Information Acquisition in Rumor-Based Bank Runs

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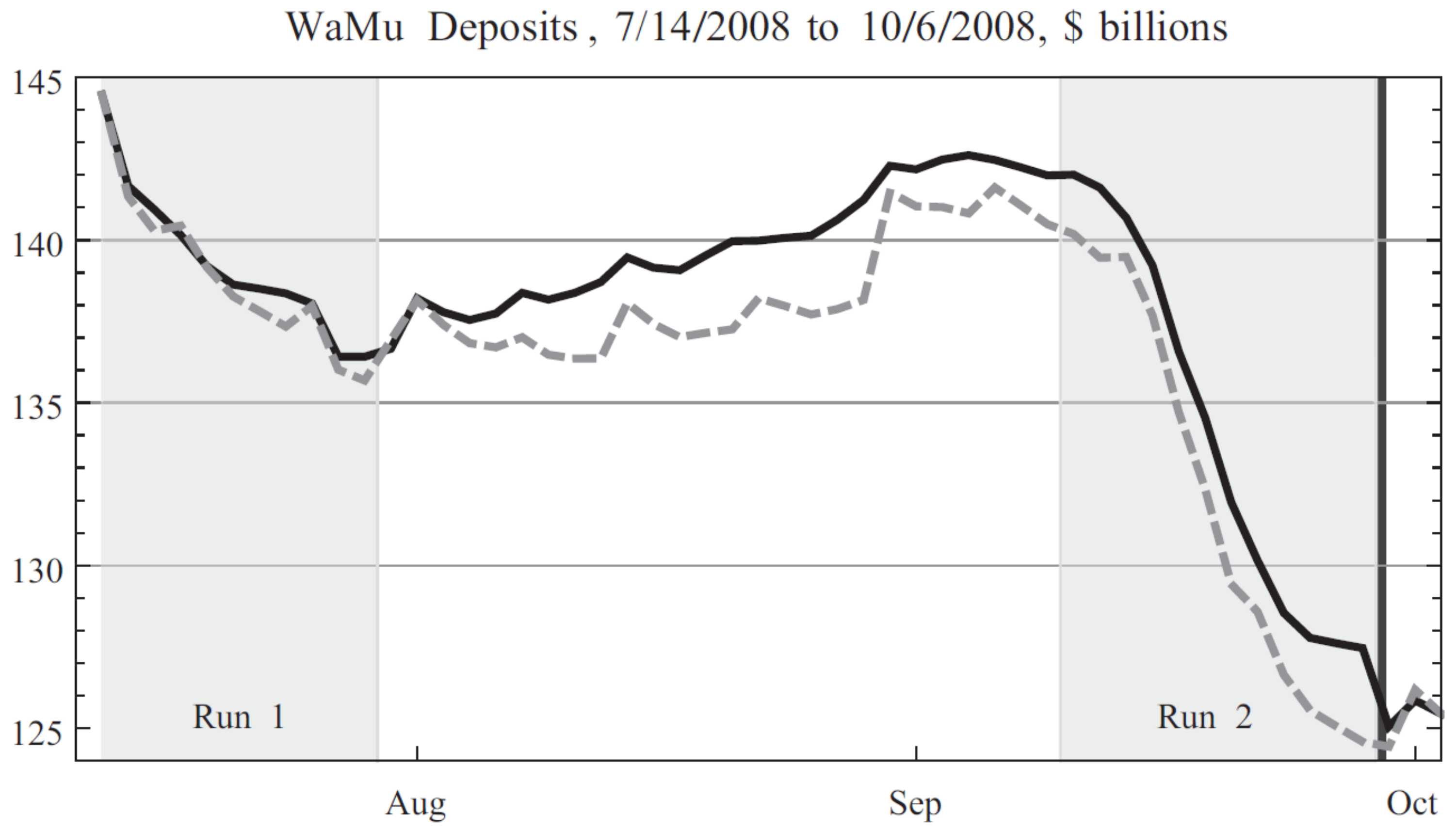
Introduction I



Introduction II – This Paper's Aim

- This paper studies the dynamic effects of information acquisition and the incentives to wait on the existence and duration of bank runs have not been studied by existing models of bank runs.

