The Leverage Cycle: A Survey of the Literature

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Congratulations to Ana and John!

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Leverage Cycles and the Anxious Economy

By Ana Fostel and John Geanakoplos*

We provide a pricing theory for emerging asset classes, like emerging markets, that are not yet mature enough to be attractive to the general public. We show how leverage cycles can cause contagion, flight to collateral, and issuance rationing in a frequently recurring phase we call the anxious economy. Our model provides an explanation for the volatile access of emerging economies to international financial markets, and for three stylized facts we identify in emerging markets and high yield data since the late 1990s. Our analytical framework is a general equilibrium model with heterogeneous agents, incomplete markets, and endogenous collateral, plus an extension encompassing adverse selection. (*JEL* D53, G12, G14, G15)

My task: A "survey" of the related literature:

- Not exhaustive: I will focus on some key contributions and subsequent impact. Apologies for missing many important papers!

Excellent research, about the past and the future

Geanakoplos' (2010), "Leverage Cycle": "My theory is not, of course, completely original. Over 400 years ago, in *The Merchant of Venice*, Shakespeare explained that to take out a loan one had to negotiate both the interest rate and the **collateral** level."

Sam Bankman-Fried in 2022 (NYT interview by Sorkin): "the international platform...is a margin trade platform... where the clients were going on — placing something as **collateral** and using that to put on a position."

Roadmap

1. Corporate finance: Credit surface, no default, and downside risk
2. Banking and financial crises: Collateral runs
3. Asset pricing: Liquidity wedge, contagion, and leveraged "bubbles"
4. Macroeconomics (Dynamics): Leverage cycle and policy implications

Contribution to CF: GE theory of collateralized debt

- Modigliani-Miller benchmark
- Rich corporate finance literature. Many theories of leverage
- But relatively little work on **collateral** (asset-based leverage)

Ana and John's approach: **General Equilibrium Theory**

- Complements the contract theory/principal-agent approach
- Many collateralized debt contracts are available for trade
- Competition "selects" the contract(s) that are actually traded

