Runs, Panics, and Contagion

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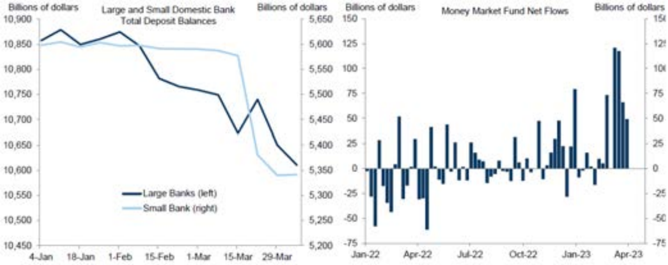
Ricardo J. Caballero

MIT

Economic Crises

Regional Banks 2023

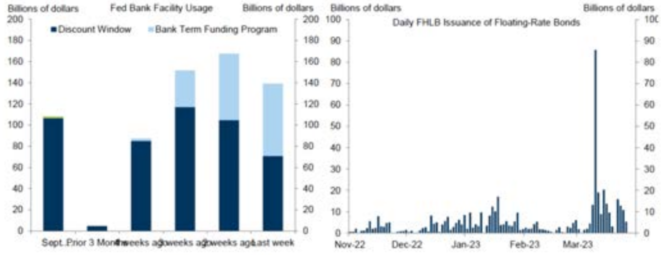
Exhibit 1: Deposit Outflows from Banks and Inflows to Money Market Funds Have Decelerated from the Peak Weeks of the Banking Turmoil



Source: Federal Reserve Board, Morningstar, Goldman Sachs Global Investment Research

Regional Banks 2023

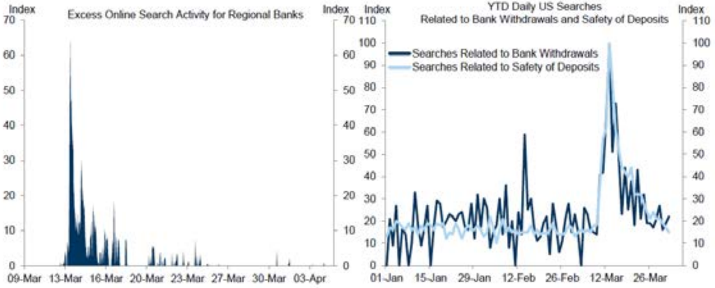
Exhibit 2: Banks' Borrowing from the Fed and Federal Home Loan Banks Has Stabilized, Suggesting That They Have Had Less Need for Additional Liquidity Over the Last Two Weeks



Source: Federal Reserve, FHLB, Goldman Sachs Global Investment Research

Regional Banks 2023

Exhibit 4: Google Search Results Indicate That the Public's Initial Focus on Troubled Regional Banks and on Withdrawing Deposits Has Faded



Source: Google Trends, Goldman Sachs Global Investment Research

References

1. Diamond, D.W. and P.H.Dybvig, "Bank Runs, Deposit Insurance, and Liquidity," *Journal of Political Economy,* 91(3), 401-419, June 1983.
2. Allen, F. and D. Gale, "Financial Contagion," *Journal of Political Economy,* 108:1-22, 2000
3. (Intuition only) Caballero, R.J. and A. Simsek,"Fire Sales in a Model of Complexity," *Journal of Finance*, 68(6), 2549-2587, 2013

Main points

- The maturity transformation of banks builds on the LLN. As such, it is inherently fragile to an endogenous breakdown in heterogeneity (coordination failure)
- Contagion can arise from network effects and fire sales of common assets

The Diamond-Dybvig model of bank runs

- Depository institutions as "pools of liquidity." They transform illiquid assets (long term inv.) into liquid liabilities (deposits).
- Danger: Bank runs (too many decide to use the "liquidity option" at the same time).
- Policy: Deposit insurance, LLR, suspension.

