Microstructure of Funding Markets

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The financial crisis of 2007-2008

- Characteristics of banking prior to the crisis:
  - increasing leverage;
  - shortening of maturities;
  - increased reliance on wholesale funding, particularly *repurchase agreements* (repo); *asset backed commercial paper* (ABCP); and *off balance sheet entities*, such as SIVs, conduits, CDOs, etc.
- Market failures during the crisis:
  - the "run" on repo;
  - collapse of the ABCP market;
  - dislocation of the interbank market
- Were these failures the result of insolvency, "endogenous" illiquidity, or both?

The "run on repo"

- The repo market:
  - the tri-party market;
  - the bilateral (DvP) market
- Types of collateral: treasuries, agency debt, sub-prime MBS, ABS (home equity loans, credit cards, auto loans), CDOs
- Haircuts (Gorton and Metrick, 2010)

AA-AAA CDO	$4.3\% \longrightarrow 53.5\%$
Unpriced ABS / MBS / All sub-prime	$3.9\% \longrightarrow 68.0\%$
A-AAA ABS-Auto / CC / SL	$0.9\% \longrightarrow 9.5\%$
AA-AAA ABS-RMBS / CMBS	$0.9\% \longrightarrow 17.1\%$
AA-AAA CLO	$0.9\% \longrightarrow 18.7\%$

Collapse of the ABCP market

- August 2007: BNP Paribas, the collapse of the ABCP market and its impact on the interbank market (Acharya and Schnabl, 2009; Heider, Hoerova and Holthausen, 2010)
- Krishnamurthy, Nagel and Orlov (2011)
  - the rehypothecation problem and the importance of ABCP
  - direct funding from MMF and Securities Lenders

ABCP	1173.2
Repo	1100

  - the contraction of funding

ABCP	−662.2
Repo	−155

An intellectual failure

"The failure to understand that a systemic crisis was possible in the U.S. is an intellectual failure. This failure should be understood and explained. It should be recognized [and] admitted. We don't understand why we didn't understand. The problem affects researchers and policymakers alike. It affects economic research; it affects regulatory actions; it affected the recent Dodd-Frank legislation, and it affects our current understanding of the future."

Market freezes

- *Leverage cycles* Geanakoplos (2009); Fostel and Geanakoplos (2008)
- *Ambiguity aversion* Caballero and Krishnamurthy (2009), Caballero and Simsek (2011)
- *Liquidity component of credit risk* Morris and Shin (2009)
- *Market liquidity and funding liquidity* Brunnermeier and Pedersen (2009)
- *Rollover risk* Acharya, Gale and Yorulmazer (2011)
- *Repo runs* Martin, Skeie and von Thadden (2011)

Brunnermeier and Pedersen "Market liquidity and funding liquidity"

- *Dates*: There are four dates $t = 0, 1, 2, 3$
- *Assets*: There are J risky assets in zero net supply (hence no aggregate risk); asset returns are random variables v^j realized at $t = 3$; the fundamental value of asset j at time t:

$$v_t^j = E_t \left[v^j \right].$$

- *Volatility*: The fundamental volatility follows ARCH process in which volatility is increasing in deviations from fundamentals.
- *Market participants*: customers; speculators; financiers

"Market Liquidity and funding liquidity" II

- *Customers*:
  - at $t = 0$, agent $k = 1, 2, 3$ has wealth consisting of W_0^k bonds and zero shares;
  - at $t = 3$, he receives endowment shock $\mathbf{z}^k = \left(z^{1,k}, ..., z^{J,k}\right)$, where $\mathbf{z}^k$ is random vector (known at $t = 0$) such that

$$\sum_{k=0}^{2} \mathbf{z}^k = 0;$$

  - w. pr. $1 - a$, all customers arrive at $t = 0$ and can trade at $t = 0, 1, 2$;
  - w. pr. a, customer k arrives at $t = k$, giving rise to *order imbalance*;
  - CARA utility

$$U\left(W_3^k\right) = -\exp\left\{-W_3^k\right\};$$

"Market Liquidity and funding liquidity" III

- *Speculators*: are risk neutral, maximize expected value of terminal wealth and accommodate early traders' needs
- *Margin requirement*:

$$\sum_{j=1}^{J} \left(x_t^{j+} m_t^{j+} + x_t^{j-} m_t^{j-} \right) \leq W_t;$$

- *Bankruptcy*: if $W_t \leq 0$, speculator cannot trade and receives utility $\varphi_t W_t$, where $\varphi_t \geq 0$.
- *Financiers*: choose margins to limit counterparty credit risk:

$$\begin{aligned} \pi &= \Pr\left[\Delta p_{t+1}^j < -m_t^{j+} | \mathcal{F}_t\right] \\ \pi &= \Pr\left[\Delta p_{t+1}^j > m_t^{j-} | \mathcal{F}_t\right] \end{aligned}$$

