Margin-Based Asset Pricing and Deviations from the Law of One Price

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Motivation: Financial Frictions in the Macro Economy

- Key friction: **margin constraints**
- These constraints can become binding; e.g., 2007-2009
- One remarkable consequence: Failure of Law of One Price
  - Corporate-bond basis: price gap between bond and CDS
  - Covered interest-rate parity

Research question:

**How do margin requirements affect asset prices?**
What We Do

- Standard Lucas economy, extended in minimal way:
  - with 2 two agents
  - facing margin constraints
- Derive equilibrium: **Margin CAPM**
- **Quantify** effects of margin
- Help **explain**:
  - CDS-bond basis
  - Failure of covered interest-rate parity (CIP)
  - The effects of the Fed’s lending facilities
  - The incentive for regulatory arbitrage
Results: Theory

- Margin (C)CAPM
  \[ E_t(r^i) - r^c_t = \lambda_t \beta^i_t + \psi_t x_t m^i_t \]

- Shadow cost of capital \( \psi_t \) can be captured by interest-rate spreads (LIBOR minus GC repo).

- Binding constraints, \( \psi_t > 0 \) (e.g., since August 2007):
  - occur following bad fundamental shocks
  - increase Sharpe market ratio: \( SR = \tilde{SR} + f(x_t) \left( \frac{\tilde{SR}}{\sigma} - \frac{1}{m} \right)^+ \)

- Basis: can arise due to difference in margins
  \[ E_t(r^i) - E_t(r^{ik}) = (\beta^{Cb,i}_t - \beta^{Cb,ik}_t) + \psi_t (m^i_t - m^{ik}_t) \]

- High-margin assets have high sensitivity to funding risk
Calibrate model using standard parameters: consumption growth, discount rate, risk aversion, observed margins

- Large pricing effect of binding constraints
  - Collateralized interest rates drop
  - Interest-rate spreads blow out
  - Margin premium rises

- High margin assets have high sensitivity to funding risk
  - higher beta
  - higher comovement with each other

Consistent with model, CDS-bond basis related to:
- credit tightness (time series)
- relative margin requirements (cross section)

Relate interest-rate spread to failure of covered interest parity

Transmission of unconventional monetary policy:
- Compute effect of Fed’s lending facilities on asset values

Quantify banks’ incentives to loosen capital requirements
Related Literature

- Direct evidence from Fed that prices depend significantly on haircuts: Ashcraft, Garleanu, and Pedersen (2010)
- Evidence on stocks, bonds, and credit markets: Frazzini and Pedersen (2010)
Continuous-time endowment economy

Multiple assets in positive supply, characterized by

- dividend stream: $\delta^i_t$
- margin requirement: $m^i_t$
- endogenous price: $dP^i_t = (\mu^i_t P^i_t - \delta^i_t) \, dt + P^i_t (\sigma^i_t) \top \, dB_t$

Multiple “derivatives”:
- derivative $i_k$ has the same payoffs $\delta^i_t$ as asset $i$
- smaller margin: $m^{i_k}_t \leq m^i_t$

Two types of risk-free lending/borrowing:
- collateralized (rate $r^c_t$)
- uncollateralized (rate $r^u_t$)
Model: Agents

- Two types of agents $g = a, b$:
  - Risk averse: $\gamma^a > 1$
  - Risk tolerant (brave): $\gamma^b = 1$ (i.e., log)

- Utility: constant relative risk aversion

$$\max_{C^g, \theta^i, \eta^u} \mathbb{E}_0 \int_0^\infty e^{-\rho s} \frac{(C^g_s)^{1-\gamma^g}}{1 - \gamma^g} \, ds$$

- Constraints:
  - Solvency: $W_t \geq 0$
  - Funding constraint: $\sum_i m^i_t |\theta^i_t| + \eta^u_t \leq 1$
  - Agent $a$
    - Does not lend uncollateralized
    - Faces derivative-trading restrictions
Agent $b$ solves

$$\max_{\theta^i_t, \eta^u_t} \left\{ r^c_t + \eta^u_t (r^u_t - r^c_t) + \sum_i \theta^i_t (\mu^i_t - r^c_t) - \frac{1}{2} \sum_{i,j} \theta^i_t \theta^j_t \sigma^i_t (\sigma^j_t)^T \right\}$$

subject to $\sum_i m^i_t |\theta^i_t| + \eta^u_t \leq 1$.

