Banking Crises and the Role of Bank Coalitions

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Disclaimer

- The views expressed in this paper are those of the author and do not necessarily reflect those of the Federal Reserve Bank of Philadelphia or the Federal Reserve System.
Introduction

- Banks have historically played a major role in the payment system
- Bank liabilities (bank notes, demand deposits, etc.) have been widely used as a means of payment
- People demand bank liabilities because they are designed to facilitate trade
- As a result, the functioning of the payment system depends on the stability of the banking system
  - No bank failures
  - No losses to bank liability holders
Introduction

- Is it possible to obtain a stable payment system in the absence of government intervention?

- Can the provision of regulation and supervision services be left to private agents?

- Is the private banking system willing to hold enough reserves to absorb the effects of shocks?
Introduction

• No major government-sponsored financial institution in the U.S. from 1837 to 1914

• Clearinghouse associations emerged in major cities in the second half of the 19th century

• Established initially to facilitate the clearing of interbank payments

• Evolved into an organizational form that promoted a very integrated approach to banking
  
  – Private provision of regulation and supervision services
Literature

- **Private bank coalitions:** Gorton (1984, 1985); Gorton and Mullineaux (1987); Moen and Tallman (1992, 2000); McAndrews and Roberds (1995); Smith and Weber (1999); Leitner (2005); Gorton and Huang (2005)

- **Interbank markets:** Battacharya and Gale (1987); Acharya, Gromb, and Yorulmazer (2012); Allen, Carletti, Gale (2013)

- **Inside money:** Cavalcanti, Erosa, and Temzelides (1999); Cavalcanti and Wallace (1999); Williamson (1999); Kahn and Roberds (1999); Azariadis, Bullard, and Smith (2001); Li (2001); Martin and Schreft (2006); Berentsen (2006); Mills (2007); Skeie (2008); Andolfatto and Nosal (2009); Huangfu and Sun (2011); Araujo and Minetti (2011); Gu, Mattesini, Monnet, and Wright (forthcoming)
Figure 2: Creation and Redemption of Bank Notes with Perfect Public Information

Stage 1

Consumer → Banker

Stage 2

Merchant

Consumer

Meeting with probability $\lambda$

Stage 3

Merchant

Banker

good x

bank note

good y

bank note

Each banker moves to the centralized location and invests in the storage technology.
Model

- Discrete time: \( t = 0, 1, 2, \ldots \)

- Each period is divided into three subperiods or stages

- Two commodities: good \( x \) and good \( y \)

- Three types of agents: consumer, merchant, banker

- \([0, 1]\) continuum of each type
Model

- Consumer wants good $y$ and produces good $x$
- Merchant wants good $x$ and produces good $y$
- Banker wants good $x$ but does not produce either good
Model

- Good $x$ is produced in the \textit{first} subperiod
  - If it is not properly stored, it depreciates completely

- Good $y$ is produced in the \textit{second} subperiod
  - Perishable and cannot be stored
Model

- Consumer produces good $x$ in the first subperiod
  - Indivisible production technology: either 0 or 1
  - Good $x$ is perfectly divisible

- Merchant produces good $y$ in the second subperiod
  - Divisible linear technology (requires effort as an input)
  - Good $y$ is perfectly divisible

- Banker has access to the technology to perfectly store good $x$
Figure 1: Sequence of Events within a Period

Stage 1
Bilateral meetings between banker and consumer

Stage 2
All bankers move to the centralized location until the end of the period
Bilateral meetings between consumer and merchant

Stage 3
All merchants move to the centralized location
Model

- Three rounds of interactions

- **First subperiod**: Each consumer is randomly matched with a banker

- **Second subperiod**: Each consumer is randomly matched with a merchant with probability $\lambda \in (0, 1)$

- **Third subperiod**: All bankers and all merchants meet in a centralized location

- Production takes place during the first and second subperiods only
Model

- Consumer’s preferences:
  \[ U^c(x, y) = u(y) - \gamma x \]

- Merchant’s preferences:
  \[ U^m(x, y) = v(x) - \omega y \]

- Banker’s preferences:
  \[ U^b(x, y) = x \]

- \( \beta \in (0, 1) \) is the common discount factor over periods
Figure 2: Creation and Redemption of Bank Notes with Perfect Public Information

Stage 1

Consumer

Banker

Stage 2

Merchant

Consumer

Meeting with probability $\lambda$

Stage 3

Merchant

Banker

Each banker moves to the centralized location and invests in the storage technology

good $x$

bank note

good $y$

bank note
Equilibrium Allocations under Perfect Public Information

- Banker is able to issue notes that perfectly identify him as a debtor

- A note is a promise to pay good $x$ on demand

- Note holdings belong to the set $\{0, 1\}$

- Number of notes issued by any banker belongs to the set $\{0, 1, 2, \ldots\}$
Equilibrium Allocations under Perfect Public Information

- Invariant distributions: $m^1 = 1$, $m^2 = \alpha \lambda$, $m^3 = \alpha \lambda$
  