Introduction III

- Liquidity event
- Liquid and illiquid banks
- Liquidity event triggers the rumor
- Withdrawal time

Introduction IV

- Stage 1: Without information Acquisition
- In this case either bank runs never occur, or depositors run on the bank immediately upon hearing the rumor

Introduction V

- Stage 2: Additional noisy signals
- Three potential signals: good, fair, bad$\Rightarrow$belief heterogeneity
- Each agent's behavior
- Information acquisition exposes otherwise safe banks to destructive runs with endogenous waiting

Introduction VI

- Stage 3: Endogenize choice of signal quality
- In this case our model features both strategic complementarity and substitutability in information acquisition

The Base Model without Information Acquisition I – Banks and Depositors

- Continuous time $t \in [0, \infty)$
- A unit mass of infinitively-lived risk neutral depositors with a zero discount rate
- Bank deposits yield: $r > 0$
- Bank’s growth stops at some “maturing” event modeled as Poisson shock with intensity $\delta > r$, and then the game ends

The Base Model without Information Acquisition II – Uncertainty about Bank Liquidity

- Two potential types of solvent banks: liquid and illiquid
- Uncertainty about bank liquidity is crucial to our analysis!
- Bank liquidity: $\tilde{\kappa} = \begin{cases} \kappa_L < 1 \\ \kappa_H > 1 \end{cases}$
- Conditional on the liquidity event the probability of the illiquid state is $p \in (0,1)$ (common knowledge)
- Fire-sale price: $\gamma \in (0,1)$ for each dollar of deposits

The Base Model without Information Acquisition III- Liquidity Event

- At $\tilde{t}_0 > 0$ (unobservable) bank becomes illiquid
$$\Phi(\tilde{t}_0) = 1 - e^{\theta t_0}$$
- After $\tilde{t}_0$ rumor spreads / Informed and Uninformed agents
- Rumor spread interval $[t_0, t_0 + \eta]$
- Number of informed agents at $t > t_0$: $1 - e^{-\beta(t-t_0)}$
- Assumption: $1 - e^{-\beta\eta} > \kappa_L$
- Agents observe neither withdrawals, nor the potential queue but have rational expectations
- Transaction cost: $c > 0$

The Base Model without Information Acquisition IV- Posterior Beliefs

- Informed agents' belief:

$$\phi(t_0|t_i) \equiv \frac{f(t_i|t_0)\,\phi(t_0)}{\int_{t_i-\eta}^{t_i} f(t_i|s)\,\phi(s)\,ds} = \frac{\theta-\beta}{e^{(\theta-\beta)\eta}-1} e^{(\theta-\beta)(t_i-t_0)} \equiv \frac{\lambda e^{\lambda(t_i-t_0)}}{e^{\lambda\eta}-1},$$

$$\Phi(t|t_i) \equiv \Pr\left(\widetilde{t_0} \le t|t_i\right) = \int_{t_i-\eta}^{t} \phi(s|t_i)\,ds = \frac{e^{\lambda\eta}-e^{\lambda(t_i-t)}}{e^{\lambda\eta}-1}.$$

The Base Model without Information Acquisition IV- Bank Failure Hazard Rate I

- Suppose that agents believe the illiquid ban fails at $t_0 + \zeta$
- ζ: survival time
- For agent i, the bank fails if $t_0 = t - \zeta = t_i + \tau - \zeta$ and its illiquid
- Bank failure hazard rate:

$$h(t_i + \tau | t_i) = \frac{p\phi(t_i + \tau - \zeta | t_i)}{1 - p\Phi(t_i + \tau - \zeta | t_i)}.$$