"Market liquidity and funding liquidity" IV

- In equilibrium, any asset j's market illiquidity $\left|p_1^j - v_1^j\right|$ is linked to its margin m_1^j and the common funding illiquidity, as measured by the speculators' marginal value of an extra dollar ϕ_1:

$$\left|p_1^j - v_1^j\right| = m_1^j \left(\phi_1 - 1\right),$$

  where $m_1^j = m_1^{j+}$ (resp. m_1^{j-}) if the speculator is long (resp. short)
- Fragility arises when the excess demand for shares can be non-monotonic in the price. While under "normal" circumstances, a high price leads to a low total demand (i.e., excess demand is decreasing), binding funding constraints along with destabilizing margins (margin effect) or speculators' losses (loss effect) can lead to an increasing demand curve

"Market liquidity and funding liquidity" V

- A *margin/haircut spiral* arises if $\frac{\partial m_1^+}{\partial p_1} < 0$ or $\frac{\partial m_1^-}{\partial p_1} > 0$, which happens with positive probability if financiers are uninformed and a is small enough. A *loss spiral* arises if speculators' previous position is in the opposite direction as the demand pressure, $x_0 Z_1 > 0$.

- *Commonality* arises because risk neutral speculators invest all capital in securities that have the greatest expected profit per unit of capital used. Hence, depends on shadow price of capital ϕ_1.

Acharya, Gale and Yorulmazer "Rollover risk and market freezes"

- *Time*: time is represented by the unit interval $[0, 1]$
- *Uncertainty*: information arrives according to a continuous-time Markov process; for the sake of illustration, suppose there are two states H and L
- *Assets*: an asset purchased at date 0 has a terminal value $V_H > V_L > 0$ at time $t = 1$; there are no intermediate payments
- *Debt finance*: the asset is funded by short-term debt with tenor τ, i.e., the rollover dates are $t_n = n\tau$ for $n = 1, ..., N$, where

$$\tau = \frac{1}{N+1};$$

note that all market participant use debt finance of the same tenor.

Rollover risk and market freezes II

- *Risk and time preferences*: all market participants are risk neutral; the risk-free rate is normalized to zero
- *Liquidation costs*: in the event of default, the asset is sold by the lender and a small transaction cost $c > 0$ is incurred
- *Objective*: to characterize the *debt capacity* of the asset, that is, the maximum amount that can be borrowed using the asset as collateral
- *Backward induction*: at each rollover date, the face value of the debt issued is chosen to maximize the market value of the debt; if the face value of the debt is too high, default costs are incurred; if too low, market value is foregone
- *Intuition*: when $\tau > 0$ is small, the probability of a change in state before the next rollover date is close to zero; therefore face value is chosen equal to next period's debt capacity assuming the state does not change; upside risk is lost in "low" states

Rollover risk and market freezes III

- Let B_n^s denote the debt capacity in state $s = H, L$ at date $t_n = n\tau$ for $n = 0, 1, ..., N$ and let $p(\tau)$ denote the probability of remaining in state H until the next rollover date.

Theorem

For τ sufficiently close to 0, the debt capacities are given by the formulae

$$B_n^H = (1 - p(\tau))^{N-n} V^H + \left[1 - (1 - p(\tau))^{N-n}\right] \lambda V^L,$$

and

$$B_n^L = V^L,$$

at each date t_n, for $n = 0, ..., N$.

Rollover risk and market freezes IV

- Debt capacity is always less than current fundamental value
- Debt capacity is less than or equal to the terminal value in the same state
- Debt capacity increases as t increases
- In the lowest state, debt capacity equals the minimum terminal value

Interbank markets

- Goodfriend and King (1986)
- Allen, Carletti and Gale (2011)
- Interbank market malfunction: Acharya and Merrouche; Ashcraft, McAndrews and Skeie; Afonso, Kovner and Schoar
- Counterparty risk: Heider, Hoerova and Holthausen (2010)
- Liquidity hoarding: Gale and Yorulmazer (2011)

Gale and Yorulmazer "Liquidity hoarding"

- *Time*: There are four dates, $t = 0, 1, 2, 3$
- *Assets*: There are two assets, a liquid asset ('cash') and an illiquid asset ('the asset')
- *Returns*: Asset pay non-stochastic returns in the final period: cash pays a return of 1 at date 3; the asset pays a return of $R > 1$ at date 3
- *Initial endowments*: Each banker has one unit of the asset and chooses whether to hold one unit of cash; the opportunity cost of holding cash is $\rho > 1$

"Liquidity hoarding" II

- *Liquidity shocks*: a banker receives a liquidity shock (demand for payment) at *one* of the dates $t = 1, 2, 3$
  - with probability θ_1 he receives a shock at date 1
  - with probability $(1 - \theta_1)\,\theta_2$ he receives a shock at date 2
  - and with probability $(1 - \theta_1)\,(1 - \theta_2)$ he receives the shock at date 3
- *Default*: On receiving a shock, a banker must either pay one unit of cash to discharge the senior claim or default and suffer a loss of 100% of the value of his portfolio (the lawyers eat everything)
- There are no forward markets, but bankers trade the asset for cash on a spot interbank market