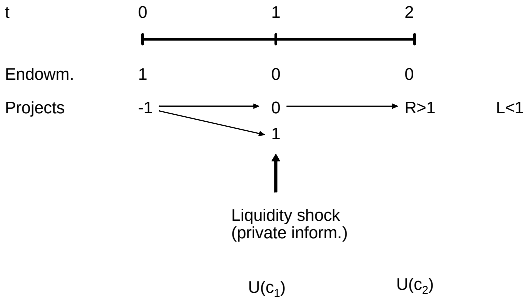
The Diamond-Dybvig model of bank runs

- Continuum 1 of individuals each endowed with one unit of currency. $t = 0, 1, 2$
- At $t = 0$, individuals can either invest in short-run project with return equal to 1, or invest in a long-run project that yields a return $R > 1$ at $t = 2$.
- If liquidate the long-run project at $t = 1$, return is $L < 1$ only.
- At $t = 1$, fraction π of individuals gets liquidity shock and only value consumption at $t = 1$. The remaining fraction $1 - \pi$ is patient and only values consumption at $t = 2$. The liquidity shock is private information
- Ex-ante expected utility is

$$U = \pi u(c_1) + (1 - \pi)u(c_2),$$

where c_1 is consumption in period 1 if impatient and c_2 consumption in period 2 if patient (*consume at only one date*); $u' > 0; u" < 0; -cu''/u' > 1$

The Diamond-Dybvig model of bank runs



Autarky

- Denote $I \in [0,1]$ the investment in the long-run project
- Under autarky, the individual solves:

$$\begin{aligned} \max_I U &= \pi u(c_1) + (1-\pi) u(c_2) \\ c_1 &= 1 - I + LI \\ c_2 &= 1 - I + RI \end{aligned}$$

- Ex-post inefficient. Would like $I = 1$ if patient ($c_2 = R$), $I = 0$ if impatient ($c_1 = 1$).

Ex-post Financial Market

- Bond at $t = 1$; p units of t_1 goods for one t_2 good.
- Impatient individuals buy t_1 goods, so

$$c_1 = pRI + (1 - I).$$

- Patient individuals buy t_2-goods, so

$$c_2 = RI + \frac{1 - I}{p}.$$

- The equilibrium price must satisfy

$$\frac{L}{R} \leq p \leq 1.$$

- Equilibrium: $p = 1/R$; $c_1 = 1$, $c_2 = R$, $I^M = 1 - \pi$.
- Better... but not great, since $c_2 >> c_1$

Planner's Problem

- Ex-post market leaves too much liquidity risk: $c_2 >> c_1$

$$\max_{I} U = \pi u(c_1) + (1-\pi)u(c_2)$$
$$c_1 = \frac{1}{\pi}(1-I)$$
$$c_2 = \frac{1}{1-\pi}RI$$
$$u(c_2) \geq u(c_1)$$

- Solution:

$$u'(c_1^*) = Ru'(c_2^*)$$

(note that IC is not binding since $c_2 > c_1$)

Planner's Problem: The Liquidity Insurance Component

- Insurance since: $c_1 > 1$ and $c_2 < R$

$$
\begin{aligned}
Ru'(R) &= u'(1) + Ru'(R) - u'(1) \\
&= u'(1) + \int_1^R \frac{\partial}{\partial s}[su'(s)]ds \\
&= u'(1) + \int_1^R [u'(s) + su''(s)]ds \\
&= u'(1) + \int_1^R u'(s)\left[1 + \frac{su''(s)}{u'(s)}\right] ds \\
&< u'(1)
\end{aligned}
$$

- Insurance follows from the fact that $u'(c_1^*) = Ru'(c_2^*)$,

Intermediation

- Can implement the planner's solution
- Financial interm. offers c_1^* or c_2^* in exchange for deposit such that:

$$\max U \qquad \text{s.t. } \pi c_1 + (1-\pi)\frac{c_2}{R} = 1$$

- Bank saves πc_1 to fulfill obligations.

