Heterogeneous Beliefs and Short-Term Credit Booms

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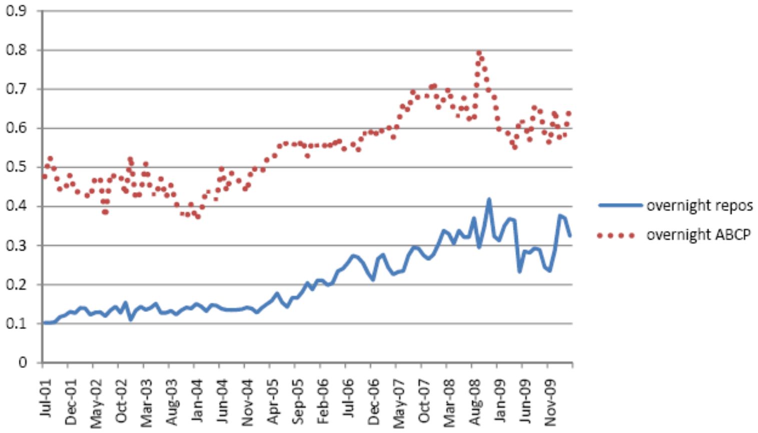
Motivation

- Standard economic theories emphasize agents' consumption and portfolio choices as the key drivers of the asset market equilibrium.
- The recent financial crisis painted a different picture with leverages and debt structure at the center:
  - Financial institutions used large leverages.
  - Debt maturity dramatically shortened before 2007.
  - Failure to roll over short-term debt triggered the crisis and systemic liquidity risk.
- How do market participants' financing choices interact with asset-market dynamics?

Maturity Shortening Before the Crisis

- Fraction of monthly issuance of overnight repos and ABCP



Summary of the Model

- A dynamic model to analyze the interactions between investors' financing choices and asset-price dynamics.
  - Joint booms in credit and asset markets.
  - Debt maturity trades off speculative and hedging incentives.
- Our model builds on the standard framework with heterogeneous beliefs and short-sales constraints:
  - e.g., Miller (1977), Harrison and Kreps (1978), Morris (1996), Chen, Hong, and Stein (2002), and Scheinkman and Xiong (2003).
  - Two groups of agents holding heterogeneous and state-contingent beliefs about the fundamental.
- Follows Geanakoplos (2009), where optimists use collateralized debt to finance their asset purchases.

Key Insights

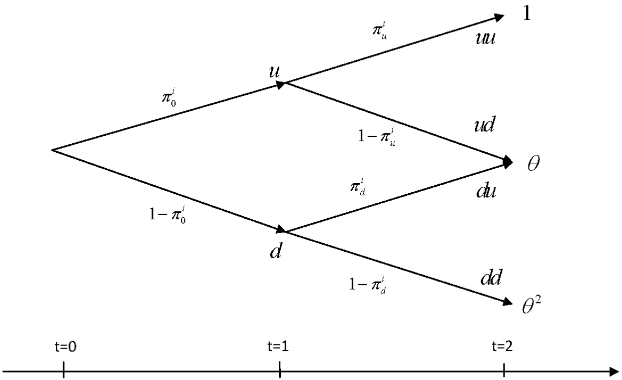
- Optimists' debt maturity choice:
  - Short-term debt permits a large leverage at a risk-free rate; but exposes the borrower to rollover risk.
  - Long-term debt hedges financing cost against future downturns.
- Distinctive roles of initial and future belief dispersion:
  - Initial belief dispersion stimulates speculative incentives.
  - Future belief dispersion after a downturn increases rollover risk.
- A short-term credit boom reflects excessive heterogeneous beliefs.
  - It fuels an asset- market boom and then exacerbates the downturn.
- Despite short-sales constraints, the price effect of heterogeneous beliefs can be ambiguous:
  - Pessimists indirectly affect prices through optimists' financing cost.
  - Higher initial belief dispersion can lead to a higher price, while higher future belief dispersion generally lowers the price.
  - Prompts attention on belief dispersion at different horizons.