Key idea: Credit surface

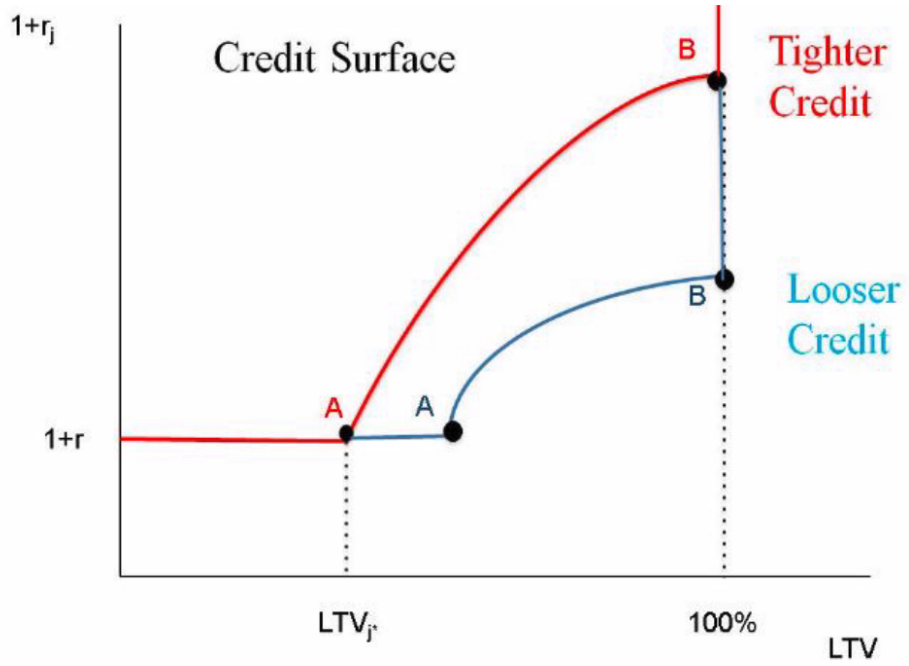


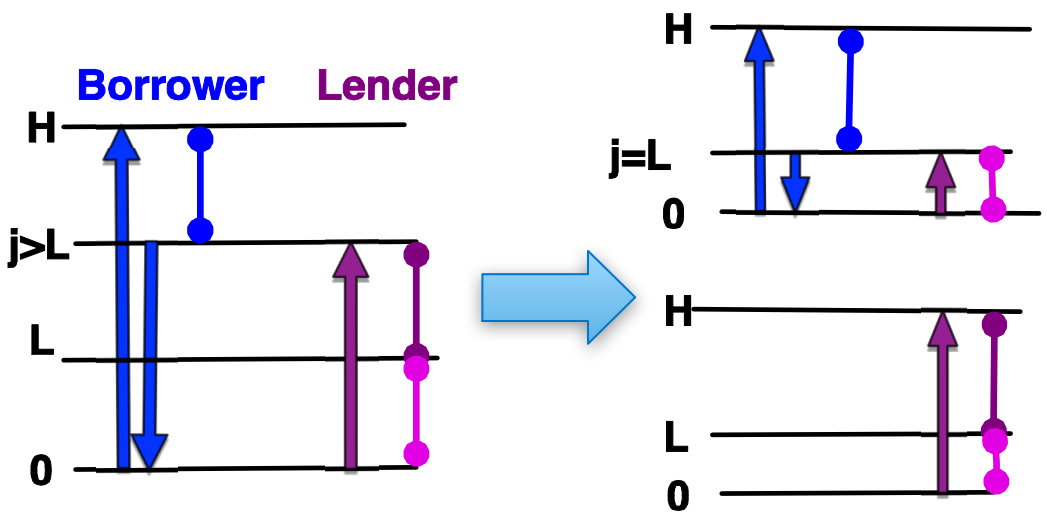
Figure 2: Loose and Tight Credit Surfaces with Identical Riskless Rates

Figure: From Geanakoplos (2022), "Leverage Cycle Theory of Economic Crises and Booms."

Key result: A no-default theorem

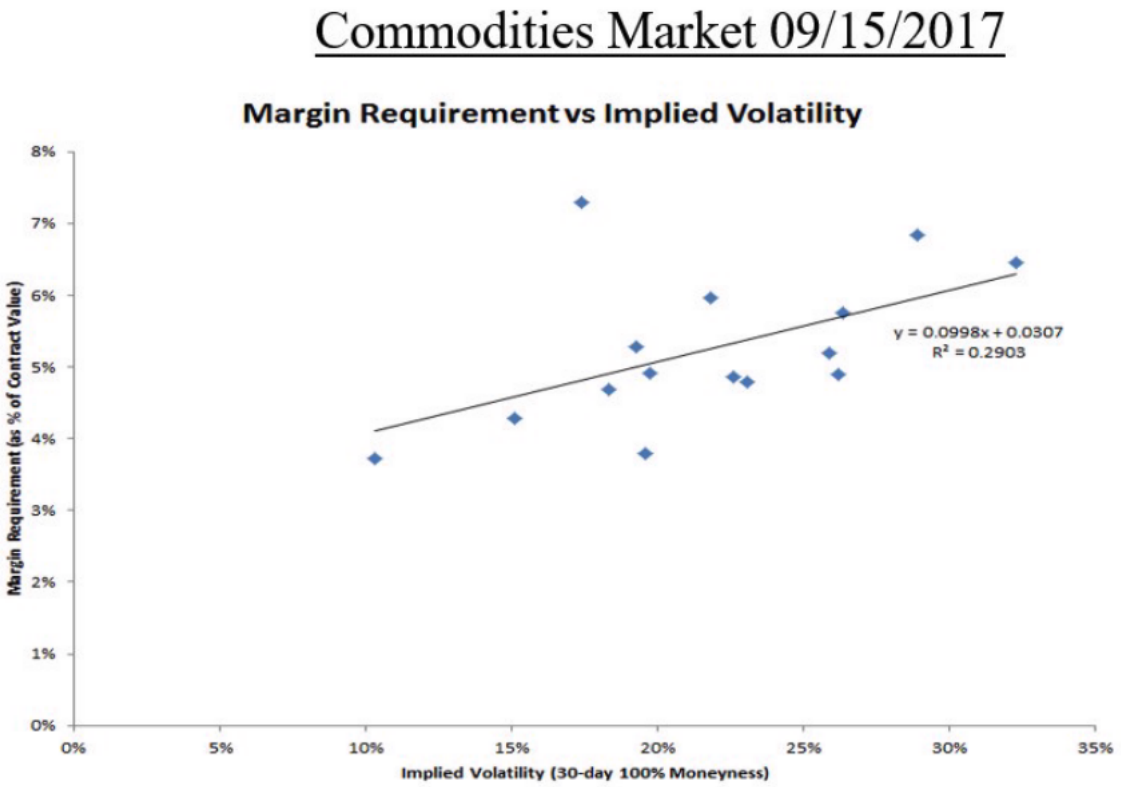
F-G (ECTA 2015) **Theorem:** With purely financial assets & two continuation states at each node, **safe debt** is sufficient (point A)