Run

- If many patient consumers withdraw early, nothing is left for those who wait. Second Nash equilibrium. Expectations can lead to bank run.
- **Sequential servicing constraint** (first come, first served) creates incentives to run early.
- Let $\lambda \geq \pi$ denote the mass of consumers that withdraw. Then, a deposit contract pays:

$$
\begin{aligned}
c_1 &= \min\left\{\frac{\pi c_1^* + L(1-\pi c_1^*)}{\lambda}, c_1^*\right\} \\
c_2 &= \max\left\{\frac{R\left(1-\pi c_1^* - \frac{1}{L}(\lambda-\pi)c_1^*\right)}{1-\lambda}, 0\right\}
\end{aligned}
$$

- Note that there is a $\lambda < 1$ such that IC is violated as $c_1 > c_2$. If patient agents think such λ will realize, they run (and $\lambda = 1$, so it is self-fulfilling)

Solutions...

- Deposit insurance, LLR, suspend convertibility (only first (small) λ of agents that arrive to the bank get money).
- Before 1913 (Fed was founded), the US experienced many runs. During the great depression it took too long for the Fed to react.
- Subprime crisis. Runs on unprotected investment banks (repo market)
- Fixed exchange rates
- Remarks:
  - Global games links runs to fundamentals
  - Modern version in DM: short term debt instead of retail deposits

Run on the Repo Market (Subprime crisis - Gorton and Metrick)

- The Panic of 2007-2008 was a run on the repo market (rather than on deposits)
- Repo (sale and repurchase): short term collateralized (often by securitized bonds) loans among financial institutions
- Securitized-banking: Packaging and reselling loans (rather than making and holding loans), with repo-agreements as the main source of funding
- Repo haircuts jump as concern for liquidity of repo underlying markets

Run on the Repo Market (Subprime crisis - Gorton and Metrick)

Traditional Banking

(1) Reserves
- Minimum levels set by regulators.
- Shortfalls can be borrowed from central bank.

(2) Deposit Insurance
- Guaranteed by the government

(3) Interest Rates on Deposits
- Can be raised to attract deposits when reserves are low.

(4) Loans Held on Balance Sheet

Securitized Banking

(1) Haircuts
- Minimum levels set by counterparties.
- No borrowing from central bank.

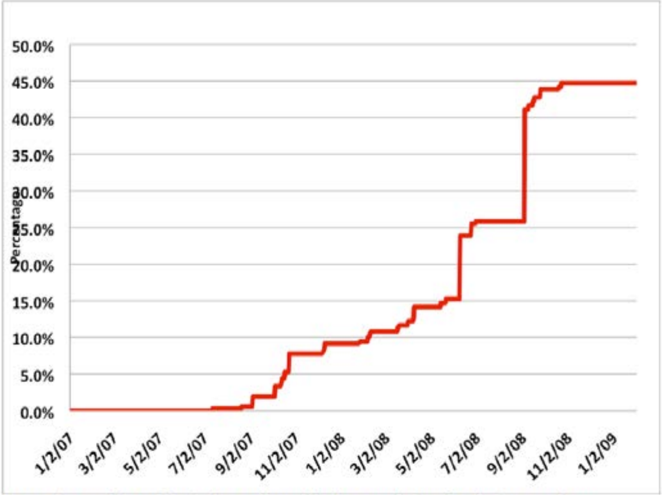
(2) Collateral
- Cash, treasury securities, loans, or securitized bonds

(3) Repo Rates
- Can be raised to attract counterparties when funds are low.

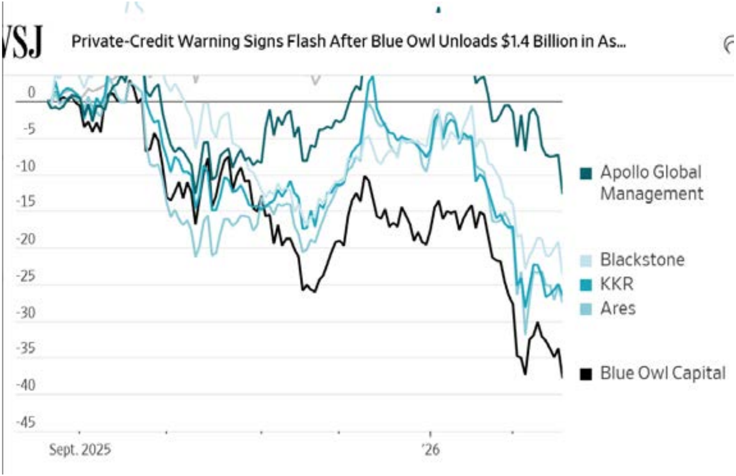
(4) Loans Securitized
- Some securitized bonds may be kept on balance sheet and used as collateral