Related Literature

- Our model differs from those on credit contraction during crises.
  - Increased margins in crises, e.g., Brunnermeier and Pedersen (2009);
  - Shortened debt maturity during crises, e.g., He and Xiong (2009a) and Brunnermeier and Oehmke (2009).
- Reasons for pervasive use of ST debt:
  - Agency problems inside firms: Calomiris and Kahn (1991), Diamond and Rajan (2009).
  - ST debt is less information sensitive: Gorton and Pennacchi (1990).
  - Our model emphasizes speculative incentives as a driving force.
- The tradeoff in our model resembles Diamond (1991).
  - The two sides: borrower's private information and liquidity risk.
  - Our model ties both sides of the tradeoff to heterogeneous beliefs and links them to asset market dynamics.
- Heterogeneous beliefs and security designs:
  - Garmaise (2001), and Landier and Thesmar (2008).

The Basic Model

- The long-term risky asset pays off at $t = 2$ as a binomial tree.
- Two groups of agents holding heterogeneous beliefs.
  - We denote optimists by h and pessimists by l.
  - In the basic model, we let $\pi_n^h > \pi_n^l$ for any $n \in \{0, u, d\}$.



Asset Market

- 1 unit of risky asset supply, $\mu \in (0, 1)$ units of optimists.
- On date 0, each optimist is endowed with 1 unit of asset and c dollars of cash.
  - Optimism motivates them to buy the remaining $1 - \mu$ units of assets from pessimists.
- The pessimists sit on the sideline, and can provide credit to the optimists.
  - We assume they always have sufficient cash to provide competitive financing to the optimists.
  - Their belief affects the financing cost.
- Risk neutral agents, zero interest rate.
- Short sales are not allowed.

Collateralized Debt Financing

- The optimists use their asset holdings as collateral to obtain debt financing.
- Only consider standard non-contingent debt contracts.
  - A non-contingent debt contract specifies a constant debt payment (face value) at maturity unless the borrower defaults.
  - Optimal in costly-state-verification models a la Townsend (1979).
  - By shifting control to the creditor after price declination, debt disciplines excessive risk-taking by optimists.
- In equilibrium, optimists always choose face value in $\left[\theta^2, \theta\right]$, as long as the asset price is between the optimists' and pessimists' asset valuation.
- In equilibrium, optimists do not save cash.
  - It is not desirable for any optimist to sell his asset on date 1.
  - He has to refinance his debt on date 1 if he uses short-term debt, or loses his asset to the creditor.

Long-Term Debt

- A long-term debt contract, collateralized by one unit of the asset.
  - It matures on date 2 with a face value of $F_L \in \left[\theta^2, \theta\right]$.
  - The random debt payment $\widetilde{D}_L(F_L) = \min\left(F_L, \widetilde{\theta}\right)$.
- On date 0, pessimistic creditors provide credit:

$$C_L(F_L) = E_0^l\left[\widetilde{D}_L\right] = \left(1 - \left(1 - \pi_0^l\right)\left(1 - \pi_d^l\right)\right) F_L + \left(1 - \pi_0^l\right)\left(1 - \pi_d^l\right)\theta^2.$$

- Financing cost to the optimistic borrower:

$$E_0^h\left[\widetilde{D}_L\right] = \left(1 - \left(1 - \pi_0^h\right)\left(1 - \pi_d^h\right)\right) F_L + \left(1 - \pi_0^h\right)\left(1 - \pi_d^h\right)\theta^2.$$

- Risky debt ($F_L > \theta^2$) is costly because the creditor undervalues the payment in the higher states.
  - The risk-free debt ($F_L = \theta^2$) is fairly valued but limits leverage.
  - What if the borrower wants a larger leverage?