The Base Model without Information Acquisition V- Bank Failure Hazard Rate II

- Hazard rate increases with τ if $p > const$.
- Two mechanisms of τ:
  - More time without failure lowers the possibility of bank illiquidity$\Rightarrow h(\tau) \downarrow$
  - Higher τ means approaching to the expected failure date $\Rightarrow h(\tau) \uparrow$

The Base Model without Information Acquisition VI- Value Functions

- $V_I(\tau)$ and $V_o(\tau)$: Value of one dollar inside and outside the bank at $t = t_i + \tau$
- Optimality conditions:
  - $V_I(\tau) \geq (1-c)V_O(\tau)$ and
  - $V_O(\tau) \geq (1-c)V_I(\tau)$

$$V_I(\tau) = \int_0^\infty e^{rs}(1-c)\,\delta e^{-\delta s} ds = \frac{(1-c)\,\delta}{\delta - r} \text{ for } \tau \geq \zeta.$$

$$V_O(\zeta) = (1-c)\,V_I(\zeta) = \frac{(1-c)^2\delta}{\delta - r}$$

The Base Model without Information Acquisition VII- Bellman Equation

$$0 = \underbrace{h(\tau)(1 - V_O(\tau))}_{\text{Bank failure}} + \underbrace{\delta(1 - V_O(\tau))}_{\text{Bank matures}} + \underbrace{V_O'(\tau)}_{\text{Time change}} .$$

$$0 = \max\left\{h(\tau)(1 - V_O(\tau)) + \delta(1 - V_O(\tau)) + V_O'(\tau), (1 - c) V_I(\tau) - V_O(\tau)\right\} .$$

$$\begin{aligned} 0 = \Big\{ & \underbrace{rV_I(\tau)}_{\text{Interest}} + \underbrace{h(\tau)(\gamma(1 - c) - V_I(\tau))}_{\text{Bank failure}} + \underbrace{\delta((1 - c) - V_I(\tau))}_{\text{Bank matures}} \\ & + \underbrace{V_I'(\tau)}_{\text{Time change}} , \underbrace{(1 - c)V_O(\tau) - V_I(\tau)}_{\text{Withdrawal}} \Big\} \end{aligned}$$

The Base Model without Information Acquisition VII- Optimal Strategy

- Naive strategy: staying outside the bank from τ to ζ and redepositing if the bank survives

$$\widehat{V}_O(\tau) = \frac{e^{\lambda\eta}(1-p) - 1 + e^{\lambda(\zeta-\tau)}p + e^{-\delta(\zeta-\tau)}(1-p)\left(e^{\lambda\eta}-1\right)\upsilon}{(1-p)\left(e^{\lambda\eta}-1\right) + \left(e^{\lambda(\zeta-\tau)}-1\right)p}.$$

- Marginal impact of postponing withdrawal on the value of this strategy:

$$g(\tau) \equiv h(\tau)(1-\gamma) - r\widehat{V}_O(\tau).$$

- In the optimal $\tau = \tau_w$:

$$\underbrace{h(\tau_w)(1-\gamma)(1-c)}_{\text{Staying cost}} = \underbrace{rV_I(\tau_w)}_{\text{Staying benefit}}.$$

The Base Model without Information Acquisition VII- Optimal Strategy II

- If $g(\zeta) \leq 0$: it is optimal to stay in the bank always
- If $g(\zeta) \geq 0$: it is optimal to withdraw at time 0 and redeposit right after ζ

The Base Model without Information Acquisition VII- Equilibrium Conditions

- Aggregate Withdrawal Condition:

$$\int_{t_0}^{t_0+\zeta-\tau_w} \beta e^{-\beta(t_i-t_0)} dt_i = 1 - e^{-\beta(\zeta-\tau_w)} = \kappa_L. \qquad \text{(AW)}$$

