Information Acquisition in Rumor-Based Bank Runs

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Bank Runs on WaMu in 2008

WaMu Deposits, 7/14/2008 – 10/6/2008, $ Billions
Stylized Features of Bank Runs in Modern Age

- Stylized features of Wamu bank runs:
  - First run July 2008, lasting about 20 days. Rumor is spreading online, but never made public
  - Wamu survived the first run, followed by deposit inflows
  - In the second fatal run in September 2008, uncertainty about bank liquidity played a key role
  - Deposit withdrawals are gradual
  - Worried depositors (even covered by FDIC insurance) scramble for information; then some withdrew immediately while others wait

- Same empirical features in recent runs on shadow banks (ABCP runs in 2007, European Debt Crisis in 2011)
Overview of the Result

- A dynamic bank run model with endogenous information acquisition about liquidity
  - **rumor**: signal about bank liquidity lacking a discernible source
  - additional information acquisition upon hearing the rumor
- We emphasize the role of acquiring informative but noisy information
  - Without information acquisition, either there is no run, or in run equilibrium depositors never wait (i.e. withdraw immediately) upon hearing the rumor
  - With information acquisition, in bank run equilibrium depositors with medium signal withdraw after an endogenous amount of time
Overview of the Result

- Information acquisition about liquidity may lead to bank run equilibrium thus inefficient
  - Suppose without information acquisition bank run equilibrium does not exist ⇒ depositors never withdraw
  - With information acquisition, medium-signal depositors worry about some depositors who get bad signal and runs immediately
  - This “fear-of-bad-signal-agents” pushes medium-signal agents to withdraw after certain endogenous time
- Public information provision can crowd out inefficient private information acquisition
Related Literature

- Diamond and Dybvig (1983), Chari and Jagannathan (1988), Goldstein and Pauzner (2005), Ennis and Keister (2008), Nikitin and Smith (2008), etc
- Green and Lin (2003), Peck and Shell (2003), Gu (2011), etc
- He and Xiong (2012), Achaya, Gale, and Yorulmazer (2011), Martin, Skeie, and von Thadden (2011) etc
Bank Deposits

- Infinitely lived risk-neutral depositors with measure 1
- Bank deposits grow at a positive rate $r$, while cash under the mattress yields zero
  - $r$ can be broadly interpreted as a convenience yield
  - to ensure bounded values, bank assets mature at Poisson event with rate $\delta$
- Bank is solvent, but fails if $\tilde{\kappa}$ measure of depositors withdraw
  - we introduce uncertainty in $\tilde{\kappa}$ to capture uncertain bank liquidity
- If bank fails, each dollar inside the bank recovers $\gamma \in (0, 1)$
Liquidity Event and Spreading Rumors

- *Liquidity event* hits at an unobservable random time $\tilde{t}_0$
  exponentially distributed: $\phi(t_0) = \theta e^{-\theta t_0}$

  - 2007/08 crisis, banks have opaque exposure to MBS and hit by adverse shocks of real estate

- Bank **may** become illiquid and a *rumor* starts spreading:
  - “the liquidity event $\tilde{t}_0$ has occurred so the bank might be illiquid;” but nobody knows the exact time of $\tilde{t}_0$

- rumor: unverified info of uncertain origin that spreads gradually
Uncertainty about Bank Liquidity

- Bank initially liquid, but may become illiquid after $\tilde{t}_0$
  - Uninformed agents not running the bank (verified later)
- Bank liquidity $\tilde{\kappa}$ can take two values:

  - **Illiquid Bank**
    \[ \tilde{\kappa} = \kappa_L \in (0, 1) \]

  - **Liquid Bank**
    \[ \tilde{\kappa} = \kappa_H > \kappa_L \]

  - $\kappa_H < 1$ but sufficiently high to rule out rumor-based runs
  - Once revealed to be liquid, agents *redeposit* their funds
Learning and Withdrawal