Short-Term Debt

- ST debt matures on date 1, with face value $F_S \in \left[\theta^2, \theta\right]$.
- The borrower refinances at $t = 1$ by promising a new debt payment $F_{S,1}$ at $t = 2$: $E_n^l \left[\min\left(F_{S,1}, \widetilde{\theta}\right)\right] = F_S$.
  - In state u, the borrower just needs to promise $F_{S,1} = F_S$.
  - In state d, the maximum credit he can raise is

$$K_d \equiv \mathbb{E}_d^l \left[\min\left(\theta, \widetilde{\theta}\right)\right] = \pi_d^l \theta + \left(1 - \pi_d^l\right)\theta^2 < \theta.$$

1. $F_S \in \left[\theta^2, K_d\right]$. Riskless with date-0 credit $C_S\left(F_S\right) = F_S$.
   - Risk-free ST debt can raise as much as K_d, higher than θ^2.
   - In state d, refinance requires new risky debt with $F_{S,1} \geq F_S \geq \theta^2$..
2. $F_S \in \left(K_d, \theta\right]$. Risky.
   - in state d, the borrower forfeits the asset to the creditor.

Position of Optimists

- Suppose that an optimist uses a contract $\widetilde{D}$ and obtains an initial credit of $C\left(\widetilde{D}\right) \equiv \mathbb{E}_0^l\left[\widetilde{D}\right]$.
- Besides 1 unit of asset endowment, he buys additional x units from the market.
  - Collateralized borrowing. He can borrow $(1+x)\, C\left(\widetilde{D}\right)$ in total.
- Budget constraint: $c + (1+x)\, C\left(\widetilde{D}\right) = xp_0 \Rightarrow x = \frac{c+C\left(\widetilde{D}\right)}{p_0 - C\left(\widetilde{D}\right)}$.
  - Assuming he does not hold any cash, which is verified in equilibrium.
- His date-0 utility is

$$V\left(\widetilde{D}\right) = \underbrace{\frac{c+p_0}{p_0 - C\left(\widetilde{D}\right)}}_{\text{leverage effect}} \underbrace{\left[\mathbb{E}_0^h\left(\widetilde{\theta}\right) - \mathbb{E}_0^h\left(\widetilde{D}\right)\right]}_{\text{debt-cost effect}}$$

Maturity Choice

- Consider two ST and LT contracts giving the same date-0 credit (i.e., fixing the leverage effect).
- Debt-cost effect: ST debt has lower cost if and only if

$$\frac{\pi_0^h}{\pi_0^l} > \frac{\left(1-\pi_0^h\right)\pi_d^h}{\left(1-\pi_0^l\right)\pi_d^l}.$$

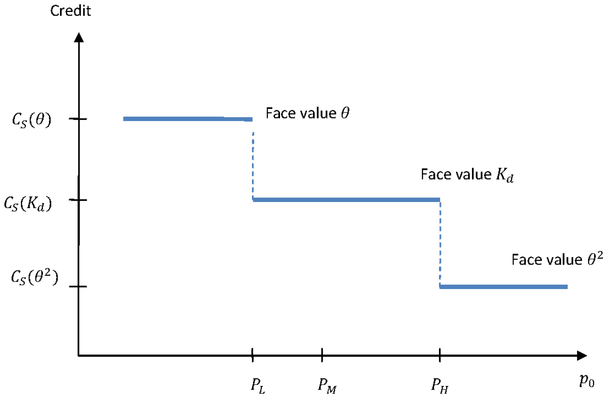
- ST debt needs refinancing: better or same term after good news, but worse term after bad news.
  - Pay less in high states, more in low states. preferred by optimists!
  - Initial belief dispersion at $t = 0$ stimulates speculative incentives.
- After bad news (state d), belief dispersion leads to rollover risk.
  - The refinancing $F_{S,1}$ payment is undervalued by the creditor.
  - Rollover risk is endogenously determined by heterogeneous beliefs.

Maturity Choice: The Static Intuition

- Geanakoplos (2009): optimists always prefer the maximum risk-free short-term leverage.
- Examine the short-term K_d contract: initially risk-free.
  - In state u, refinance by another risk-free contract;
  - In state d, refinance by turning the asset to creditor.
- This intuition ignores the rollover risk and does not hold if the future belief dispersion in state d is sufficiently large.
- Our model shows that short-term debt is desirable only if initial belief dispersion is high and future dispersion in state d is low.
  - Long-term debt could be optimal because it hedges the financing cost against future downturns.

