Why are Banks Fragile?
Diamond-Dybvig and Beyond

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(updated to include list of references at the end)

An assignment

- The Diamond-Dybvig model has been very influential
- As substantial literature has developed based on it
  - >10,000 google scholar citations (so far)
  - also influential in policy circles (example: Bernanke, 2009)
- My aim: a brief overview of one strand of this literature
- Focus: is banking really fragile?
  - that is, subject to DD-style self-fulfilling crises of confidence
  - if so, why?
- I will discuss some well-known papers and results, but …
  - aim to bring out broad themes that may be underappreciated

Sketch of environment

- $t = 0,1,2$
- Depositors: each have utility $u(c_1 + \omega_i c_2)$
  - where $\omega_i = \begin{Bmatrix} 0 \\ 1 \end{Bmatrix}$ means depositor is $\begin{Bmatrix} \text{impatient} \\ \text{patient} \end{Bmatrix}$
  - ω_i is revealed at $t = 1$, private information
- Technologies:
  - goods not consumed at $t = 1$ yield $R > 1$ at $t = 2$
  - depositors can pool resources at $t = 0$ in a machine ("bank")
    - and program the machine to dispense goods at $t = 1,2$ ("contract") (Wallace, 1988)
- Let's begin $t = 0$ with endowments pooled in the bank
  - not innocuous (Peck & Setayesh, later today)

DD fragility

- Suppose the bank is programmed to:
  - pay a fixed amount ("face value") $c_1^* > 1$ at $t = 1$ (if feasible)
  - divide remaining resources evenly at $t = 2$

"simple contract"

- Creates a withdrawal game for depositors
- Depositors' withdrawal decisions are strategic complements
  - if others withdraw early, less is available at $t = 2$ (per capita)
  - ⇒ increases my incentive to withdraw early as well
- Game has two (symmetric, pure strategy) Nash equilibria
  - patient depositors wait until $t = 2$ ⇒ desired allocation
  - everyone withdraws at $t = 1$ ⇒ a bank run

Another benchmark

- Consider a different way of programming the bank
- Let $\rho =$ the fraction of depositors who chose $t = 1$
- Solve: $\max_{\{c_1, c_2\}} \ \rho u(c_1) + (1-\rho)u(c_2)$

  subject to $\rho c_1 + (1-\rho)\frac{c_2}{R} = 1$

"(fully) ρ-contingent contract"

- Pay withdrawing depositors $c_1(\rho)$ or $c_2(\rho)$
  - this approach seems natural as well
  - interpretation: impose withdrawal fee of $(c_1^* - c_1(\rho))$ at $t = 1$
- The solution to this problem has $c_1(\rho) < c_2(\rho)$ <u>for all ρ</u>

  $\Rightarrow$ no bank run equilibrium

Implication:

- Maturity transformation does not necessarily generate fragility
  - Green & Lin (2003; first part of the paper)
- DD fragility requires some other friction(s) in the environment

The question:

Q: Why doesn't this simple approach solve the problem?

- Any theory of financial fragility in the DD tradition must provide an answer to this question
  - answer matters for understanding what is going on in a crisis
  - and for what policies might be desirable/effective

My plan

- High-level overview of approaches to answering this question
  - broad brush strokes; will be incomplete (and biased)

Outline:

1. Sequential service
   a) Can bank runs occur?
   b) If so, how costly is the problem?
2. Other frictions
   a) Policy intervention
   b) Agency problems
3. Final thoughts

But first ...

A comment

- There is a large literature that uses the DD model (vs. studies)
  - assumes particular contractual arrangements
  - studies the consequences of fragility …
  - … without looking closely at the underlying causes
  - ex: Allen & Gale (2009) and many, many others
- I will not discuss this literature
  - in part because it is much too large for the time allotted
- It is clearly important to understand the foundations on which this literature rests
  - and the extent to which its conclusions are consistent with these foundations

1. Sequential service

Q: Why doesn't the ρ-contingent contract solve the problem?