- Individual Optimality Condition:

$$g(\tau_w;\zeta) = \frac{(\lambda(1-\gamma)-r)\, p e^{\lambda(\zeta-\tau_w)} - r\left[(1-p)\left(e^{\lambda\eta}-1\right)\left(1+\upsilon e^{-\delta(\zeta-\tau_w)}\right)-p\right]}{(1-p)\left(e^{\lambda\eta}-1\right)+\left(e^{\lambda(\zeta-\tau_w)}-1\right)p} = 0. \quad \text{(IO)}$$

- Both conditions only depend on $\zeta - \tau_w$ (As a result of stationarity)

The Base Model without Information Acquisition VII- Bank Run Equilibrium

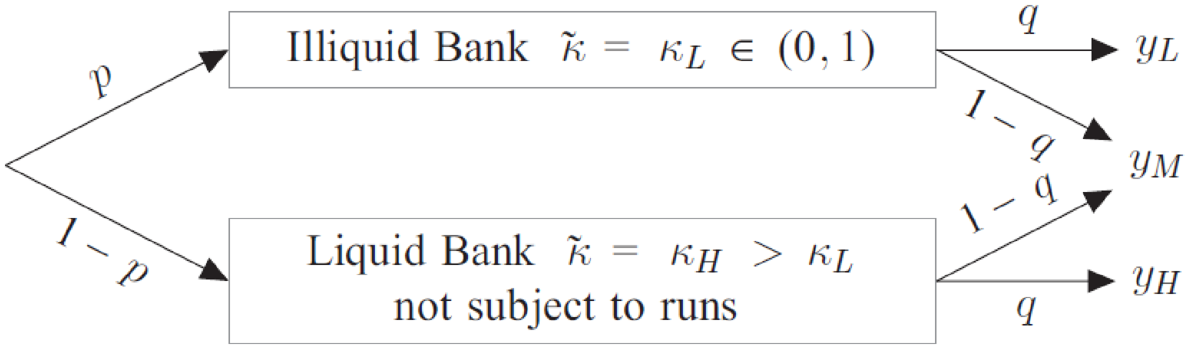
- AW and IO conditions are not consistent with each other.
- Proposition: The bank run equilibrium is as follows:
  - If $G(\tau_r^u) > 0$: $\tau_w = 0\ , \zeta = -\frac{\ln(1-\kappa_L)}{\beta}$
  - If $G(\tau_r^u) < 0$: a bank run equilibrium doesn't exist
  - If $G(\tau_r^u) = 0$: any $\tau_w \geq 0\ and\ \zeta = \tau_w + \tau_r^u$ constitute a bank run equilibruim

The Model with Information Acquisition I - Introduction

- Noisy Information acquisition ⇒ ex-post belief heterogeneity
- This changes the AW condition so that ζ responds less than one-to-one to τ_w
- This makes solvent banks that are free from runs prone to runs, and shortens the survival time of failing banks

The Model with Information Acquisition II - Information

- Signals: $\tilde{y} \in \{y_L, y_M, y_H\}$



- For y_L agents: withdraw immediately
- For y_H agents: stay inside the bank forever
- For y_L agents: individual optimality$\Rightarrow G(\tau_r) = 0$