- Agent $t_i$’s information set at $t$: $\mathcal{F}^{t_i}_t = \{t_i, t, \tilde{y}_{t_i}, 1^B_F\}$
  - $1^B_F$ is bank failure indicator, $\tilde{y}_{t_i}$ is agent specific signal
  - $\tau = t - t_i$, $\zeta$: equilibrium survival time of illiquid bank
  - Failure hazard rate $h(\tau) = \Pr(\text{fail at } [\tau, \tau + dt]|\text{survive at } \tau)$

- Proposition. *Given survival time $\zeta$, threshold strategy, i.e. withdraw after $\tau_w$, is optimal.*
Individual Optimality: When to Withdraw?

- Withdrawal decision trades-off bank failure vs growth
- Optimal withdrawal time $\tau_w \geq 0$ satisfies FOC:

$$h(\tau_w) \times (1 - \gamma) = r \times V_O(\tau_w)$$

  - failure hazard
  - expected loss
  - convenience yield
  - value of a dollar outside the bank

- Given conjectured bank survival time $\zeta$, the above FOC only depends on $\zeta - \tau_w$:

$$g(\zeta - \tau_w) = 0$$

- If $\zeta$ goes up by $\Delta$, $\tau_w$ goes up by $\Delta$: if banks survive longer, why don’t I wait longer?
- Stationarity: my extra waiting time is exactly the increased bank survival time
Aggregate Withdrawal Condition

- Failure occurs when aggregate withdrawals reach the illiquid bank’s capacity:
  \[ \int_{t_0}^{t_0 + \zeta - \tau_w} \beta e^{-\beta(t_i-t_0)} dt_i = 1 - e^{-\beta(\zeta - \tau_w)} = \kappa L. \]

- Again, as in individual optimality condition, the aggregate withdrawal condition only depends on \( \zeta - \tau_w \)

- Except in knife-edge cases, “aggregate withdrawal” and “individual optimality” conditions have different solutions for \( \zeta - \tau_w \)

- It has important implications for bank run equilibrium without information acquisition
No Endogenous Waiting in Bank Runs

- Generically, either bank runs never occur, or bank runs occur without waiting so $\tau_w = 0$
  - Suppose the conjectured bank survival time is $\zeta$. Aggregate withdrawal condition gives $\zeta - \tau_w$
  - Suppose individual optimality condition $g(\zeta - \tau_w) > 0$ so that every agent postpones withdrawal. Say $\tau_w + \Delta$ is optimal
  - Aggregate withdrawal condition says the new survival time becomes $\zeta + \Delta$!
  - Then the individual optimality condition says agents should wait $\tau_w + 2\Delta$, and so on so forth...
  - In equilibrium, no bank run occurs
  - If $g(\zeta - \tau_w) < 0$, then bank run occurs, but the above argument pushes $\tau_w = 0$
The Model with Information Acquisition

- Each agent, upon hearing the rumor, acquires an additional signal with quality $q$ at some cost $\chi > 0$

![Diagram showing the model with information acquisition]

- Pr. $q$ perfect signals ($y_H$ or $y_L$); Pr. $1 - q$ uninformative ($y_M$)
Individually Optimal Withdrawal

- $y_L$ agents immediately withdraw upon hearing the rumor, $y_H$ agents never withdraw.
- $y_M$ agents wait some endogenous time $\tau_w > 0$.

![Diagram showing the timing of withdrawal decisions for different types of agents.](Diagram.png)
Modified Aggregate Withdrawal Condition

- Introduction of noisy signals changes the aggregate withdrawal condition

\[ q \left(1 - e^{-\beta \zeta}\right) + (1 - q) \left(1 - e^{-\beta(\zeta - \tau_w)}\right) = \kappa_L \]

- Conditional on illiquid bank, \( y_L \) agents are running over \([0, \zeta]\) but \( y_M \) agents running over \([\tau_w, \zeta]\)
Bank Run Equilibrium with Waiting