- Intuition: Buying by issuing risky debt = Buying less with safe debt



Corollary: Higher downside risk $\Longrightarrow$ Lower available LTV/higher margins

Risk reduces the (available) leverage in practice



Repo and brokerage margins are typically set to rule out default

With default, downside risk steepens the credit surface

More general insight: Even when risky debt contracts are traded, equilibrium contracts are **relatively** safe. Downside risk **steepens** the credit surface substantially to reduce the equilibrium LTVs/raise margins

Simsek (ECTA 2013): With continuum of states, downside disagreements reduce the equilibrium LTV (upside disagreements can raise it)

- Borrower-buyers also like the risky debt more than the lenders
- Adding default/foreclosure costs would strengthen the result

Downside risk steepens the credit surface in practice

Source: Geanakoplos and Rappoport (2019) using Black Knight Financial Services and BLS.

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Contribution to financial crises: Collateral runs

- Crises feature severe amplification mechanisms
- Literature: "Bank" net worth, fire sales, liquidity and bank runs
- No prior work on tightening of collateral constraints/**collateral runs**

Ana and John's approach provides a natural theory of collateral runs:

- Higher downside risk $\Longrightarrow$ Lower available LTV $\Longrightarrow$ Run on collateral

Related to Gorton & Holmstrom: Debt becomes "information sensitive"

GFC: Downside risk of MBS triggered run on repo & ABCP

Table 4
Repo Haircuts
(percent)

	Repo haircuts (%)			
	Spring 2007	*Spring 2008*	*Fall 2008*	*Spring 2009*
U.S. Treasuries (short-term)	2	2	2	2
U.S. Treasuries (long-term)	5	5	6	6
Agency mortgage-backed securities	2.5	6	8.5	6.5
Corporate bonds, A–/A3 or above	5	10	20	20
Collateralized mortgage obligations, AAA	10	30	40	40
Asset-backed securities, AA/Aa2 and above	10	25	30	35

Source: The data in the first three columns is from the Depository Trust and Clearing Corporation (provided by Tobias Adrian of the New York Fed), with the column for fall of 2008 filled out from reports of investment banks.

Figure: Krishnamurthy (2010), "How Debt Markets Have Malfunctioned..."

- See also Gorton and Metrick (2009) on the rise of repo haircuts
- Krishnamurthy, Nagel, Orlov (2014): Even bigger run on ABCP

Mechanism is different from & complements DD runs

- Diamond-Dybvig run mechanism relies on **coordination problems between multiple lenders** that have joint claims on illiquid assets
- With collateralized debt, lenders can each have a claim on specific collateral: Less room for coordination problems between lenders
- F-G mechanism is different: driven by **"fundamental" downside risk**
- During the GFC, both DD and collateral runs were arguably relevant

