Lecture 9
The Financial Crisis, Asset Bubbles

Macroeconomics EC2B1

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London School of Economics, Lent 2023

Plan

1. Run on Silicon Valley Bank

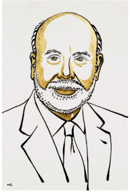
2. The 2008 financial crisis: some facts

3. Asset bubbles

4. Financial frictions and amplification

A Nobel Prize for Work on Financial Crises

The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 2022



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Ben S. Bernanke

Prize share: 1/3

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Douglas W. Diamond

Prize share: 1/3

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Philip H. Dybvig

Prize share: 1/3

The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 2022 was awarded jointly to Ben S. Bernanke, Douglas W. Diamond and Philip H. Dybvig "for research on banks and financial crises"

Source: https://www.nobelprize.org/prizes/economic-sciences/2022/summary/

Readings

- Two supplements with derivations on moodle:
  - asset bubbles
  - financial frictions and amplification
- EC1B1 lecture notes 3 “Great Depression & Lender of Last Resort”
- Jones, chapter 10.4
- Additional readings for the interested (not examinable)
  - Brunnermeier (2008) “Bubbles”
    https://link.springer.com/referenceworkentry/10.1057/978-1-349-95121-5_44-2
  - Bernanke and Gertler (1989), “Agency Costs, Net Worth, and Business Fluctuations”
  - Kiyotaki and Moore (1997), ”Credit Cycles”
  - Mian and Sufi (2011) “House Prices, Home Equity-Based Borrowing, and the U.S. Household Leverage Crisis” (2011)
  - Mian and Sufi (2014) “What Explains the 2007–2009 Drop in Employment?”
  - Noah Smith on SVB https://noahpinion.substack.com/p/why-was-there-a-run-on-silicon-valley
  - Adam Tooze on SVB https://adamtooze.substack.com/p/chartbook-200-something-broke-the
  - Jiang et al (2023) “Monetary Tightening and U.S. Bank Fragility in 2023”
    https://www.nber.org/papers/w31048

Run on Silicon Valley Bank

Bank runs as multiple equilibria (from EC1B1)

- Bank takes deposits of $1 from many borrowers and lends out to project that yields a gross return of R>1 in 2 years
- Bank can call in loan before project is finished. But only at a substantial loss (gross return 0<r<1)
- Should you run on this bank?

	Everyone else withdraws	**Everyone else does not withdraw**
You withdraw	r	1
You do not withdraw	0	R

- Multiple (symmetric Nash) equilibria:
  - If everyone else is going to withdraw, you should too
  - If no one else is going to withdraw, you should not.
- Fear of run can become self-fulfilling
  - If you believe everyone else will run, your best response is to run

Deposit insurance

- Solution? Deposit insurance
- In theory on previous slide:
    - eliminates bad equilibrium
    - never even has to be paid out
- In U.S., Federal Deposit Insurance Corporation (FDIC) insures all deposits up to $250,000

This works not only in theory but also in practice

Figure 1

The introduction of deposit insurance led the number of bank failures to plummet

Number of bank failures each year

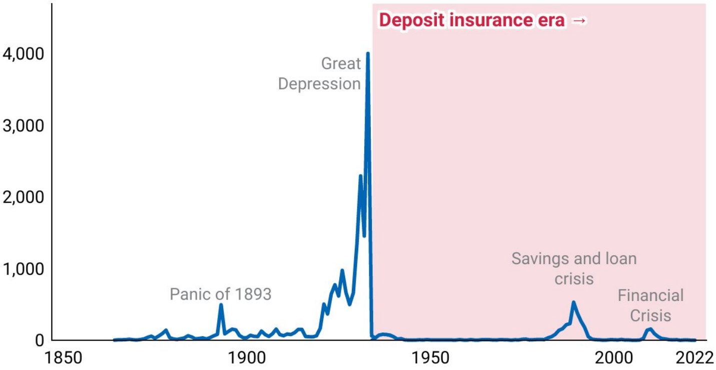

Chart: © Worth Publishers • Source: Historical Statistics of the United States and FDIC