Run on the Repo Market (Subprime crisis - Gorton and Metrick)

Figure 4: The Repo-Haircut Index



Private credit (late 2024-2026?)



Private credit (late 2024-2026?)

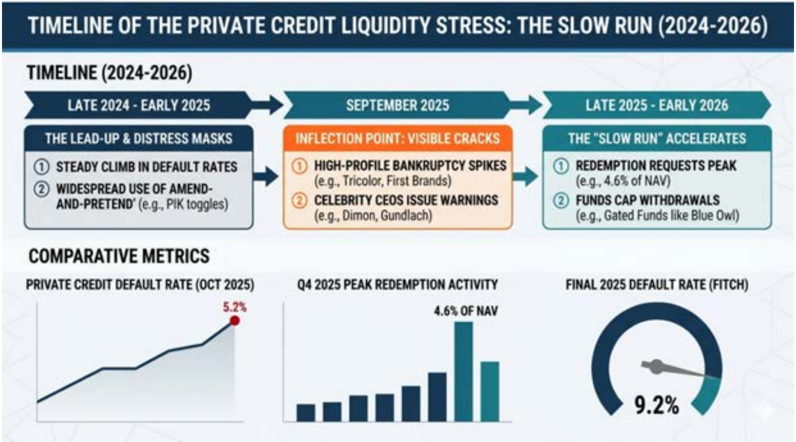


Image created using ChatGPT. 2026. Ricardo Caballero.

Financial Contagion

- "Small" shocks can spread through linkages
- Financial markets have all sort of linkages
- Allen and Gale (2000)
- [Caballero and Simsek (2013)]

Financial Contagion

- Allen and Gale model captures: Small shocks, which initially affect a few institutions, spread by contagion to the rest of the financial sector
- D-D structure (sans the runs)+ interbank insurance markets (regional deposit shocks are insured through deposits crossholdings)
- Linkages can turn into a disaster if banks start liquidating cross holdings to generate liquidity
- The particular form of interconnectedness is very important (incomplete networks)

Financial Contagion

- DD structure: Three dates, long term asset has return R at maturity and $0 < r < 1$ if liquidated prematurely.
- Four ex-ante identical regions: A, B, C, and D; each with its depositors a la DD (prob ω early consumer). Two (symmetric) states:

TABLE 1

REGIONAL LIQUIDITY SHOCKS

	A	B	C	D
S_1	ω_H	ω_L	ω_H	ω_L
S_2	ω_L	ω_H	ω_L	ω_H

Financial Contagion (first best)

- Let the average fraction of early consumers be: $\gamma \equiv (\omega_H + \omega_L)/2$.
- x and y represent the percapita amount invested in the long and short asset, respectively $(x + y \leq 1)$
- The planner first maximizes average consumers utility subject to feasibility constraints:

$$\gamma c_1 \leq y; \qquad (1-\gamma)c_2 \leq Rx$$

- Then the planner (subject to same informational constraints as private sector) transfers from low to high liquidity demand regions:

$$(\omega_H - \gamma)c_1 = (\gamma - \omega_L)c_1$$

- And at date 2 we reverse the flow:

$$(\omega_H - \gamma)c_2 = (\gamma - \omega_L)c_2$$

Financial Contagion (decentralization)

- Each region has a continuum of identical banks; DD structure and deposit is not contingent on regional liquidity shock
- Interbank market to avoid costly liquidation of long term assets (banks exchange deposits at the first date): $z^i = (\omega_H - \gamma)/2$ of deposits in each other regions
- Suppose a bank needs liquidity (hit by ω_H), then it liquidates deposits in other regions. Its budget constraint at this date is:

$$\left(\omega_H + \frac{\omega_H - \gamma}{2}\right) c_1 = y + 3\left(\frac{\omega_H - \gamma}{2}\right) c_1$$

- Which simplifies to the planner's constraint:

$$\gamma c_1 = y$$

- A symmetric argument holds for the banks that have low liquidity demand

Financial Contagion (Incompleteness)

- For example, banks in each region hold deposits only in adjacent region.