Optimal Short-term Debt Face Value: Leverage Choice

- Suppose that short-term debt is desirable.
  - The default risk is different for F_S inside $\left[\theta^2, K_d\right]$ and $[K_d, \theta]$.
- Two thresholds P_H and P_L for price p_0. The higher the asset price p_0, the lower the leverage that the optimists will take.



Equilibrium of Asset and Credit Markets on Date 0

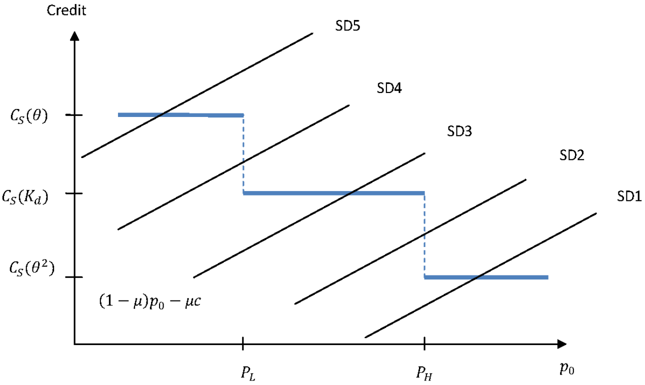
- Recall the optimists (with measure μ) buy $x = \frac{c+C(\widetilde{D})}{p_0 - C(\widetilde{D})}$ units from the market, and pessimists sell $1-\mu$ to the market.
- Market clearing: the optimists' asset purchases $\mu x = 1 - \mu$.
- If all the buyers use the same debt contract $\widetilde{D}(p_0)$, then

$$\mu \frac{c + C\left(\widetilde{D}(p_0)\right)}{p_0 - C\left(\widetilde{D}(p_0)\right)} = 1 - \mu$$

which is equivalent to

$$\underbrace{C\left(\widetilde{D}(p_0)\right)}_{\text{credit demand}} = \underbrace{(1-\mu)\, p_0 - \mu c}_{\text{cash shortfall}}.$$

Market Equilibrium



Equilibrium on Date 1

- We look for shadow price on date 1, which has two states u and d.
- In state u, the optimistic asset holders are in a good financial situation, and the asset price is determined by their valuation:

$$p_u = \mathbb{E}_u^h\left[\widetilde{\theta}\right] = \pi_u^h + \left(1 - \pi_u^h\right)\theta.$$

- In state d, the equilibrium depends on the date-0 debt contracts:
  - If all asset holders use riskless debt contracts, then optimists who hold the asset determines the price:

$$p_d = \mathbb{E}_d^h\left[\widetilde{\theta}\right] = \pi_d^h\theta + \left(1 - \pi_d^h\right)\theta^2.$$

  - Otherwise, some asset holders are forced to transfer assets to pessimistic creditors:

$$p_d = \mathbb{E}_d^l\left[\widetilde{\theta}\right] = \pi_d^l\theta + \left(1 - \pi_d^l\right)\theta^2.$$

Heterogeneous Beliefs and Asset Price Cycles

- Standard Miller result: in the absence of short-sales, heterogeneous beliefs cause asset overvaluation.
- We evaluate this result after accounting for optimists' financing cost.
- We use the following baseline parameters:

$$\begin{aligned} \mu &= 0.3, c = 0.5, \theta = 0.4, \pi_0^h = 0.7, \pi_0^l = 0.3, \\ \pi_u^h &= 0.6, \pi_u^l = 0.4, \pi_d^h = 0.6, \pi_d^l = 0.4. \end{aligned}$$