- $y_M$’s withdrawal decision: bank failure vs. $r$ growth
- Suppose all $y_M$ agents withdraw immediately ($\tau_w = 0$), then
  - few $y_L$ agents have withdrawn, takes longer to fail
  - longer remaining survival time $\zeta - \tau_w$, lower failure hazard
- When wait longer $\tau_w \uparrow$, $y_M$ agents know that more and more $y_L$ agents have withdrawn before them
  - shorter remaining survival time $\zeta - \tau_w$, higher failure hazard
  - the effect of “fear-of-bad-signal-agents”
Comparative Statics

- Suppose agent can choose precision $q$ at some convex cost
- What is the impact of rumor spreading rate $\beta$ and awareness window $\eta$ on equilibrium outcomes?

Counter-intuitive: when the awareness window widens and potentially more agents run, the illiquid bank survives longer

Key The agent who hears the rumor also observes the bank is alive

Conditional on the bank surviving this long, the bank is more likely to be liquid
Strategic Substitution vs Strategic Complementarity

- Our model features strategic complementarity between information acquisition
  - Two equilibria: either no-acquisition-no-run, or acquisition-and-run
- Strategic complementarities in bank runs!
- But, we have strategic substitution in information acquisition as well
  - The mere bank survival is a public signal in our dynamic model
  - When other agents learn more, bank survival becomes a better information for bank liquidity
  - Thus individual agents acquire less information
- This strategic substitution effect is behind the counter-intuitive awareness window result
Extension: Insolvent Banks and Stress Tests

- Suppose that bank can also be insolvent
- Upon hearing the rumor, the agent can spend effort $e$ to know whether the bank is solvent (full revelation)
- Studying solvency inevitably tells us something about liquidity
  - the baseline quality of liquidity signals $\tilde{y}$ becomes $e$ by uncovering insolvency
  - then, agents can further choose $q > e$ with cost $\frac{\alpha}{2} (q - e)^2$
- A high $e$ triggers the bank run equilibrium
  - agents study hard to detect insolvent banks, but also learn something about bank liquidity
  - if others know a lot about liquidity, bank runs are possible and I want to learn more as well
Policy Implication: Stress Tests

- Public provision of solvency information (lower $\epsilon$) can mitigate bank runs by crowding-out individual depositors’ effort to acquire liquidity information.
Extension: Switching between Two Banks

- Often agents move funds from weak banks to stronger ones. Highly inefficient.
  - instead of keeping cash under the mattress (with zero return), the outside option is endogenous
- Suppose we have two banks one of which is illiquid with probability $\frac{1}{2}$
- The whole analysis goes through with only $y_L$ agents withdrawing
Policy Implication: Injecting Noise about Solvent Banks

- Injecting noise about solvent banks increases the cost of liquidity information (a higher $\alpha$) can eliminate the run.
- October 13, 2008: Bailout of Big 9 Banks
- Paulson forces strongest banks to participate
- The government was in fact injecting noise about the liquidity of competing solvent banks into the economy
Conclusion

- Individuals acquire information about bank liquidity excessively when bank runs are a concern
  - gradual withdrawal and dynamically learning bank liquidity is new to the literature

- Government can play an active role in information policy

- We consider other theoretical issues
  - uninformed agents’ problems, what if choosing acquisition timing, etc

- Our dynamic model can be taken to data, when available
Nonexistence of DD Pure-Strategy Sunspot Runs

- Interestingly, we can rule out the following Diamond-Dybvig pure-strategy bank runs triggered by sunspot.
- Say that all agents, both those who have heard the rumor and those who have not, coordinate to run on the bank on some arbitrary time \( T \).
  - As bank could be illiquid when time elapses, running could be incentive compatible.
- However, if \( T > 0 \), every agent would like to preempt and withdraw at \( T - \epsilon \).
- Therefore \( T = 0 \). But it is common knowledge that the bank at \( T = 0 \) is liquid (so will not fail even if others are running)!
- Of course, equilibria with mixed strategies may exist.