Mechanism is related to VaR constraints

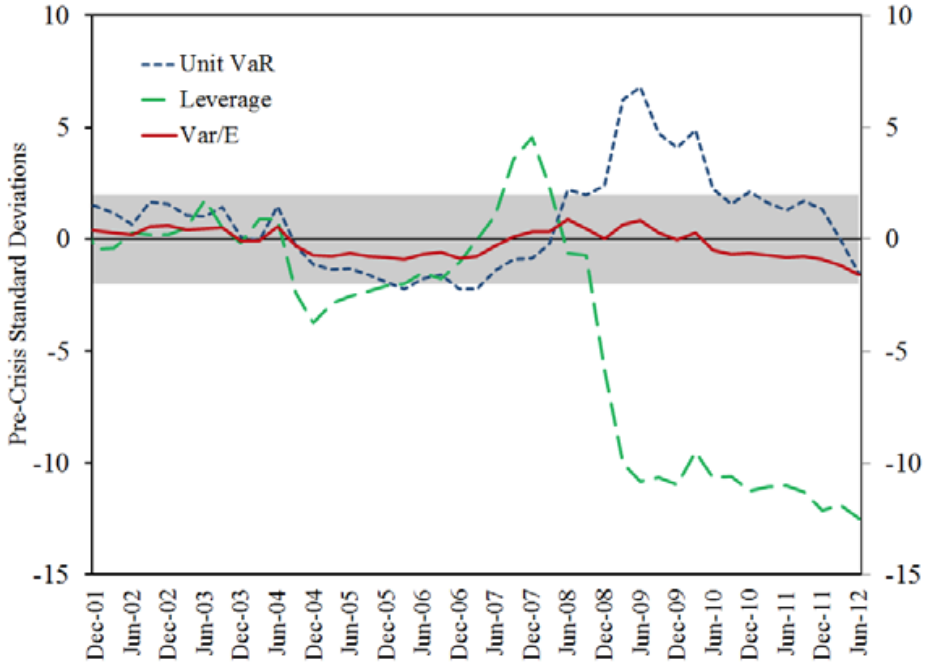

Figure: Adrian and Shin (RFS, 2014): Unit VaR (a measure of downside risk) and book leverage for the eight large commercial and investment banks

F-G mechanism is a special VaR constraint (no default)

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Contribution to AP: Collateral constraints and asset prices

- No-constraints AP benchmark: Asset demand is relatively elastic
- Heterogeneity ("natural buyers") and constraints: Inelastic demand
  - Limits to arbitrage and fire sales literatures (Shleifer and Vishny...)
  - Supply-demand effects (recent work by Koijen, Yogo, Gabaix...)
- But less **prior** work on asset pricing effects of collateral constraints
  - Kiyotaki-Moore (JPE, 1998), but no risk so mostly "exogenous" LTV
  - Gromb and Vayanos (JFE, 2002), but focus on limits to arbitrage

Ana and John's contributions:

- Conceptual: Liquidity wedge and collateral value
- Applications: Contagion, financial innovation, leveraged "bubbles"

Liquidity wedge and collateral value

- Absent constraints, we have the standard formulas:

$$E_0^i\left[M_s^i\right] = \frac{1}{1+r} \text{ and } P_{0j} = E_0^i\left[M_s^i D_{sj}\right] \text{ for risky asset } j$$

