bar{\omega}^j_{t+1}} \left(\omega - \bar{\omega}^j_{t+1}\right) dF_t(\omega) = E(\omega) + \pi_t\left(\bar{\omega}^j_{t+1}\right) - \bar{\omega}^j_{t+1},$$

where

$$\pi_t\left(\bar{\omega}^j_{t+1}\right) \equiv \int^{\bar{\omega}^j_{t+1}} \left(\bar{\omega}^j_{t+1} - \omega\right) dF_t(\omega)$$

is the value of *put option* with strike price $\bar{\omega}^j_{t+1}$; same for $\tilde{F}_t(\omega)$

Incentive compatibility constraint (3)

- Bank's net return proportional to value of *call option* on island risk,

$$\int_{\bar{\omega}^j_{t+1}} \left(\omega - \bar{\omega}^j_{t+1}\right) dF_t\left(\omega\right) = E\left(\omega\right) + \pi_t\left(\bar{\omega}^j_{t+1}\right) - \bar{\omega}^j_{t+1},$$

where

$$\pi_t\left(\bar{\omega}^j_{t+1}\right) \equiv \int^{\bar{\omega}^j_{t+1}} \left(\bar{\omega}^j_{t+1} - \omega\right) dF_t\left(\omega\right)$$

is the value of *put option* with strike price $\bar{\omega}^j_{t+1}$; same for $\tilde{F}_t\left(\omega\right)$

- FOSD of F over $\tilde{F}$ implies

$$\tilde{\pi}_t\left(\bar{\omega}_{t+1}\right) > \pi_t\left(\bar{\omega}_{t+1}\right)$$

for all $\bar{\omega}_{t+1}$. Bank trades off lower mean return against *higher option value*

Incentive compatibility constraint (3)

- Bank's net return proportional to value of *call option* on island risk,

$$\int_{\bar{\omega}^j_{t+1}} \left(\omega - \bar{\omega}^j_{t+1}\right) dF_t\left(\omega\right) = E\left(\omega\right) + \pi_t\left(\bar{\omega}^j_{t+1}\right) - \bar{\omega}^j_{t+1},$$

  where

$$\pi_t\left(\bar{\omega}^j_{t+1}\right) \equiv \int^{\bar{\omega}^j_{t+1}} \left(\bar{\omega}^j_{t+1} - \omega\right) dF_t\left(\omega\right)$$

  is the value of *put option* with strike price $\bar{\omega}^j_{t+1}$; same for $\tilde{F}_t\left(\omega\right)$

- FOSD of F over $\tilde{F}$ implies

$$\tilde{\pi}_t\left(\bar{\omega}_{t+1}\right) > \pi_t\left(\bar{\omega}_{t+1}\right)$$

  for all $\bar{\omega}_{t+1}$. Bank trades off lower mean return against *higher option value*
- Furthermore, $\Delta\pi\left(\bar{\omega}\right) \equiv \tilde{\pi}\left(\bar{\omega}\right) - \pi\left(\bar{\omega}\right)$ is increasing in $\bar{\omega} = \bar{B}^j / R^A_{+1} A^j$: incentive to invest in $\tilde{F}$ increases with (normalized) debt commitment

Solution to unregulated bank's problem

Bank maximizes stream of dividends s.t. above constraints[max] . Solution:

- Bank retains all earnings (pays dividends only at exogenous exit)

Solution to unregulated bank's problem

Bank maximizes stream of dividends s.t. above constraints[max] . Solution:

- Bank retains all earnings (pays dividends only at exogenous exit)
- Participation and IC constraints both hold with equality,

$$A_t^j = \frac{1}{1 - E_t \Lambda_{t,t+1} R_{t+1}^A \left[\bar{\omega}_{t+1} - \pi\left(\bar{\omega}_{t+1}; \sigma_t\right)\right]} N_t^j \equiv \phi_t N_t^j,$$

$$1 - \tilde{E}\left(\omega\right) = E_t \left\{ \frac{\Lambda_{t,t+1} R_{t+1}^A \left(\theta \lambda_{t+1} + 1 - \theta\right)}{E_t \Lambda_{t,t+1} R_{t+1}^A \left(\theta \lambda_{t+1} + 1 - \theta\right)} \Delta \pi \left(\bar{\omega}_{t+1}; \sigma_t\right) \right\},$$

where $\bar{\omega}_{t+1} = \bar{b}_t / R_{t+1}^A$, $\bar{b}_t \equiv \bar{B}_t^j / A_t^j$. *Leverage ratio* ϕ_t and normalized debt repayment $\bar{b}_t$ equalized across islands

Solution to unregulated bank's problem

Bank maximizes stream of dividends s.t. above constraints[max] . Solution:

- Bank retains all earnings (pays dividends only at exogenous exit)
- Participation and IC constraints both hold with equality,

$$A_t^j = \frac{1}{1 - E_t \Lambda_{t,t+1} R_{t+1}^A \left[\bar{\omega}_{t+1} - \pi\left(\bar{\omega}_{t+1}; \sigma_t\right)\right]} N_t^j \equiv \phi_t N_t^j,$$

$$1 - \tilde{E}\left(\omega\right) = E_t \left\{ \frac{\Lambda_{t,t+1} R_{t+1}^A \left(\theta \lambda_{t+1} + 1 - \theta\right)}{E_t \Lambda_{t,t+1} R_{t+1}^A \left(\theta \lambda_{t+1} + 1 - \theta\right)} \Delta\pi\left(\bar{\omega}_{t+1}; \sigma_t\right) \right\},$$

  where $\bar{\omega}_{t+1} = \bar{b}_t / R_{t+1}^A$, $\bar{b}_t \equiv \bar{B}_t^j / A_t^j$. *Leverage ratio* ϕ_t and normalized debt repayment $\bar{b}_t$ equalized across islands

- Given ϕ_t and $\bar{b}_t$, we can calculate

Solution to unregulated bank's problem

Bank maximizes stream of dividends s.t. above constraints[max] . Solution:

- Bank retains all earnings (pays dividends only at exogenous exit)
- Participation and IC constraints both hold with equality,

$$A_t^j = \frac{1}{1 - E_t \Lambda_{t,t+1} R_{t+1}^A \left[\bar{\omega}_{t+1} - \pi\left(\bar{\omega}_{t+1}; \sigma_t\right)\right]} N_t^j \equiv \phi_t N_t^j,$$

$$1 - \tilde{E}\left(\omega\right) = E_t \left\{ \frac{\Lambda_{t,t+1} R_{t+1}^A \left(\theta \lambda_{t+1} + 1 - \theta\right)}{E_t \Lambda_{t,t+1} R_{t+1}^A \left(\theta \lambda_{t+1} + 1 - \theta\right)} \Delta \pi\left(\bar{\omega}_{t+1}; \sigma_t\right) \right\},$$

  where $\bar{\omega}_{t+1} = \bar{b}_t / R_{t+1}^A$, $\bar{b}_t \equiv \bar{B}_t^j / A_t^j$. *Leverage ratio* ϕ_t and normalized debt repayment $\bar{b}_t$ equalized across islands

- Given ϕ_t and $\bar{b}_t$, we can calculate
  - Loan size: $B_t^j = \left(\phi_t - 1\right) N_t^j \Rightarrow$ LTV ratio $= B_t^j / A_t^j = \frac{\phi_t - 1}{\phi_t} = 1 -$ haircut

Solution to unregulated bank's problem

Bank maximizes stream of dividends s.t. above constraints[max] . Solution:

- Bank retains all earnings (pays dividends only at exogenous exit)
- Participation and IC constraints both hold with equality,

$$A_t^j = \frac{1}{1 - E_t \Lambda_{t,t+1} R_{t+1}^A \left[\bar{\omega}_{t+1} - \pi\left(\bar{\omega}_{t+1}; \sigma_t\right)\right]} N_t^j \equiv \phi_t N_t^j,$$

$$1 - \tilde{E}\left(\omega\right) = E_t \left\{ \frac{\Lambda_{t,t+1} R_{t+1}^A \left(\theta \lambda_{t+1} + 1 - \theta\right)}{E_t \Lambda_{t,t+1} R_{t+1}^A \left(\theta \lambda_{t+1} + 1 - \theta\right)} \Delta \pi\left(\bar{\omega}_{t+1}; \sigma_t\right) \right\},$$

  where $\bar{\omega}_{t+1} = \bar{b}_t / R_{t+1}^A$, $\bar{b}_t \equiv \bar{B}_t^j / A_t^j$. *Leverage ratio* ϕ_t and normalized debt repayment $\bar{b}_t$ equalized across islands

- Given ϕ_t and $\bar{b}_t$, we can calculate
  - Loan size: $B_t^j = \left(\phi_t - 1\right) N_t^j \Rightarrow$ LTV ratio $= B_t^j / A_t^j = \frac{\phi_t - 1}{\phi_t} = 1-$ haircut
  - 'Repo' rate: $\bar{B}_t^j / B_t^j = \bar{b}_t / (B_t^j / A_t^j) = \bar{b}_t \phi_t / \left(\phi_t - 1\right)$