- One answer: it is not feasible
  - the bank does not observe ρ right away
  - instead, depositors arrive at the bank sequentially at $t = 1$, and …
  - bank only observes depositors' choices when they arrive
- The simple contract is still feasible, but … so are others
- Sequential service was a key element of DD (1983)
  - formalized by Wallace (1988)
- Does this friction generate DD-style fragility?

More precisely:

Q: Can the restrictions imposed by sequential service …

… on the flow of information to the bank …

… about withdrawal demand …

… alone …

… explain DD-style banking fragility?

- Or, when sequential service is the only friction:

a) Does a bank run equilibrium exist?

b) If so, how costly is the problem?

Divide into two distinct parts

1(a) Does a bank run equilibrium exist?

- There is a substantial literature on this question
- First step: find best feasible contract
  - involves *gradual withdrawal fees* (Wallace, 1990)
- Ask if resulting withdrawal game has a bank run equilibrium
- Answer: it depends …

Takeaways from this literature:

(i) The answer depends on the details

- when does a bank find out an depositor is not withdrawing?
- what do depositors know when making withdrawal decision?
- how are depositors' preferences correlated?

} examples

- in some settings, no run equilibrium exists
  - Green & Lin (2000, 2003), Andolfatto, Nosal & Wallace (2007)
- in others, there is a run equilibrium:
  - Peck & Shell (2003), Ennis & Keister (2009b, 2016), Azrieli & Peck (2012), Sultanum (2014), Shell & Zhang (2019)
- see Ennis & Keister (2010b) for a (non-technical) summary

(ii) Key issue: how quickly does the bank learn that withdrawal demand is high?

- if fast enough → payouts adjust quickly → no fragility
  - "close enough" to a fully ρ-contingent contract
- if slow enough → payouts remain high too long → fragility
  - "close enough" to the original (simple) contract

fairly intuitive

(iii) Implications:

- we might observe fragility in some settings, but not others
- seemingly-small changes could substantially change outcomes
  - example: recent reforms to money-market mutual funds (Ennis, 2012)

1(b) How costly are bank runs?

- Rather than trying to implement the best feasible allocation …
- Ask: What is the best run-proof contract?
  - aim to achieve a (potentially) less desirable allocation
  - as the unique Nash equilibrium of the withdrawal game
    - Cooper & Ross (1998)
- The welfare difference between these two allocations …
  - the best feasible allocation and the best run-proof allocation
- … gives an upper bound on the size of the problem
- There is some work on this question as well
  - takeaways …

(i) If aggregate uncertainty is small → cost is small

- special case: no aggregate uncertainty → zero cost (DD, 1983)
- small uncertainty → by continuity
  - Sultanum (2014), Bertolai et al. (2014)

(iii) Significant aggregate uncertainty → cost may still be small

- if bank can infer things quickly through observation (de Nicolo, 1996)
- or, find another way to infer depositors' choices, perhaps using an indirect mechanism
  - that is, ask for more information than "withdraw or wait?"
  - Cavalcanti & Monteiro (2016), Andolfatto, Nosal, & Sultanum (2017)

- Work in this area is ongoing

2. Beyond sequential service

Summary so far:

Q: Can sequential service alone explain banking fragility?

A: Yes, but…

- Given this answer, might want to think about other frictions that could be important

- I will discuss two:

  a) policy intervention

  b) agency frictions

2(a) Policy interventions

- So far: depositors choose a contract (i.e., program their bank)
  - if a run occurs, the bank simply follows the contract
- In practice, governments often intervene in a crisis
  - change the terms of existing banking contracts
  - Argentina (2001), Iceland (2008), Cyprus (2013)
- How can we model such interventions in the DD framework?
  - and might they help explain fragility?
- One approach: introduce a benevolent policy maker
  - only power: can re-program the banking machine at any time
  - cannot commit: will re-program the machine whenever doing so raises welfare