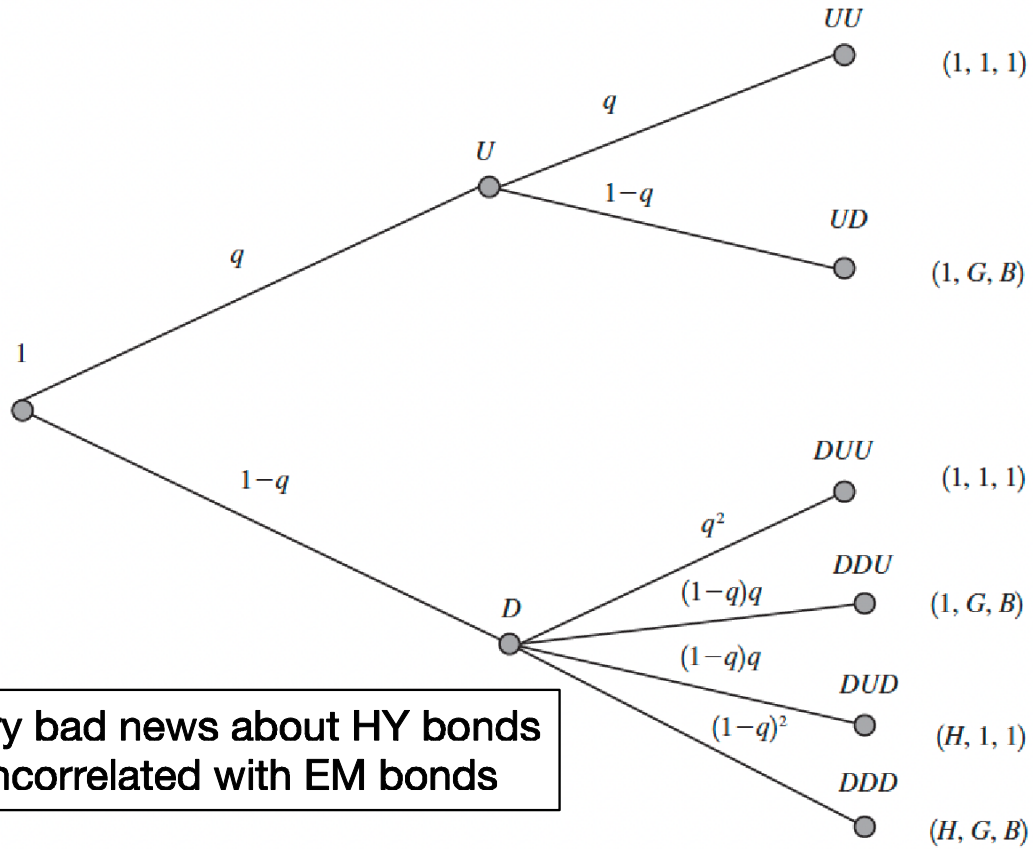
- With binding **collateral constraint,** we instead have (appendix):

$$E_0^i\left[M_s^i\right] = \frac{1}{1+r} \overbrace{\frac{1}{1+\omega_0^i}}^{\text{liquidity wedge}}$$

$$P_{0j} = E_0^i\left[M_s^i D_{sj}\right] + \overbrace{\frac{\omega_0^i}{1+\omega_0^i}\frac{D_{\min,j}}{1+r}}^{\text{collateral value}}$$

Liquidity wedge depresses asset valuations, and more so for assets j with a lower collateral capacity $D_{\min,j}$ (value in worst-case scenario)

Setup: Scary bad news and crossover investors



Scary bad news about HY bonds
Uncorrelated with EM bonds

"Optimists" have higher q for all bonds: **Experts/Crossover investors**

Key result: Contagion

Contagion via crossover investors:

- Better investment opportunities and higher margins raise their ω^i
- This reduces price of other assets (EM) in which they are experts

Related to literature on Global Financial Cycle (Rey and coauthors):

- Bruno & Shin (2014): Global banks' leverage drives capital flows

Related to the literature on amplification from funding constraints:

- Brunnermeier & Pedersen (RFS 2009): Market & funding liquidity
- Adrian & Shin (JFI 2010): Intermediary leverage and asset prices

Cross-sectional implications: Flight to collateral

Flight to collateral:

- The price drop is greater for assets with lower $D_{\min}$/higher margins

Related to cross-sectional asset pricing with collateral-constraints:

- Garleanu & Pedersen (RFS 2011): Margin based asset pricing
- Cipriani, Fostel, Houser (JF 2018): Lab evidence for collateral value

Relationship with intermediary asset pricing

More broadly, related to large literature on intermediary asset pricing:

- Intermediaries' M^i (their net worth etc) matters for asset prices
- When collateral constraints bind, **so do their** ω^i and asset margins
- Adrian, Moench, Shin (2013): Return predictability from broker-dealer leverage (proxy for $1/\omega^i$). See also Adrian, Etula, Muir (JF 2014)

Joint pricing of asset motivates financial innovation

Asset pricing formulas with binding constraints also imply:

$$P_{0j} = \overbrace{E_0^i\left[M_s^i\left(D_{sj} - D_{\min,j}\right)\right]}^{\text{priced by } \textbf{constrained} \text{ borrower-buyers}} + \overbrace{\frac{D_{\min,j}}{1+r}}^{\text{priced by unconstrained lenders}}$$

Asset is **jointly priced** by borrowers & lenders. This motivates financial innovations that enable **finer tranching** than leverage

- F-G (AEJ:Macro, 2012): "Tranching, CDS, and Asset prices"
- Geerolf (2018), Gong&Phelan (2021): Pyramiding (debt-on-debt)
- Coval et al. (JEP, 2009): A key driver of securitization in practice!