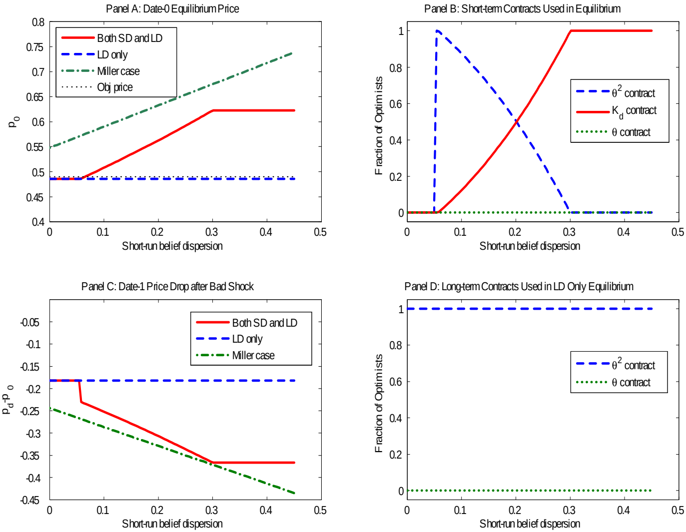
- To evaluate the effect of initial belief dispersion on date 0 (speculative incentives), we let

$$\pi_0^h = 0.5 + \delta_0 \text{ and } \pi_0^l = 0.5 - \delta_0.$$

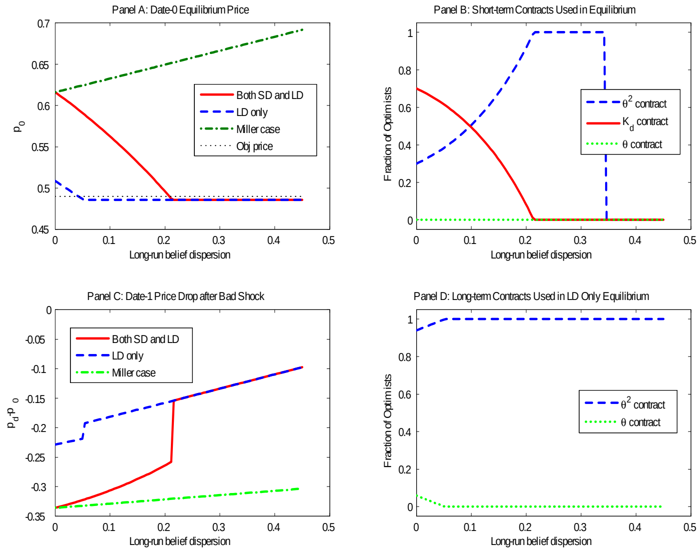
- To evaluate the effect of belief dispersion in state d of date 1 (rollover risk), we let

$$\pi_d^h = 0.5 + \delta_d, \text{ and } \pi_d^l = 0.5 - \delta_d.$$

The Initial Belief Dispersion on Date 0



The Future Belief Dispersion in State d of Date 1



An Extended Model with Learning

- Now we endogenize state-contingent belief dispersions.
  - Learning can lead to flips of beliefs, amd thus resale options to asset holders, a la Harrison and Kreps (1978).
  - Learning can also lead to more divergent beliefs after a negative shock, thus more severe rollover risk.
- Each agent updates his belief on date 1 based on the realized fundamental shock.
  - Learning can lead to flips of beliefs, introducing resale option value.
- Three groups A, B, and C. The prior of group $i \in \{A, B, C\}$ has beta distribution with $\left(\alpha^i, \beta^i\right)$.
  - The mean of this distribution is $\pi_0^i \equiv \frac{\alpha^i}{\gamma^i}$ where $\gamma^i \equiv \alpha^i + \beta^i$.
  - π_0^i is mean, γ^i captures confidence.
- In state u, the posterior mean is $\pi_u^i = \frac{\gamma^i}{\gamma^i+1}\pi_0^i + \frac{1}{\gamma^i+1}$.
- In state d, the posterior mean is $\pi_d^i = \frac{\gamma^i}{\gamma^i+1}\pi_0^i$.