  - $m^1 \in [0, 1]$ is the measure of consumers holding a note after trading in stage 1
  
  - $m^2 \in [0, 1]$ is the measure of merchants holding a note after trading in stage 2
  
  - $m^3 \in [0, 1]$ is the volume of notes retired in stage 3 (settlement stage)

- What matters for equilibrium allocation is the aggregate amount of notes issued by the banking sector
Equilibrium Allocations under Perfect Public Information

- Bellman equations for a consumer

\[ V^0 = -\gamma + \alpha \lambda \left[ u(y) + \beta V^0 \right] + (1 - \alpha \lambda) \beta V^1 \]

\[ V^1 = \alpha \lambda \left[ u(y) + \beta V^0 \right] + (1 - \alpha \lambda) \beta V^1 \]

- A merchant accepts a bank note as a means of payment with probability \( \alpha \in [0, 1] \)
Equilibrium Allocations under Perfect Public Information

- Bellman equations for a merchant

$$W^0 = \beta \left[ \lambda W^1 + (1 - \lambda) W^0 \right]$$

$$W^1 = \max_{\alpha \in [0,1]} \alpha [-\omega y + v(\phi)] + \beta \left[ \lambda W^1 + (1 - \lambda) W^0 \right]$$

- A note costs 1 unit of good $x$ and is a promise to pay $\phi \in [0,1]$ unit of good $x$ on demand
Equilibrium Allocations under Perfect Public Information

- Bellman equations for a banker

\[ J^0 = 1 - \phi + \beta \left[ \alpha \lambda J^0 + (1 - \alpha \lambda) J^1 \right] \]

\[ J^1 = \beta \left[ \alpha \lambda J^0 + (1 - \alpha \lambda) J^1 \right] \]

- Banker can commit to set aside the face value \( \phi \) for each note issued


Equilibrium Allocations under Perfect Public Information

- Consumer’s participation constraint (second stage)
  \[ u(y) - \beta \gamma \geq 0 \]

- Merchant’s participation constraint
  \[ -\omega y + v(\phi) \geq 0 \]

- Consumer makes a take-it-or-leave-it offer:
  \[ y = \omega^{-1} v(\phi) \]
Equilibrium Allocations under Perfect Public Information

- Consumer’s participation constraint (first stage)

\[-\gamma + \alpha \lambda u (\omega^{-1} v (\phi)) + \beta (1 - \alpha \lambda) \gamma \geq 0\]

- Banker’s participation constraint

\[\phi \leq 1\]
A stationary monetary equilibrium is an array

\[ \{J^0, J^1, V^0, V^1, W^0, W^1, \phi, y, \alpha, m^1, m^2, m^3\} \]

satisfying Bellman equations, participation constraints, \( m^1 = 1 \), \( m^2 = m^3 = \alpha \lambda \), and \( \alpha > 0 \)
Equilibrium Allocations under Perfect Public Information

• Any value \( \phi \) satisfying

\[
v^{-1} \left( \omega u^{-1} \left( \frac{\gamma [1 - \beta (1 - \alpha \lambda)]}{\alpha \lambda} \right) \right) \leq \phi \leq 1
\]

can be supported as an equilibrium value of notes

• End-of-period excess reserves are \((1 - \lambda) \phi\) at each date
Equilibrium Allocations under Imperfect Public Information

- Need to provide incentives to induce bankers to hold the appropriate level of reserves

- People do not observe whether a banker has set aside reserves

- Restrict attention to equilibria without bank failures (no losses to note holders)

- Private provision of regulation and supervision services
Figure 3: Creation and Redemption of Bank Notes with Imperfect Public Information

Stage 1

Consumer

good x

Banker

bank note

Clearinghouse

balance (credit)

Stage 2

Merchant

good y

Consumer

Meeting with probability \( \lambda \)

Banker

balance (debit)

Stage 3

Merchant

Banker

Clearinghouse

bank note

good x

bank note

balance (debit)
Equilibrium Allocations under Imperfect Public Information

- Clearinghouse (CH)
  - Recordkeeping and safekeeping device

- Accepts deposits from member banks and retires notes issued by member banks

- A banker who fails to report the creation of a note will have his membership revoked
  - It might take several periods for the clearinghouse to detect a deviation
Equilibrium Allocations under Imperfect Public Information

- People observe only a banker’s membership status (record of compliance with CH rules)
  - Signal of “financial rectitude”

- Merchant is willing to accept a note issued by a member bank
  - Merchant observes the CH requirements

- Consumer is willing to acquire a note because he knows a merchant will accept it as a means of payment
Equilibrium Allocations under Imperfect Public Information

- Banker’s truth-telling constraint

\[ 1 - \phi + \beta \left[ \lambda J^0 + (1 - \lambda) J^1 \right] \geq J^d \]

- \( J^d \) is the value associated with a best deviation strategy

- This value is bounded

\[ 1 \leq J^d \leq \frac{1 - (1 - \lambda)^2 \beta}{1 - (1 - \lambda) \beta} \]
Equilibrium Allocations under Imperfect Public Information