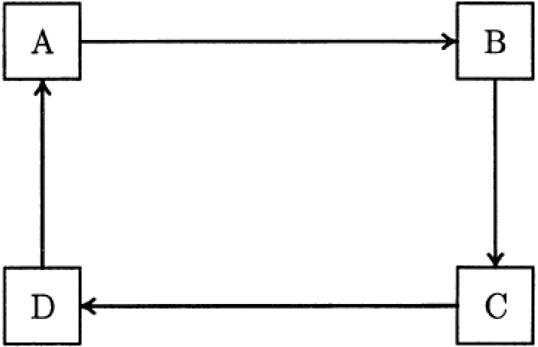


FIG. 2.—Incomplete market structure

- Still can implement first best:

$$\omega_H c_1 = y + (\omega_H - \gamma) c_1$$

Financial Contagion (Fragility)

- Suppose and unexpected (prob 0) aggregate event takes place:

REGIONAL LIQUIDITY SHOCKS WITH PERTURBATION

	A	B	C	D
S_1	ω_H	ω_L	ω_H	ω_L
S_2	ω_L	ω_H	ω_L	ω_H
$\bar{S}$	$\gamma + \epsilon$	γ	γ	γ

- Main result: *Incomplete network (example) does a lot worse in managing the aggregate shortage of liquidity*

Financial Contagion (Fragility)

- Assumptions: If bank cannot meet liquidity demand of impatient consumers, it must liquidate all long term assets and proceeds are split pro rata among all depositors (no first come, first served).
- Banks can be solvent, insolvent (meets depositors demand but only after liquidating some assets), or bankrupt
- Pecking order: short assets, deposits, long assets (assumptions about R, etc.)
- Liquidation value (all depositors must be treated equally):

$$q^A = \frac{y + rx + zq^B}{1+z}$$

- If B is solvent, then $q^B = c_1$, if not, then we need a similar equation that now involves a q^C, and so on
- *Note that if A is bankrupt, D is hit hard since it has a* **large** *deposit in A (while in the complete network total cross-deposits are larger but individual deposits are smaller)*

Financial Contagion (Fragility)

- **Buffer:** Suppose a bank is insolvent (but not bankrupt), then the cash generated by the long term assets that can be liquidated and made available for early consumers without causing a run of patient consumers is:

$$b(\omega) \equiv r\left[x - \frac{(1-\omega)c_1}{R}\right]$$

where the term in squared brackets comes from

$$R\left(x - [.]\right) = (1-\omega)c_1$$

- Note that cross bank deposits do not enter this expression since once a bank withdraws on another bank, all cross-bank deposits are withdrawn, so they net (no aggregate liquidity is created from these deposits)

Financial Contagion (Fragility)

- In region A the bank is short ϵc_1 units of liquidity. It can meet this shortage without external help iff :

$$\epsilon c_1 \leq b(\gamma + \epsilon)$$

and recall that $b' = (r/R)c_1$

- If ϵ is small, banks in A are insolvent but the other regional banks are spared.
- If ϵ is large, the buffer is insufficient and $q^A < c_1$, which means bank D experiences a loss. If D is insolvent, it pays on its cross-deposits c_1 but it only receives q^A. But if it is bankrupt, the whole network comes down!