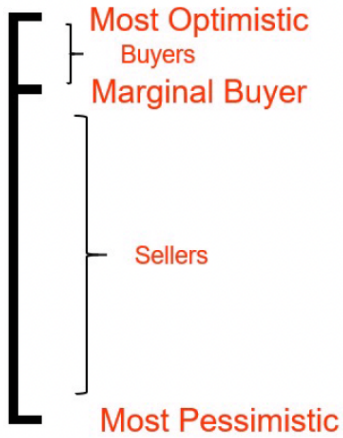
Another contribution: Leveraged asset price booms

- Asset price boom-bust cycles ("bubbles") are common. In many episodes, buyers rely on collateralized debt (buying on margin)
- Literature: Rational bubbles, optimism, heterogeneous beliefs...
- But relatively little work on buyers' ("optimists") collateral constraints

Ana and John's theory provides a natural approach to the problem:

- **Marginal buyer** is determined by available leverage—**downside risk**

Low downside risk can induce leveraged asset booms



- With short-sale constraints, MB is optimistic as in Miller (JF 1977)
  - This can induce speculative bubbles (Scheinkman-Xiong (JPE 2003))
- **Leverage** raises optimists' demand and **makes MB more optimistic**

Results:

- Reduction in downside risk can induce leveraged asset price booms
- Conversely, an increase in downside risk can trigger a collapse