"Liquidity hoarding" III

Theorem

The planner's optimal strategy is characterized by an initial holding of cash and the decision rules $x_1(\theta_1)$ *and* $x_2(\theta_1, \theta_2)$ *satisfying:*

$$x_1(\theta_1) = \min\{m_0, \theta_1\};$$

$$x_2(\theta_1, \theta_2) = \min\{m_0 - \theta_1, (1-\theta_1)\theta_2\}$$

and the first-order condition

$$R\left(1 - \int_0^{m_0} F_2\left(\frac{m_0 - \theta_1}{1-\theta_1}\right) f_1(\theta_1)\, d\theta_1\right) + 1 = \rho.$$

"Liquidity hoarding" IV

- The equilibrium level of liquidity in equilibrium is always less than the optimal amount

$$1 - \alpha < m_0$$

- Hoarding always occurs in equilibrium; in fact, there exists a state $\bar{\theta}_1$ and a number $\bar{\lambda} < 1$ such that the supply of liquidity at date 1 is

$$\bar{\lambda}(1 - \alpha) < \theta_1$$

  for every $\theta_1 > \bar{\theta}_1$ whereas all liquidity needs are met for $\theta_1 < \bar{\theta}_1$

- There are three sources of inefficiency:
  - the planner's objective includes the welfare of creditors
  - the allocation of liquidity is inefficient at date 2
  - firesales at date 2 cause hoarding at date 1 (speculative and precautionary motives)

Central bank policy

- Suppose that $\alpha = m_0$ and that the Bank pursues the socially optimal policy
- Let $p_1(\theta_2)$ and $p_2(\theta_1, \theta_2)$ be the market-clearing prices assuming that bankers hold no cash between periods
- Then it is optimal fo bankers to hold no cash between periods
- In other words, the central bank can implement the planner's solution and markets will clear ...
- ... but is this realistic or desirable?

Maturity transformation

- Dynamic bank runs: He and Xiong
- Incentive effects of short-term debt: Calomiris and Kahn (1991); Diamond and Rajan (2001); Huberman and Repullo (2011); Eisenbach (2011)
- The maturity rat race: Brunnermeier and Oehmke (2011)
- Maturity and the debt overhang: He and Diamond (2011)

Brunnermeier and Oehmke "The maturity rat race" I

- A risk neutral firm can invest in a long-term project at $t = 0$; the investment cost is normalized to 1.
- At time T, the investment's payoff is a r.v., $\theta \geq 0$; there is no discounting and the $NPV > 0$
- A signal s_t is received at date $t = 1, ..., T$. It is assumed that for each date $t = 1, ..., T$, S_t is a sufficient statistic for the history $\{s_1, ..., s_t\}$.
- If the project is prematurely liquidated at $t < T$, the payoff is a fraction $\lambda E[\theta|S_t]$ of its conditional expectation, where $\lambda < 1$. Thus, early liquidation is always inefficient. Any fraction of the project can be liquidated.

Brunnermeier and Oehmke "The maturity rat race" II

- The firm has no equity capital and raises financing by issuing debt to a large number of small, risk-neutral lenders.
- A debt contract specifies a face value and a date at which the debt is due. If the firm defaults at t, all debt is accelerated and there is equal priority among holders of different maturities of debt. There is no distinction between principal and accrued interest.
- The firm's maturity structure is opaque. This makes sense for financial institutions, but not for industrial companies.

Brunnermeier and Oehmke "The maturity rat race" III

- Seniority by maturity
- Information about *probability of default* (PD) versus information about *loss given default* (LGD)
- Under certain conditions, information about PD leads to a cascade of movements to shorter maturities, whereas information about LGD is consistent with long-term debt
- Short-term debt is always inefficient; since lenders receive the market rate, the firm loses
- Why can't the firm commit to long-term debt?
- Alternative financing structures

Restructuring the financial system

- The goal of financial regulation is an efficient, innovative and competitive financial system
- Basel III and the Dodd-Frank Act
- Resolution regime for systemically important financial institutions (SIFI)
- Banks that are "too big to fail" are simply too big, period
- Also, "too complex to manage"
- The parallel banking system (PBS) provides a more transparent, efficient and stable model

Narrow banks (LPFCs) I

- The target returns to capital providers will be low, but stable,
- The activities that the Narrow Bank can engage in (e.g., the type of securities held) must be fully defined by a charter that is transparent to capital and debt investors and to regulators.
- The capital structure must be responsive to
  - (i) the credit quality of the portfolio;
  - (ii) the maturity of the assets;
  - (iii) the diversification of the portfolio; and
  - (iv) the asset-liability maturity gap.

(For example, the capital requirements could be based on a Basel-type formula that incorporates measures of credit quality, maturity, diversification, and asset-liability gap).

Narrow banks (LPFCs) II

- No off-balance-sheet exposures or contingent risk exposures would be allowed.
- There would be no proprietary trading and most assets would be held to maturity.
- Interest rate and currency exposure would be fully hedged.
- Risk management would be consistent with 'best practice;' in particular, asset quality evaluation would be based on in-house research and would not rely on rating agencies.
- Most importantly, the Narrow Bank would be regulated by the FRS and would have access to central bank liquidity facilities.