Financial Contagion (Fragility)

- **Proof:** Suppose for a moment that B does not go bankrupt so we get an upper bound for q^A:

$$\overline{q}^A = \frac{y + rx + zc_1}{1 + z}$$

- Then a sufficient condition for D to go bankrupt is:

$$z(c_1 - \overline{q}^A) > b(\gamma)$$

- But if this is the case we know that

$$q^D \leq \overline{q}^A$$

- So C must go bankrupt as well. But then B must be bankrupt (which in turn means $q^A < \overline{q}^A$), which means all banks are bankrupt and the only continuation equilibrium has:

$$q^i = y + rx < c_1$$

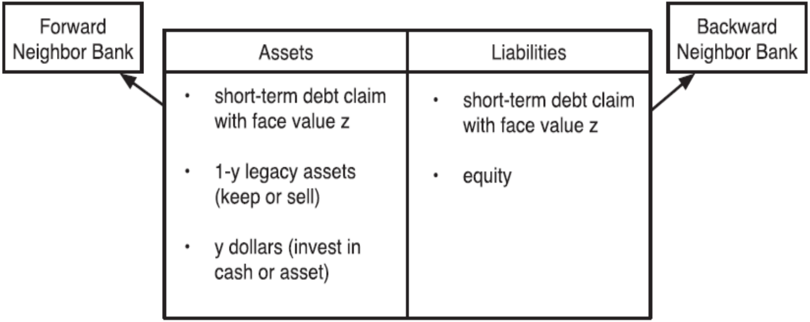
- **Important:** Note that with the complete network the deposit of D (and any other region) on A would have been smaller, and hence it would have been harder for D (or any other region) to go bankrupt (and the same is true in a very incomplete network...)

Caballero-Simsek Model (intuition only...)

- A model of the sudden rise in uncertainty and its interaction with asset fire sales.
- Normal times: Banks collect information about their trading partners, which assures them of their soundness.
- Acute financial distress in parts of the financial network: Need to learn about the health of the trading partners of the trading partners...
- At some point, it becomes too complex (in the common language sense of "too complicated"):
  $\Longrightarrow$ Increase in banks' perceived uncertainty.
  $\Longrightarrow$ Fire sales and flight to quality.

Modeling outline

- Financial system is a network of interlinkages (as in Allen and Gale, 2000)).



Modeling outline

- A surprise liquidity shock hits the network (at date 0 banks learn this shock is coming at date 1)
- Banks in distress withdraw their cross-loans, sell legacy assets, and cut back on new loans to meet the surprise liquidity shock.
- This leads to a partial domino.
- When shock is small, the domino is short and assets fetch their "fair price," which keeps the domino effect limited.
- When shock is large, the domino lengthens, perceived uncertainty rises, potential buyers withdraw, prices plummet, lengthening the domino....

Known Network (no shock is "too big")

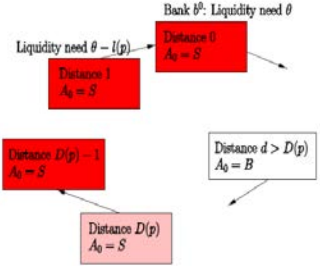


Figure 3: The partial domino effect and flight to quality in the certainty benchmark.

$$
\begin{aligned}
l(p) &= y + (1 - y)p \\
D(p) &= \left\lceil \frac{\theta}{l(p)} \right\rceil - 1
\end{aligned}
$$

Known Network (no shock is "too big")

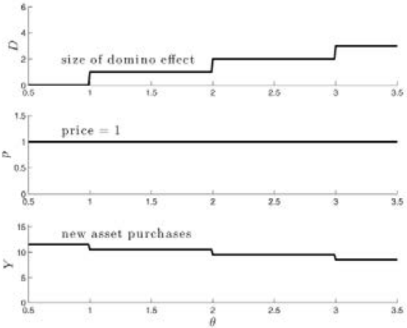
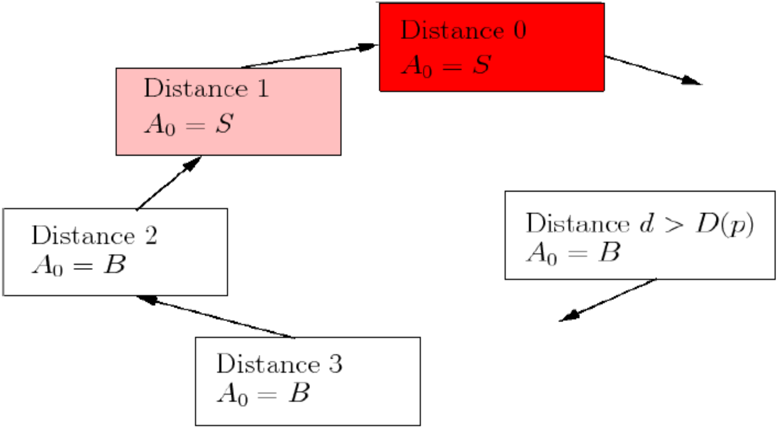