The Model with Information Acquisition III – Equilibrium Conditions

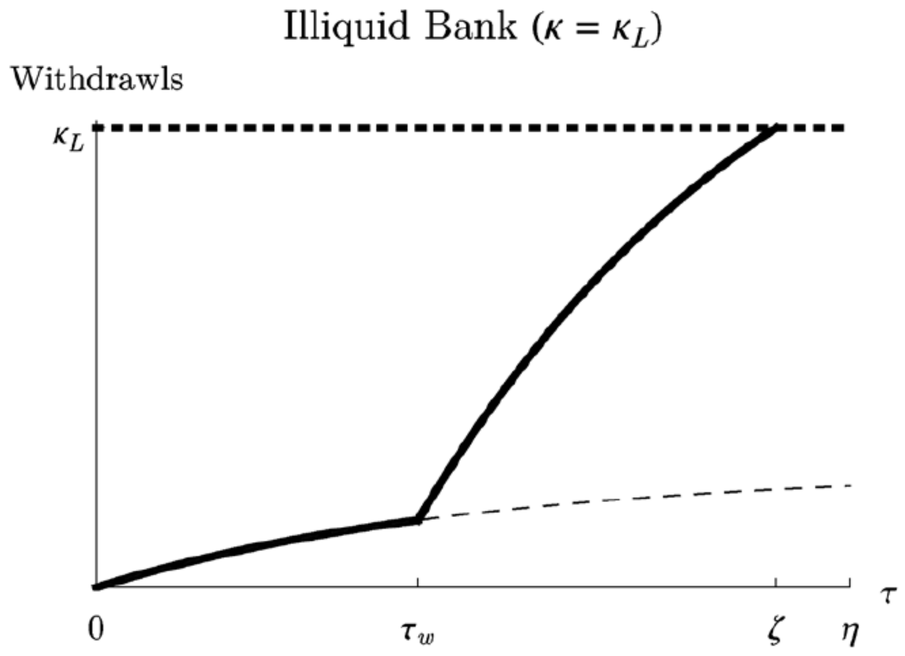
- Illiquid bank fails if

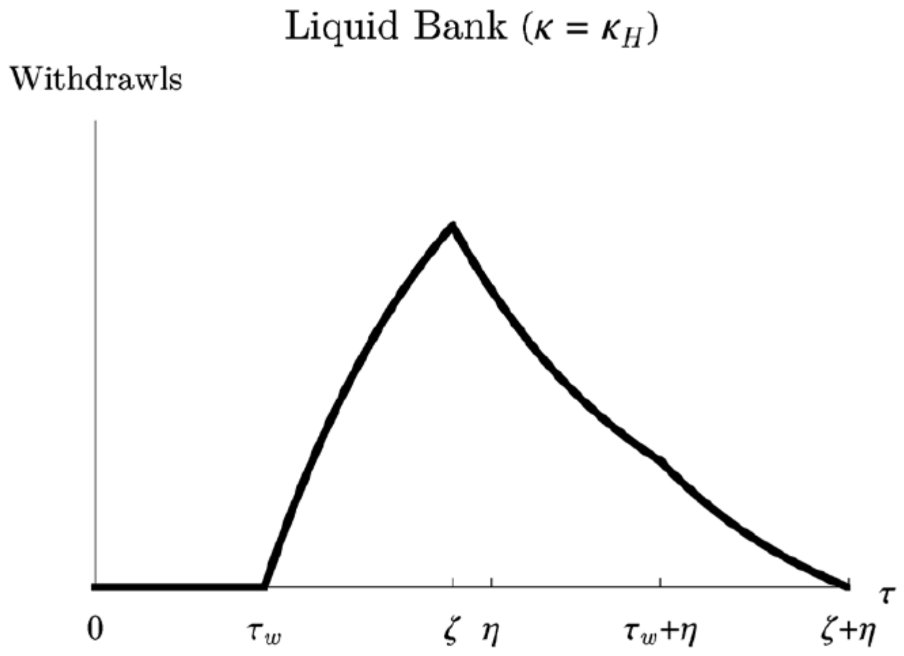
$$q\left(1-e^{-\beta\zeta}\right)+(1-q)\left(1-e^{-\beta\tau_r}\right)=\kappa_L.$$

- ζ is obtained endogenously

$$\zeta=-\frac{1}{\beta}\ln\left[1-\frac{\kappa_L-(1-q)\left(1-e^{-\beta\tau_r}\right)}{q}\right].$$