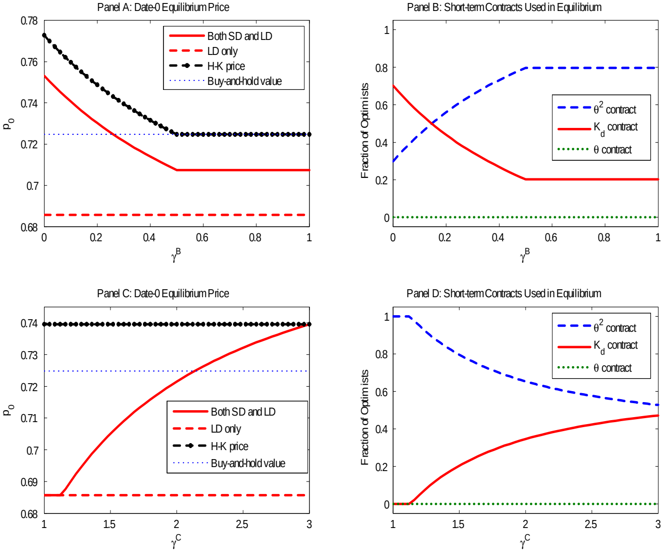
An Extended Model with Learning

- On date 0, we assume $\pi^h \equiv \pi_0^A > \pi^l \equiv \pi_0^B = \pi_0^C$, $\gamma^C > \gamma^A > \gamma^B$.
  - Group-B (future buyers) has strongest reaction to positive shock in state u, and group-C (creditors) has weakest reaction to negative shock in state d.
- The asset holders' resale option on date 1, e.g., Harrison and Kreps (1978), Morris (1996), and Scheinkman and Xiong (2003).
  - $p_u = \max\left\{\pi_u^A + \left(1 - \pi_u^A\right)\theta,\ \pi_u^B + \left(1 - \pi_u^B\right)\theta\right\}$.
  - B-agents become buyers of A-agents' asset in state u if

$$\pi_u^B = \frac{\gamma^B}{\gamma^B + 1}\pi^l + \frac{1}{\gamma^B + 1} > \pi_u^A = \frac{\gamma^A}{\gamma^A + 1}\pi^h + \frac{1}{\gamma^A + 1}.$$

- Agent-C are natural creditors to agent-A at $t = 0$.

Financing Bubbles



Discussion on Short-term Credit Booms

- Several episodes of short-term credit booms:
  - before the credit crisis of 2007-2008;
  - before the debt crises of emerging economies in 1990s;
  - before the great crash of 1929.
- A short-term credit boom can fuel an asset-market boom and then exacerbate the downturn after the asset fundamental deteriorates.
  - The importance of financing choices for understanding asset-market dynamics and financial crises.
- Our model characterizes a set of conditions for short-term credit booms to emerge:
  - large short-term belief dispersion;
  - and future belief convergence.

Discussion on Heterogeneous Beliefs and Asset Bubbles

- There is a large literature on asset bubbles generated by heterogeneous beliefs and short-sales constraints.
  - Miller (1977) and Chen, Hong and Stein (2002): a larger belief dispersion leads to a higher asset price and a lower expected return.
  - Harrison and Kreps (1978), Morris (1996) and Scheinkman and Xiong (2003): more volatile belief dispersion leads to more valuable resale option and more frequent asset trading.
- These studies ignore financing cost and heterogeneous beliefs in different horizons.
- Our model highlights the differences between initial and future belief dispersion when optimists need financing.
  - A higher initial belief disperion can lead to a higher asset price;
  - while a higher future belief dispersion after fundamental deterioration reduces asset price.

Conclusion

- Our model shows that financing choices can exacerbate asset-market boom-and-bust cycles.
- Optimists' debt maturity choice: a tradeoff between speculative incentive and rollover risk.
  - Initial belief dispersion stimulates speculative incentives, while future belief dispersion after a downturn increases rollover risk.
  - A short-term credit boom requires not only large short-term belief dispersion but also expected belief convergence.
- Despite short-sales constraints, the price effect of heterogeneous beliefs can be ambiguous:
  - Pessimists indirectly affect price through optimists' financing cost.
  - Higher initial belief dispersion can lead to a higher price, while higher future belief dispersion generally lowers the price.
  - Prompts attention on belief dispersion at different horizons.