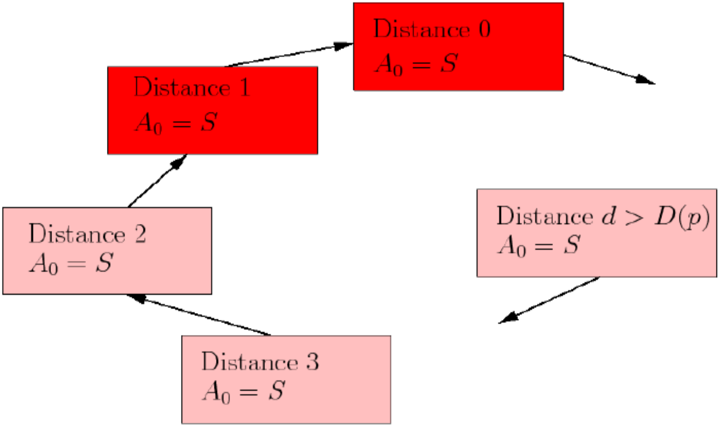
Figure 4. Equilibrium in the certainty benchmark. The top, middle, and bottom panels, respectively, plot the size of the domino effect, the asset price, and the aggregate new asset purchases as a function of the losses in the originating bank.

Small shock in an Unknown Network

Banks don't know the network structure.



Large shock in an Unknown Network



Large shock in an Unknown Network

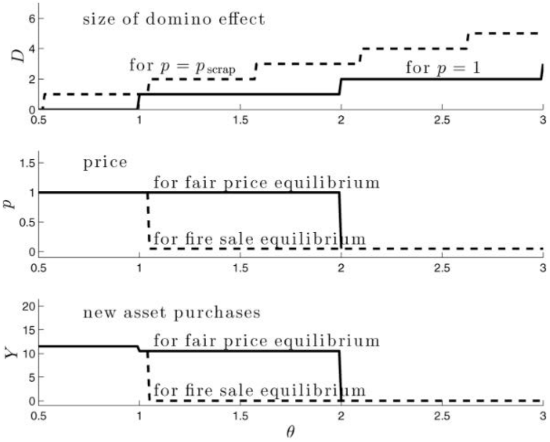


Figure 6. Equilibria with network uncertainty. The panels plot various equilibrium variables as a function of the shock, θ. The top panel plots the size of the domino effect in partial equilibrium, $D(p)$, for price level $p = p_{\text{scrap}}$ (dashed line) and price level $p = 1$ (solid line). The second panel plots the general equilibrium price, p. The last panel plots the aggregate new asset purchases, $\mathcal{Y}$.

Final remarks

- Financial markets, and banks in particular, provide many services to the real sector and consumers
- But they are inherently fragile
  - They rely extensively on statistical regularities, which human beings can quickly destroy when in panic mode
  - They are embedded in a very complex and dynamic structure, which is bound to remain only partially understood, and this is in itself an enormous source of uncertainty and fears
- The real consequences of these crises can be enormous. Regulatory efforts (sometime) help to slowdown the speed and shift the nature of the next crisis... but financial panics and crises have been with us for centuries, and they will probably remain so, often mutating a little (for example from depositors runs to securitized banking runs), but the core recipe does not change much