Regulated banks

- Contrary to unregulated banks,
  - regulated banks' liabilities (deposits) are guaranteed ($\Rightarrow$ no participation constraint)
  - they are subject to capital ratio regulation $\Leftrightarrow$ constraint on leverage: $A_t^{r,j} / N_t^{r,j} \leq \phi^r$
  - to simplify, no access to substandard technology ($\Rightarrow$ no IC constraint)
- Solution to bank's problem,

$$A_t^{r,j} = \phi^r N_t^{r,j},$$

$$\bar{\omega}_t^r \equiv \frac{R_{t-1} D_{t-1}^j}{R_t^A A_{t-1}^{r,j}} = \frac{R_{t-1}}{R_t^A} \frac{\phi^r - 1}{\phi^r}.$$

- Lower ϕ^r reduces default probability of regulated banks, $F_{t-1}\left(\bar{\omega}_t^r\right)$

Aggregation & market clearing

- Bank credit,

$$\begin{aligned} A_t &= \phi_t N_t \\ A_t^r &= \phi^r N_t^r, \end{aligned}$$

- For each bank that closes down (defaults or exogenous exits), household opens a new bank with starting net worth = fraction τ of last period's assets (Gertler & Karadi, 2011). Aggregate net worth,

$$\begin{aligned} N_t &= \theta \left[1 - F_{t-1}\left(\bar{\omega}_t\right)\right] \left[E_{t-1}\left(\omega \mid \omega^j \geq \bar{\omega}_t\right) - \bar{\omega}_t\right] R_t^A \phi_{t-1} N_{t-1} \\ &\quad + \left\{1 - \theta \left[1 - F_{t-1}\left(\bar{\omega}_t\right)\right]\right\} \tau A_{t-1}^j, \end{aligned}$$

analogously for N_t^r.

- Physical capital,

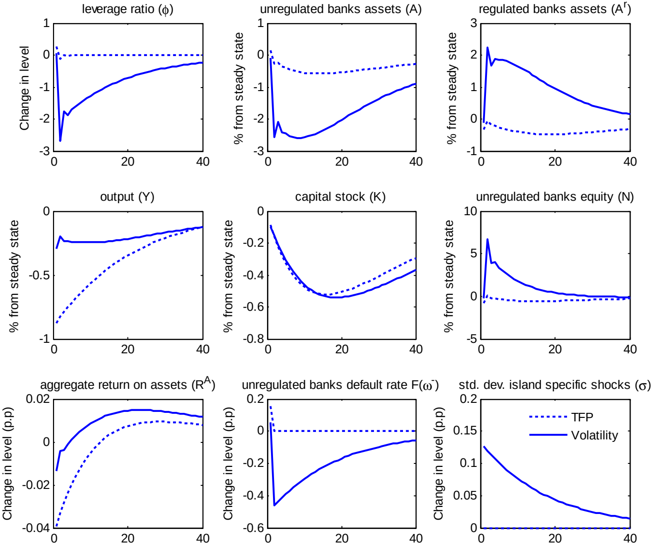
$$K_{t+1} = A_t + A_t^r,$$

- Market clearing for final good, etc.

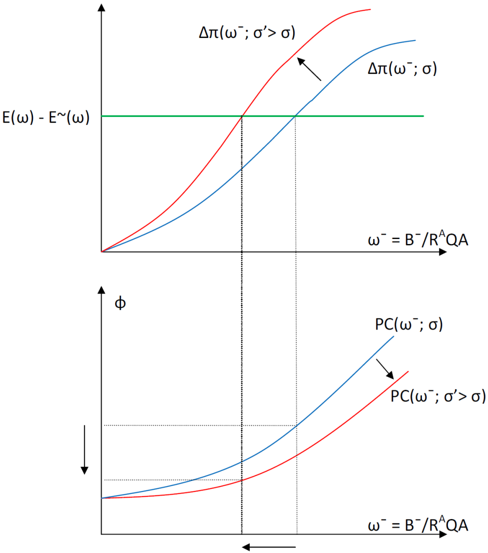
Calibration

Parameter	Value	Description	Source/Target
RBC parameters			
β	0.99	discount factor	$R^4 = 1.04$
α	0.36	capital share	$WL/Y = 0.64$
δ	0.025	depreciation rate	$I/K = 0.025$
φ	1	inverse labor supply elasticity	macro literature
$\bar{Z}$	0.5080	steady-state TFP	$Y = 1$
ρ_z	0.9297	autocorrelation TFP	FRB San Francisco-CSIP TFP series
σ_z	0.0067	standard deviation TFP	FRB San Francisco-CSIP TFP series
Non-standard parameters			
ϕ^r	10.66	leverage of regulated banks	leverage commercial banks
σ	0.0272	steady-state island-specific volatility	leverage security broker/dealers (ϕ=29.30)
ρ_σ	0.9457	autocorr. island-specific volatility	NBER-CES manufacturing industry TFP
σ_σ	0.0465	standard dev. island-specific volatility	NBER-CES manufacturing industry TFP
η	3.1442	variance substandard technology	$(\bar{R}/R)^4 - 1 = 0.25\%$
ψ	0.01	mean substandard technology	illustrative
τ	0.0015	equity injections new unreg. banks	$A = A^r$, law of motion N
τ^r	0.030	equity injections new regulated banks	$A = A^r$, law of motion N^r
θ	0.75	continuation prob. unregulated banks	$\tau > 0$
θ^r	0.75	continuation prob. regulated banks	$\theta^r = \theta$