The Model with Information Acquisition IV – Equilibrium



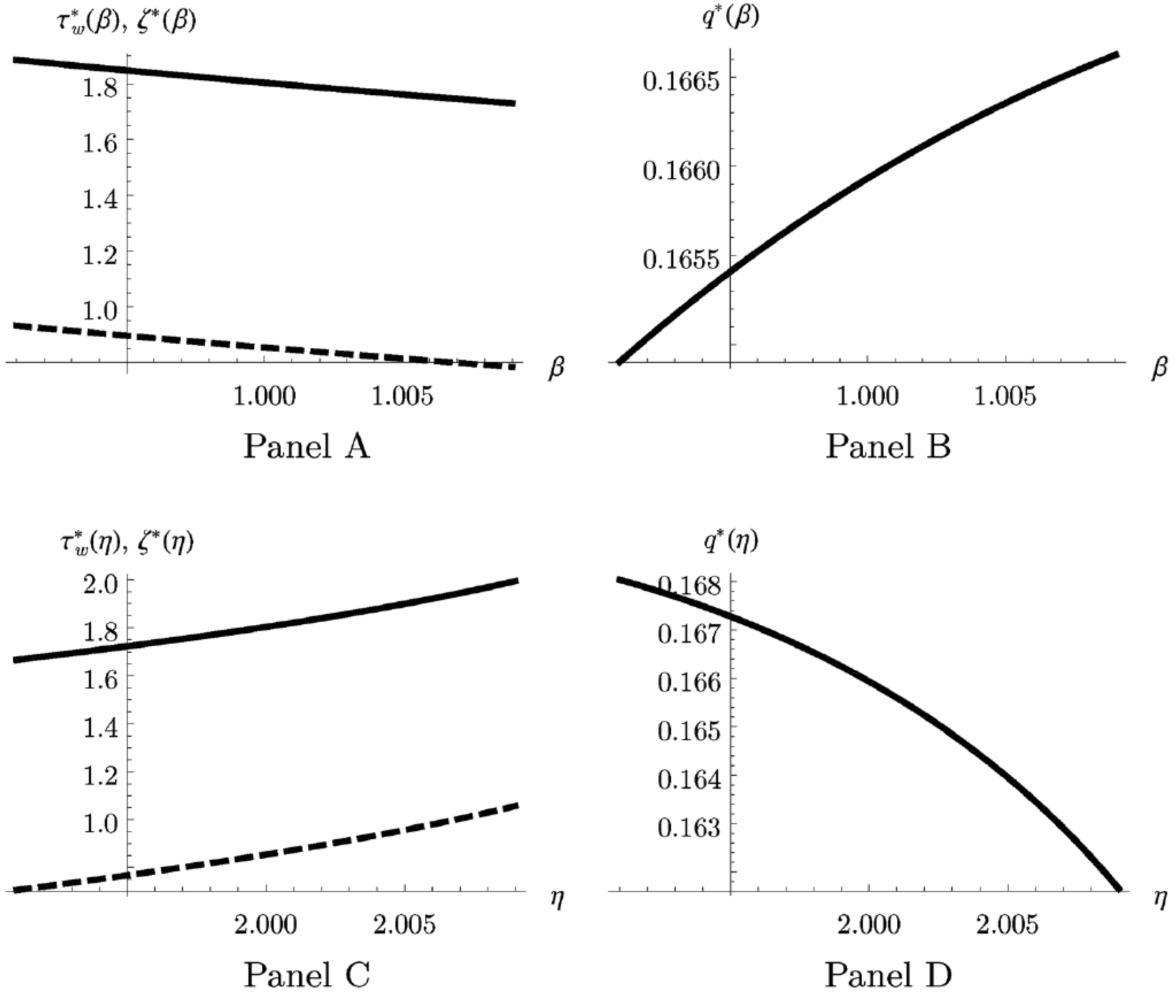


The Model with Information Acquisition V – Endogenous Information Acquisition

- Signal cost: $\chi > 0$ per dollar of deposit
- Collecting information is individually beneficial but socially wasteful
- We can endogenize q in a setting with acquisition cost $\chi(q) = \frac{\alpha}{2} q^2$
- Three cases:

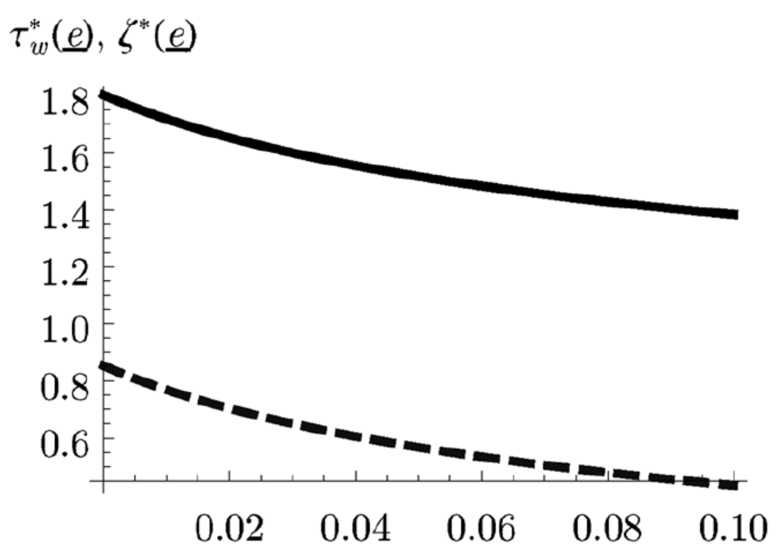
1. No information acquisition no bank run
2. Two equilibria: No information acquisition no bank run and bank run with information acquisition
3. Bank run without information acquisition

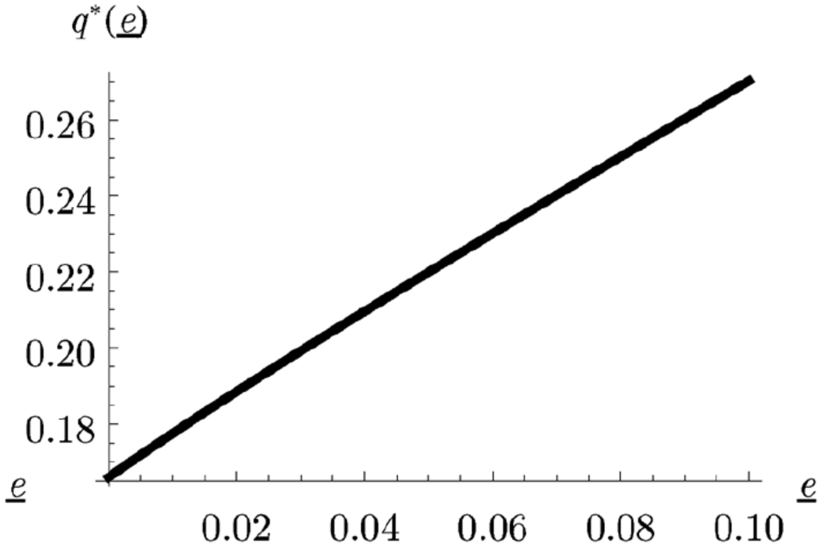
The Model with Information Acquisition VI – Strategic Complementarity vs. Substitutability



Extensions and Discussions I – Solvency Information vs. Liquidity Information

- Learning about liquidity of the bank is a by-product of learning about bank solvency
- government can use stress tests to reduce *e* to eliminate runs on solvent but illiquid banks





Extensions and Discussions II – Multiple Solvent Banks

- a bank run in this setting involves the transfer of deposited funds from one illiquid bank to another more liquid one
- Information is privately more valuable in this setup
- it shortens the survival time of the illiquid bank
- Thus, it is socially beneficial to blur the differences between competing solvent banks.

Conclusion

- Information acquisition about liquidity exposes otherwise safe banks to destructive runs
- The model makes new prediction linking the likelihood of a run to the spreading rate of the rumor, the cost of acquiring information, and the recovery value in the case of bankruptcy
- It also generates the unique prediction that, for banks that survive a run, we should observe agents withdraw at the same time earlier-informed agents redeposit