- Effectively shrinks set of feasible contracts
  - in particular: rules out some contracts that are useful for preventing bank runs
- Result: a bank run equilibrium can exist and be costly
  - Ennis & Keister (2009a, 2010a)
- We will hear more about this issue in the next presentation
  - Ennis (2019)
- Emphasize: offers a clean, tractable foundation for studying *consequences* of fragility
  - examples: Keister (2016), Li (2017), Mitkov (2018)
  - much more could be done

Other interventions

- Policy makers do more than enforce/rewrite contracts
- Often intervene by bailing out institutions, depositors
- Anticipation of being bailed out affects incentives
  - Karaken & Wallace (1978)
- In particular, when depositors are programming the bank
  - suppose bank observes ρ is high (right away)
  - could decrease payouts as in fully ρ-contingent contract above
  - or … allow withdrawals at face value $\Rightarrow$ receive larger bailout
- Result: this type of intervention may be a source of fragility
  - Keister & Mitkov (2017)

2(b) Agency frictions

- Suppose bank is operated by a self-interested banker
  - observes ρ right away, but depositors do not
  - might be able to lie about situation, enrich self
- Idea was used informally to justify simple contracts
  - Freeman (1988), Cooper & Ross (1998), others
  - but has not (to my knowledge) been investigated fully
- Could combine agency frictions with sequential service
  - resulting analysis can be complex (Andolfatto & Nosal, 2008)

- One can think of more possibilities
  - perhaps legal restrictions (Peck and Shell, 2010) or changes in the investment technology (Andolfatto & Nosal, tomorrow)
- Seem to be many fertile areas for future research
- But … what is the eventual goal?
- Perhaps: a catalog of possible causes of fragility
  - together with the empirical implications of each
    - compare to recent work by Foley-Fisher et al. (2018), Martin et al. (tomorrow), Gallagher et al. (tomorrow)
  - and the policy prescriptions each generates

Final thoughts

- The Diamond-Dybvig model is 36 years old
  - why are we still talking about it?
- Financial stability policy is important
  - perhaps much more so than we thought in 2007
- And less well understood than, say, monetary policy
  - how do we evaluate policy proposals?
- Diamond & Dybvig provided a framework that has been both influential and useful
  - I hope I have convinced you there is still more to be learned
  - the “DD revolution” continues …

References

Allen, F. and D. Gale (2009) *Understanding Financial Crises*, Oxford University Press.

Andolfatto, D. and E. Nosal (2008) “Bank incentives, contract design, and bank runs,” *Journal of Economic Theory* 142, 28–47.

Andolfatto, D. and E. Nosal (2018) “Bank runs without sequential service,” presented in this conference.

Andolfatto, D., E. Nosal, and B. Sultanum (2017) “Preventing bank runs,” *Theoretical Economics* 12, 1003–1028.

Andolfatto, D., E. Nosal, and N. Wallace (2007) “The role of independence in the Green-Lin Diamond-Dybvig model,” *Journal of Economic Theory* 137, 709-715

Azrieli, Y. and J. Peck (2012) “A bank runs model with a continuum of types,” *Journal of Economic Theory* 147, 2040–2055.

Bernanke, B. (2009) “Reflections on a year of crisis,” speech given at the Federal Reserve Bank of Kansas City’s Annual Economic Symposium, Jackson Hole, August 19.

Bertolai, J.D.P., R. Cavalcanti, and P.K. Monteiro (2014) “Run theorems for low returns and large banks,” *Economic Theory* 57, 223-252.

Cavalcanti, R. and P.K. Monteiro (2016) “Enriching information to prevent bank runs,” *Economic Theory* 62, 477-494.

Cooper, R. and T.W. Ross (1998) “Bank runs: Liquidity costs and investment distortions,” *Journal of Monetary Economics* 41, 27-38.

De Nicolo, G. (1996) “Run-proof banking without suspension or deposit insurance,” Journal of Monetary Economics 38, 377-390.

Diamond, D.W. and P.H. Dybvig (1983) “Bank runs, deposit insurance, and liquidity,” *Journal of Political Economy* 91, 401-419.