Impulse responses: TFP & cross-sectional volatility



The volatility-leverage channel

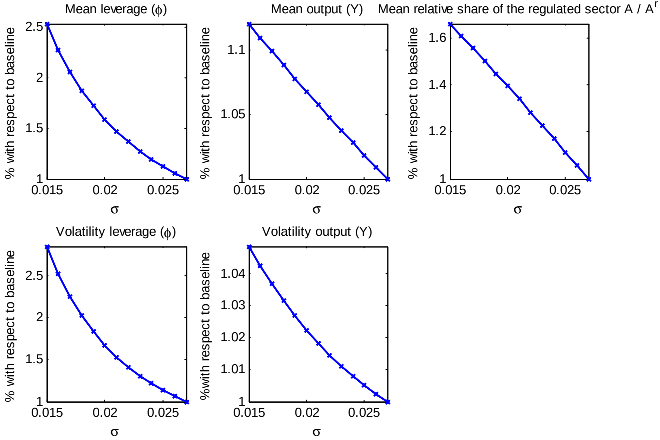


Business cycle statistics

	Data	TFP	Model Volatility	Both
Standard deviations (%)				
GDP	1.03	1.02	0.27	1.06
Assets regulated banks	1.30	0.26	2.40	2.46
Assets unregulated banks	7.57	0.50	2.98	3.02
Leverage unregulated banks	7.62	0.40	9.27	9.12
Correlations				
Assets regulated - GDP	0.46	0.46	−0.89	−0.19
Assets unregulated - GDP	0.47	0.36	0.87	0.29
Leverage unregulated - GDP	0.22	−0.04	0.90	0.25
Assets -leverage (unregulated)	0.76	0.64	0.91	0.89
Correlations (unfiltered)				
Assets regulated - GDP		0.79	−0.86	−0.03
Assets unregulated - GDP		0.82	0.96	0.54
Leverage unregulated - GDP		−0.14	0.86	0.31
Assets -leverage (unregulated)		0.08	0.92	0.90

Note: Model statistics are obtained by simulating the model for 5,000 periods and discarding the first 500 observations. The model is solved using a first-order perturbation method. Both data and model-simulated series have been logged and detrended with a band-pass filter that preserves cycles of 6 to 32 quarters (lag length $K = 12$), except indicated otherwise.

The 'risk diversification paradox'



- *Lower* steady-state cross-sectional volatility (σ) $\Rightarrow$ GDP is higher on average but *more volatile*

Conclusions

- Stylized facts of the US financial intermediation sector
  - Leverage and total assets are several times more volatile than GDP
  - For unregulated intermediaries, leverage is strongly procyclical wrt to assets and marginally procyclical wrt GDP
  - For regulated intermediaries, leverage is rather *a*cyclical wrt to both assets GDP
- A general equilibrium model with a two-tier financial intermediation sector and endogenous leverage (moral hazard)
  - TFP shocks are unable to replicate the stylized facts
  - Shocks to cross-sectional volatility ('risk shocks', 'uncertainty shocks') do help the model replicate the facts
  - Mechanism: following an increase in uncertainty, investors force unregulated banks to deleverage
- Model trade-off between output level and volatility. Reminiscent of Minsky's *financial instability hypothesis*.

Unregulated bank's maximization problem

Bank j solves

$$V_t\left(\omega^j, A^j_{t-1}, \bar{B}^j_{t-1}\right) = \max_{N^j_t}\left\{\Pi^j_t + \bar{V}_t\left(N^j_t\right)\right\}, \qquad \text{(max)}$$

$$\bar{V}_t(N^j_t) = \max_{A^j_t, \bar{B}^j_t} E_t \Lambda_{t,t+1} \int_{\bar{\omega}^j_{t+1}} \left[\theta V_{t+1}(\omega, A^j_t, \bar{B}^j_t) + (1\text{-}\theta)\left(R^A_{t+1} A^j_t \omega\text{-}\bar{B}^j_t\right)\right] dF_t(\omega),$$

subject to (1) resource constraint, (2) non-negativity constraint on dividends, (3) definition of $\bar{\omega}^j_t$, (4) participation constraint and (5) IC constraint