**Proposition:** The shadow cost of the margin constraint is

$$\psi^u_t = r^u_t - r^c_t$$

**Proposition:** If agent $b$ is long asset $i$, its excess return is

$$\mu^i_t - r^c_t = \beta^{C^b,i}_t m^i_t + \psi^u_t m^i_t$$

where $\beta^{C^b,i}_t = \text{cov}_t \left( \frac{dC^b}{Cb}, \frac{dP^i}{Pi} \right)$
Suppose that agent \( a \) is unconstrained w.r.t. asset \( i \) and let

\[
\frac{1}{\gamma_t} = \frac{1}{\gamma^a} \frac{C_t^a}{C_t} + \frac{1}{\gamma^b} \frac{C_t^b}{C_t}
\]

\[
x_t = \frac{C_t^a}{\gamma^a} + \frac{C_t^b}{\gamma^b}
\]

\[
\beta^C,i_t = \text{COV}_t \left( \frac{dC}{C}, \frac{dP_i}{P_i} \right)
\]

Proposition:

\[
\mu^i_t - r^c_t = \gamma_t \beta^C,i_t + x_t \psi_t m^i_t
\]
Let $q$ be the portfolio with highest correlation with aggregate consumption and

$$\beta_t^i = \frac{\text{cov}_t \left( \frac{dP^i_t}{P^i_t}, \frac{dP^q_t}{P^q_t} \right)}{\text{var}_t \left( \frac{dP^q_t}{P^q_t} \right)}$$

Proposition:

$$\mu_t^i - r_t^C = \lambda_t \beta_t^i + x_t \psi_t m_t^i$$
Proposition:

- If agent $b$ is long asset $i$ and derivative $i_k$

$$\mu_t^i - \mu_t^{i_k} = \psi_t (m_t^i - m_t^{i_k}) + (\beta_t^{C^b,i} - \beta_t^{C^b,i_k})$$

- If he is long $i$ and short $i_k$, then

$$\mu_t^i - \mu_t^{i_k} = \psi_t (m_t^i + m_t^{i_k}) + (\beta_t^{C^b,i} - \beta_t^{C^b,i_k})$$

- The derivative price $P_t^{i_k}$ decreases with $m_t^{i_k}$. 
Explicit Equilibrium

Specializing the setup for tractability to consider explicit equilibrium and calibration:

- Aggregate consumption $C$ is geometric Brownian motion
- Continuum of underlying assets with dividend $\delta^i = Cs^i$, where $s^i$ independent martingales
- All underlying assets have the same margin $m^i = m$
- Derivatives with $m^{ik} \leq m$ traded only by $b$

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Solving Explicitly

- It suffices to calculate equilibrium as if there were one underlying paying $C$ and derivatives on it
- State variables: $C$ and $c^b = C^b / C$
- Pricing kernel for underlying assets: Agent $a$ is marginal:
  \[
  \xi_t = e^{-\rho t} (C^a)^{-\gamma^a}
  \]
  \[
  d\xi_t = \xi_t \left( \mu^\xi_t dt + \sigma^\xi_t dw_t \right)
  \]
- Collateralized interest rate:
  \[
  r^c_t = -\mu^\xi_t = -\frac{D \left( e^{-\rho t} (C^a)^{-\gamma^a} \right)}{e^{-\rho t} (C^a)^{-\gamma^a}}
  \]
- Market price of aggregate wealth $P_t = C_t \zeta(c^b_t)$:
  \[
  P_t \xi_t = \mathbb{E}_t \int_t^\infty C_s \xi_s \, ds
  \]
Proposition:

- Agent $b$’s margin constraint binds iff
  \[ \frac{\mu - r^c}{\sigma^2} = \frac{SR}{\sigma} \geq \frac{1}{m} \]

- The price-to-dividend ratio $P_t/C_t = \zeta(c^b_t)$ is given as the solution to an ODE and all other endogenous variables are explicit functions of $\zeta$.