Ennis, H.M. (2012) “Some theoretical considerations regarding net asset values for money market funds,” Federal Reserve Bank of Richmond *Economic Quarterly* 98, 231-254.

Ennis, H.M. (2019) “The Role of Commitment in Bank Runs,” presented at this conference.

Ennis, H.M. and T. Keister (2009a) “Bank runs and institutions: The perils of intervention,” *American Economic Review* 99, 1588-1607.

Ennis, H.M. and T. Keister (2009b) “Run equilibria in the Green-Lin model of financial intermediation,” *Journal of Economic Theory* 144, 1996-2020.

Ennis, H.M. and T. Keister (2010a) “Banking panics and policy responses,” *Journal of Monetary Economics* 57, 404-419.

Ennis, H.M. and T. Keister (2010b) “On the fundamental reasons for bank fragility,” Federal Reserve Bank of Richmond *Economic Quarterly* 96(1), 35-58.

Ennis, H.M. and T. Keister (2016) “Optimal banking contracts and financial fragility,” *Economic Theory* 61, 335-363.

Foley-Fisher, N., B. Narajabad, and S. Verani (2018) “Self-fulfilling runs: Evidence from the U.S. life insurance industry,” working paper, October.

Freeman, S. (1988) “Banking as the provision of liquidity,” *Journal of Business* 61, 45-64.

Gallagher, E., L. Schmidt, A. Timmermann, and R. Wermers (2019) “Investor Information Acquisition and Money Market Fund Risk Rebalancing During the 2011-12 Eurozone Crisis,” presented at this conference.

Green, E.J. and P. Lin (2000) “Diamond and Dybvig's classic theory of financial intermediation: what's missing?” Federal Reserve Bank of Minneapolis *Quarterly Review* 24, 3-13.

Green, E.J. and P. Lin (2003) “Implementing efficient allocations in a model of financial intermediation,” *Journal of Economic Theory* 109, 1-23.

Kareken, J.H. and N. Wallace (1978) “Deposit insurance and bank regulation: A partial-equilibrium exposition,” *Journal of Business* 51, 413-438.

Keister, T. (2016) “Bailouts and financial fragility.” *Review of Economic Studies* 83, 704-736.

Keister, T. and Y. Mitkov (2017) “Bailouts, Bail-ins and Banking Crises,” working paper, October.

Keister, T. and V. Narasiman, (2016) “Expectations vs. fundamentals-based bank runs: when should bailouts be permitted?” *Review of Economic Dynamics* 21, 89-104.

Martin, C., M. Puri, and A. Ifier (2018) “Deposit inflows and outflows in failing banks: The role of deposit insurance,” presented at this conference.

Mitkov, Y. (2018) “Inequality and financial fragility,” presented in poster session at this conference.

Sultanum, B. (2014) “Optimal Diamond–Dybvig mechanism in large economies with aggregate uncertainty,” *Journal of Economic Dynamics and Control* 40, 95-102.

Peck, L. and A. Setayesh (2019) “A Diamond-Dybvig Model in Which the Level of Deposits is Endogenous,” presented at this conference.

Peck, J., and K. Shell (2003) “Equilibrium bank runs,” *Journal of Political Economy* 111, 103-123.

Peck, J., and K. Shell (2010) “Could making banks hold only liquid assets induce bank runs?,” *Journal of Monetary Economics* 57, 420-427.

Shell, K. and Y. Zhang (2019) “The ongoing Diamond-Dybvig revolution: Extensions to the original DD paper,” presented at this conference.

Wallace, N. (1988) “Another attempt to explain an illiquid banking system: the Diamond and Dybvig model with sequential service taken seriously,” Federal Reserve Bank of Minneapolis *Quarterly Review* 12, 3-16.

Wallace, N. (1990) “A banking model in which partial suspension is best,” Federal Reserve Bank of Minneapolis *Quarterly Review* 14, 11-23.