Correlations during the GFC support the mechanisms

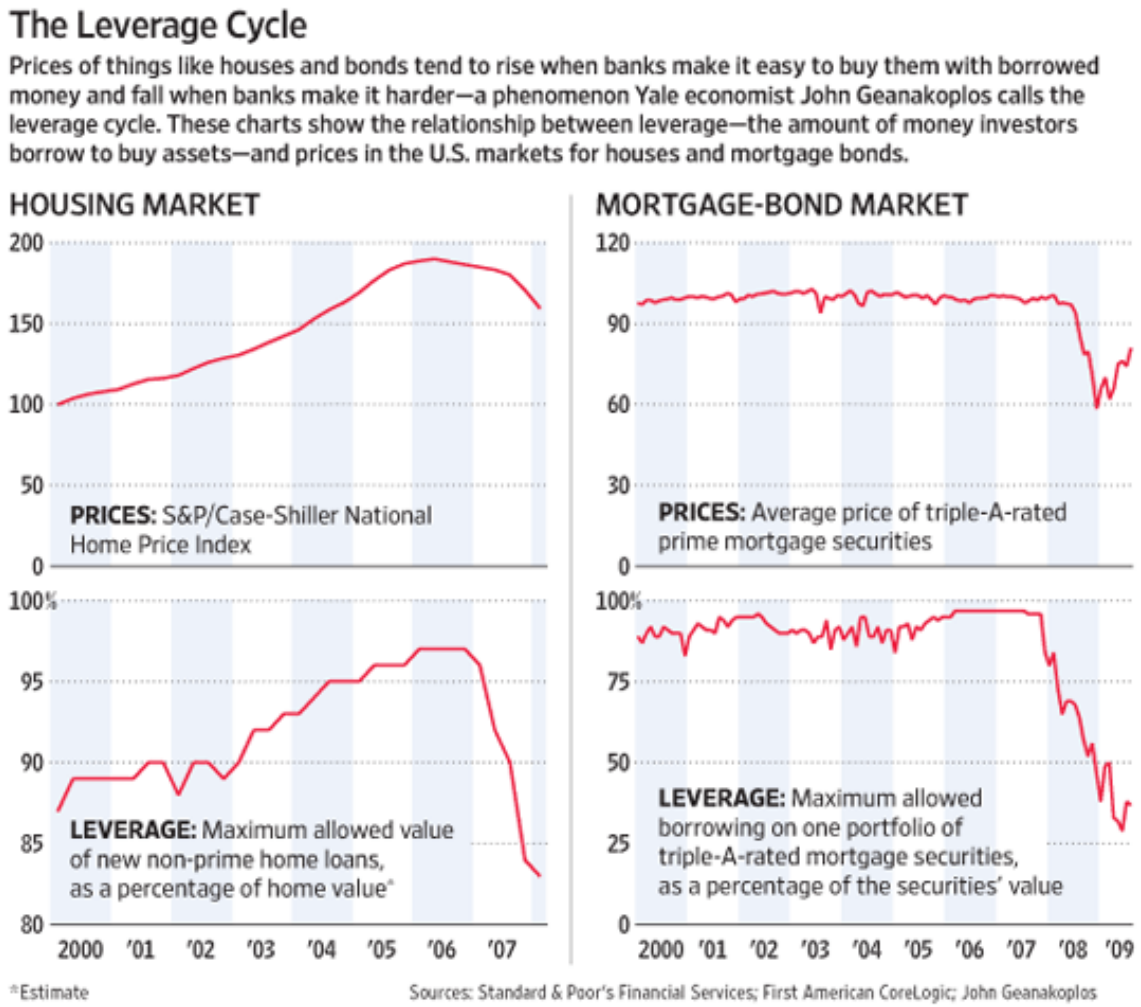


Figure: https://www.wsj.com/articles/SB12572015991222387 3

Detailed empirical evidence supports the mechanisms

- Ma, Paligorova, Peydro (2022): Banks' beliefs about downside (not normal) scenarios for an MSA drives their credit supply to that MSA
- Mian-Sufi (JFE 2021): Credit supply exacerbated the pre-GFC housing boom by facilitating speculation by a small group of optimists
  - Belief heterogeneity between homebuyers vs the general public

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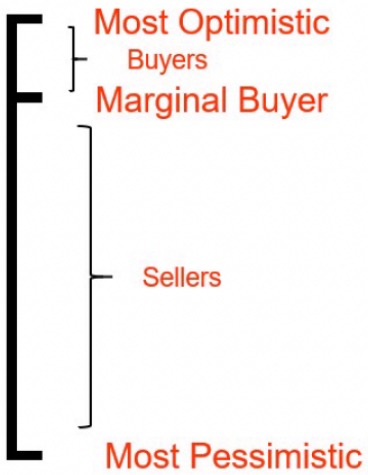
Leverage cycle: Low risk followed by scary bad news



Scary news (anxious times) reduces prices for two non-standard reasons:

1. Lowers available LTVs and can induce **margin calls**
2. Increases **pessimists' relative wealth** (levered optimists make losses)

Leveraged speculation amplifies asset price fluctuations

Prior work: Speculation amplifies price volatility via wealth transfers

- Detemple and Murthy (JET 1994), Dumas et al. (JF 2009)...

Ana and John's contribution: **Leveraged** speculation and **margin calls**

- Martin and Papadimitriou (AER 2022): log utility and rich dynamics

Speculation amplifies business cycles & motivates policy

Caballero&Simsek (QJE 2020): Asset prices affect aggregate demand $\Longrightarrow$

- Speculation (leverage cycle) amplifies demand-driven business cycles
  - Gao et al. (2020): Housing speculation amplified the Great Recession
- Macroprudential policy that restricts optimists' risk taking in the boom (LTV constraints) can improve welfare (AD externalities)

This was partly motivated by policy discussions in Geanakoplos (2010):

- "Theory... implies a CB can smooth economic activity by curtailing leverage in normal times and propping up leverage in anxious times"

Leverage cycle also induces belief-neutral inefficiencies

Leverage cycle has other costs. Geanakoplos (2010): Inequality, less investment and debt overhang in anxious times, foreclosure costs...

But these costs don't necessarily induce ex-ante **Pareto** inefficiency:

- "These (foreclosure) losses are foreseen...and yet they still arise"
- Disagreements induce **collective** damage—all beliefs can't be correct!
- This motivated Brunnermeier, Simsek, Xiong (2014): **Belief-neutral welfare criterion** detects negative-sum speculation as inefficient

Conclusion: Inspiring research with many contributions

The paper (and related work by Ana and John) makes many contributions:

- CF: Collateralized debt is often near-safe. *Downside risk drives LTVs*
- Banking and crises: *A rise in downside risks can induce collateral runs*
- AP: *Experts' liquidity wedge* affects prices and can induce *contagion*
- AP: Changes in *downside risk* can induce *leveraged asset boom-busts*
- Macro: *Leverage cycle* raises *price&output volatility*, motivates *policy*

Congrats to John & Ana for **inspiring** papers and a well-deserved award!