- Binding margin constraint increases the Sharpe Ratio:
  \[ SR = \bar{SR} + \frac{x}{1-x} \frac{\bar{\sigma}}{1 - \zeta'_{c^b} m\zeta} \left( \frac{\bar{SR}}{\sigma} - \frac{1}{m} \right)^+ \]

where $\bar{SR} = \gamma \sigma^C$ and $\bar{\sigma}$ are the Sharpe and return volatility without constraints.
Proposition:

As $c^b \to 0$, the basis between asset $i$ and derivative $i_k$ becomes

$$\mu^i - \mu^{i_k} = \psi (m^i - m^{i_k})$$

where

$$\psi = \frac{(\sigma C)^2}{m} \left( \gamma^a - \frac{1}{m} \right)^+$$

In the cross section of asset-derivative pairs,

$$\frac{\mu^i - \mu^{i_k}}{m^i - m^{i_k}} = \frac{\mu^j - \mu^{j_k}}{m^j - m^{j_k}}$$
We use the following parameter values:

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<th>Parameter</th>
<th>Value</th>
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<td>$\mu^C$</td>
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<tr>
<td>$\sigma^C$</td>
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<td>$\gamma^a$</td>
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<td>$\rho$</td>
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<td>$m$</td>
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<tr>
<td>$m^{low}$</td>
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</table>

Constraint binds for $c^b \leq 0.22$

Since $b$ is levered more than $a$, low $c^b$ is the result of bad shocks to fundamentals.
Calibration: Interest Rates

Figure: Interest rates: complete markets, collateralized with constraints \( (r_c) \), and uncollateralized with constraints \( (r_u) \).
Calibration: Bases

Figure: Return spreads of high-margin underlying versus low-margin derivative (i.e., large margin spread $m_{\text{underlying}} - m_{\text{low}} = 30\%$) and versus intermediate-margin derivative (i.e., small margin spread $m_{\text{underlying}} - m_{\text{medium}} = 10\%$).
Calibration: Sharpe Ratios

**Figure:** Sharpe ratios: complete markets, underlying with constraints, and two derivatives with constraints.
Figure: **Price Premium.** The figure shows how the price premium, $P_{\text{derivative}} / P_{\text{underlying}} - 1$ for three derivatives with identical cash flows and different margins.
Figure: The CDS-Bond basis, the LIBOR-GCrepo Spread, and Credit Standards.
CDS-Bond Basis: Cross Section

Figure: Investment Grade (IG) and High Yield (HY) CDS-Bond Bases, Adjusted for Their Margins.

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Margin-Based Asset Pricing
Monetary Policy and Lending Facilities

- Term Auction Facility (TAF), Dec. 2007
- Term Securities Lending Facility (TSLF), March 2008
- Term Asset-Backed Securities Loan Facility (TALF), Nov 2008

Goal: Improve funding conditions and “help market participants meet the credit needs of households and small businesses by supporting the issuance of asset-backed securities”

The model suggests that when the Fed offers lower margins, liquidity risk and required returns go down:

$$E(r_{i,Fed}^i) - E(r_{i,no \text{ Fed}}^i) \approx \lambda(\beta^{Fed,i} - \beta^{no \text{ Fed},i}) + \psi x(m^{Fed,i} - m^{i}) + \Delta\psi x m^{i} < 0$$

I.e., ABS yield down, access to credit eases, helping the real economy
Two Monetary Tools: Interest Rates and Haircuts (Ashcraft, Garleanu, and Pedersen (2009))

![Graph showing yields for different haircut regimes and maturities.](graph.png)
Two Monetary Tools: Interest Rates and Haircuts (Ashcraft, Garleanu, and Pedersen (2009))

Price Relative to No-TALF Price

- Low TALF haircut
- High TALF haircut
- No TALF

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Evidence on Monetary Policy and Margins Affecting Prices (Ashcraft, Garleanu, and Pedersen (2009))

Figure: Market reaction to TALF-related announcements.
Failure of the Covered Interest Rate Parity

Figure: Average Deviation from Covered-Interest Parity and the TED Spread.

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Margin-Based Asset Pricing
Regulatory Arbitrage

- Pressure to free capital by moving assets off the balance sheet or titling portfolios towards low capital-requirement assets
- Basel requirement is similar to the margin constraint
  \[ \sum_i m^{\text{Reg},i} |\theta^i| \leq 1 \]
- Required return increased by \( m^{\text{Reg},i,\psi} \)
Conclusion

- Margin-based general-equilibrium model
  - Strong asset pricing predictions
  - Predicts that a decline in fundamentals leads to
    - Binding constraints
    - Drop in Treasury and GC repo rates
    - Spikes in interest-rate spreads, risk premium, margin premium
    - Basis between securities with identical cash flows, related to margin differences

- Calibrated model predicts large margin premium in crisis

- Applications:
  - CDS-bond basis
  - Covered interest parity
  - Monetary policy, fed lending facilities
  - Banks’ incentives to use off-balance-sheet instruments