- Issuing notes without depositing reserves increases probability of failure

- To illustrate this point, consider the following strategy:

\[
\hat{J} = 1 + (1 - \lambda) \beta \hat{J}_1
\]

\[
\hat{J}_i = \lambda \left[ 1 + (1 - \lambda)^{i+1} \beta \hat{J}_{i+1} \right] + (1 - \lambda) (1 - \lambda)^i \beta \hat{J}_i
\]
Equilibrium Allocations under Imperfect Public Information

- A stationary monetary equilibrium is an array
  \[ \{ J^0, J^1, J^d, V^0, V^1, W^0, W^1, \phi, y, \alpha, m^1, m^2, m^3 \} \]
  satisfying Bellman equations, participation constraints, truth-telling constraint, \( m^1 = 1 \), \( m^2 = m^3 = \lambda \), and \( \alpha = 1 \)

- \( J^d \) is the value associated with a best deviation strategy, given \( \phi \)
Equilibrium Allocations under Imperfect Public Information

- Provided $\chi < 1$, there exists $\bar{\phi} \in (0, 1)$ such that any value $\phi$ satisfying
  \[
  \chi \leq \phi \leq \bar{\phi}
  \]
  can be supported as an equilibrium value of notes

- $\chi \equiv v^{-1} \left( \omega \nu^{-1} \left( \frac{\gamma [1 - \beta (1 - \lambda)]}{\lambda} \right) \right)$

- End-of-period excess reserves are $(1 - \lambda) \phi$ at each date
Bank Coalition

- Is it possible to eliminate excess reserves without compromising the stability of the payment system?

- Suppose members of CH issue notes that are joint obligations

- Members continue to deposit reserves with CH

- CH manages reserves to ensure that each note is retired at par value
Bank Coalition

- Take $\phi \in [\chi, \bar{\phi}]$

- CH requires the deposit amount $\lambda\phi < \phi$ at date 0
  - At date 0, each banker has an opportunity to issue a note

- CH requires the usual deposit amount $\phi$ at any subsequent date
Bank Coalition

• Coalition is solvent at date 0
  – Total reserves at the end of stage 1 are given by $\lambda \phi$
  – Volume of redemptions is given by $\lambda \phi$

• After date 0, the coalition is also solvent
  – Total reserves at the end of stage 1 are given by $\lambda \phi$
  – Volume of redemptions is given by $\lambda \phi$
Bank Coalition

- Banker gets $1 - \lambda \phi$ at date zero

- Banker gets $1 - \phi$ when he has an opportunity to issue a note at any other date

- Coalition allows each banker to temporarily increase his consumption
Bank Coalition

- This allocation Pareto dominates the allocation obtained without a coalition

- Efficient management of reserves

- Fractional reserve banking

- Safety of bank liabilities is preserved (no losses occur in equilibrium)
Aggregate Shock

- Aggregate shock affecting the return to storage only at date 0

- With probability $\pi \in (0, 1)$, the return equals $\theta < 1$

- With probability $1 - \pi$, the return equals one

- Shock is realized in the third subperiod
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Stage 3
All merchants move to the centralized location
Aggregate Shock

- Relevant measure for individual solvency:
  - Ratio of the value of all reserves to the value of all notes presented for redemption

- Formally

\[
\frac{\theta \phi_0}{\lambda \phi_0} = \frac{\theta}{\lambda}
\]

- Suppose \( \lambda \leq \theta \)
  - Coalition is solvent regardless of shock realization
Aggregate Shock

- For any \( \phi \in [\chi, \overline{\phi}] \), I can construct an equilibrium in which each note holder receives the face value \( \phi \)
  - Safety of bank liabilities is preserved

- Banker gets \( 1 - \theta^{-1} \lambda \phi \) at date zero

- Banker gets \( 1 - \phi \) when he has an opportunity to issue a note at any other date

- Note that \( 1 - \theta^{-1} \lambda \phi \leq 1 - \lambda \phi \)
Aggregate Shock

• Suppose $\lambda > \theta$
  
  – Coalition is *insolvent* if the adverse state is realized

• Partial suspension:
  
  – Note holder fully anticipates that he will get only a fraction $\lambda^{-1}\theta$ of face value in the adverse state
Aggregate Shock

- Quantity traded in bilateral meetings (second stage) is given by
  \[ y_0 = \omega^{-1} \left[ (1 - \pi) v(\phi) + \pi v(\lambda^{-1} \theta \phi) \right] \]

- At any subsequent date, consumer gets \( \omega^{-1} v(\phi) \)

- Each banker gets \( 1 - \phi \) when he has an opportunity to issue a note

- \( \phi \in [\chi', \bar{\phi}] \), where \( \chi' > \chi \)
banker’s consumption at $t=0$
Conclusions

- It is possible to construct a stable payment system in the absence of government intervention

- A joint-liability scheme is a welfare-improving arrangement
  - It allows each member bank to build a capital buffer

- Banker is willing to absorb some losses in case there is a shock to the value of banking assets

- The coalition is able to preserve the safety of bank liabilities if the shock is not too big