How do collateral constraints affect asset prices?

- Consider the problem of an investor i subject to collateral constraints
- There are two dates $\{0, 1\}$. Continuation states s in period 1
  - Risky assets j with prices P_{0j} and continuation values $\{D_{sj}\}_s$
  - Safe asset (or debt) with payoff $1 + r$
- Investors start with positions $\{y_{-1j}\}_j, \phi_{-1}$ and endowments $e_0, \{e_s\}_s$
- Choose new positions $\{y_{0j}\}_j$ & (total) promise ϕ_0 subject to **collateral constraint:** Debt can't exceed assets' worst-case payoff

$$\max_{\{y_{0j}\}_j, \phi_0} \; U\left(C_0^i\right) + \beta E_0^i \left[U\left(C_s^i\right)\right]$$

$$C_0^i + \sum_j P_{0j} y_{0j} = e_0 + \sum_j P_{0j} y_{-1j} - \phi_{-1} + \frac{\phi_0}{1+r}$$

$$C_s^i = e_s + \sum_j y_{0j} D_{sj} - \phi_0$$

$$\underbrace{\phi_0 \leq \sum_j y_{0j} D_{\min,j} \text{ where } D_{\min,j} \equiv \min_s D_{sj}}_{\text{collateral constraint}}$$

Absent constraints, we have the usual pricing formulas

- First remove the collateral constraint (or assume it doesn't bind)
- Then, we recover the standard present discounted value formulas

$$\begin{aligned} E_0^i\left[M_s^i\right] &= \frac{1}{1+r} \\ P_{0j} &= E_0^i\left[M_s^i D_{sj}\right] \text{ for each } j \end{aligned}$$

where

$$M_s^i = \beta \frac{U'\left(C_s^i\right)}{U'\left(C_0^i\right)}$$

With binding constraints, standard formulas don't apply

- Now suppose collateral constraint binds with multiplier $\lambda > 0$
- Then FOCs imply (assuming an interior solution with $C_0^i > 0$)

$$\begin{aligned} \frac{1}{1+r} U'\left(C_0^i\right) - \beta E_0^i\left[U'\left(C_s^i\right)\right] - \lambda &= 0 \\ -P_{0j} U'\left(C_0^i\right) + \beta E_0\left[U'\left(C_s\right) D_{sj}\right] + \lambda D_{\min,j} &= 0 \end{aligned}$$

- Define the liquidity wedge $\omega_0^i = \frac{\lambda}{E_0^i[\beta U'(C_s^i)]} > 0$ to obtain

$$\begin{aligned} E_0^i\left[M_s^i\right] &= \frac{1}{1+r}\frac{1}{1+\omega_0^i} \\ P_{0j} &= E_0^i\left[M_s^i D_{sj}\right] + \frac{\omega_0^i}{1+\omega_0^i}\frac{D_{\min,j}}{1+r} \text{ for each } j \end{aligned}$$

Buying on margin implies the asset is a "joint venture"

- Now consider raising the risky position y_{0j} by a small amount ε and total debt ϕ_0 by a corresponding amount $\varepsilon y_0 D_{\min,j}$
- This trade corresponds to **buying the asset j on margin**
- This trade does not tighten (or loosen) the collateral constraint. Thus, the FOC for ε implies a standard formula:

$$P_{0j} - \frac{D_{\min,j}}{1+r} = E_0^i \left[M_s^i \left(D_{sj} - D_{\min,j} \right) \right]$$

- This in turn implies asset is jointly priced by borrowers and lenders:

$$P_{0j} = \overbrace{E_0^i \left[M_s^i \left(D_{sj} - D_{\min,j} \right) \right]}^{\text{priced by } \textbf{constrained} \text{ borrower-buyers}} + \overbrace{\frac{D_{\min,j}}{1+r}}^{\text{priced by unconstrained lenders}}$$