But most SVB accounts were > $250, 000 so not FDIC insured

Exhibit 1 – Deposits Less than $250k as a Percentage of Total Deposits

	Company Name	Ticker	4Q22 (%)	2021 (%)	2020 (%)	2019 (%)	2018 (%)
1	Northwest Bancshares, Inc.	NWBI	64.5	65.0	66.3	71.6	72.5
2	NBT Bancorp Inc.	NBTB	55.8	52.9	55.0	51.8	53.6
3	WesBanco, Inc.	WSBC	53.8	55.3	58.1	60.1	62.1
4	Glacier Bancorp, Inc.	GBCI	53.0	51.3	56.6	62.8	65.3
5	Regions Financial Corporation	RF	52.5	49.9	50.1	53.3	54.1
6	First Hawaiian, Inc.	FHB	52.2	38.5	41.2	43.1	40.8
7	Independent Bank Corp.	INDB	51.5	51.8	52.4	57.5	56.9
8	Capital One Financial Corporation	COF	50.6	54.1	57.6	60.3	61.3
9	First National of Nebraska, Inc.	FINN	50.4	45.4	49.2	55.4	55.8
10	Commerce Bancshares, Inc.	CBSH	50.2	44.2	46.3	53.2	52.5
11	First Citizens BancShares, Inc.	FCNC.A	50.2	45.6	49.3	55.1	56.1
12	Webster Financial Corporation	WBS	50.1	56.8	58.8	62.2	64.5
13	Community Bank System, Inc.	CBU	50.1	49.0	51.6	55.4	56.7
14	Simmons First National Corporation	SFNC	50.0	42.5	47.0	47.2	49.0
15	First Bancorp	FBNC	49.8	46.8	50.8	55.4	60.8
16	First Interstate BancSystem, Inc.	FIBK	49.6	46.9	51.1	57.1	57.6
17	Umpqua Holdings Corporation	UMPQ	49.5	45.6	48.1	50.6	53.0
18	First Financial Bancorp.	FFBC	49.3	46.8	50.5	56.7	57.1
19	Banner Corporation	BANR	49.2	49.0	50.7	56.1	60.0
20	Fulton Financial Corporation	FULT	49.2	48.4	49.9	54.0	53.0
21	United Bankshares, Inc.	UBSI	48.9	49.8	52.4	50.5	51.7
22	Washington Federal, Inc.	WAFD	48.7	49.2	54.7	63.6	66.5
23	International Bancshares Corporation	IBOC	47.6	46.7	50.3	52.7	52.6
24	Merchants Bancorp	MBIN	47.2	36.7	26.5	47.5	40.3
25	First Busey Corporation	BUSE	46.7	44.8	46.8	51.9	58.6
26	Atlantic Union Bankshares Corporation	AUB	46.4	45.4	48.3	51.5	58.6
27	M&T Bank Corporation	MTB	46.4	33.7	37.6	40.9	41.4
28	Old National Bancorp	ONB	45.9	49.9	51.8	56.2	58.4
29	Citizens Financial Group, Inc.	CFG	45.4	43.1	42.8	47.8	52.3
30	SouthState Corporation	SSB	45.0	45.9	50.9	47.6	53.5
31	United Community Banks, Inc.	UCBI	44.8	43.7	48.7	55.4	58.1
32	Trustmark Corporation	TRMK	44.7	42.8	43.5	49.6	49.0
33	Eastern Bankshares, Inc.	EBC	44.5	36.3	44.7	51.0	53.0
34	The PNC Financial Services Group, Inc.	PNC	44.5	41.3	40.4	44.4	46.9
35	Fifth Third Bancorp	FITB	44.1	36.8	37.6	41.1	45.5
36	Berkshire Hills Bancorp, Inc.	BHLB	44.1	40.7	50.2	56.0	59.1
37	F.N.B. Corporation	FNB	43.3	44.2	46.4	52.2	56.7
38	Customers Bancorp, Inc.	CUBI	43.1	19.3	26.3	35.3	36.7
39	Sandy Spring Bancorp, Inc.	SASR	43.1	38.1	42.6	45.7	50.3
40	Associated Banc-Corp	ASB	43.0	41.7	41.4	42.7	45.5
41	Wintrust Financial Corporation	WTFC	42.9	41.2	44.4	48.7	50.0
42	First Merchants Corporation	FRME	42.8	40.1	42.5	46.7	49.4
43	Truist Financial Corporation	TFC	42.8	41.9	43.1	44.8	45.8
44	Wells Fargo & Company	WFC	41.6	40.6	40.2	39.2	40.9
45	Huntington Bancshares Incorporated	HBAN	41.1	63.2	63.4	66.5	63.4
46	Prosperity Bancshares, Inc.	PB	40.9	40.0	45.4	43.7	47.4
47	Renasant Corporation	RNST	40.8	39.3	43.2	47.4	49.6
48	First BanCorp.	FBP	40.7	39.1	46.1	53.5	56.9
49	Heartland Financial USA, Inc.	HTLF	40.6	37.8	41.1	40.2	44.5
50	PacWest Bancorp	PACW	40.0	29.6	32.4	32.7	26.2

Source: S&P Global Market Intelligence.

	Company Name	Ticker	4Q22 (%)	2021 (%)	2020 (%)	2019 (%)	2018 (%)
51	KeyCorp	KEY	40.0	37.4	40.0	41.3	45.1
52	OceanFirst Financial Corp.	OCFC	39.9	35.2	43.0	45.6	49.9
53	Silvergate Capital Corporation	SI	39.7	0.6	1.4	22.1	6.6
54	Synovus Financial Corp.	SNV	39.6	34.4	37.6	45.5	48.4
55	Hancock Whitney Corporation	HWC	39.5	38.2	40.3	43.3	45.5
56	First Financial Bankshares, Inc.	FFIN	39.2	39.4	43.0	45.2	47.1
57	Bank of Hawaii Corporation	BOH	39.0	39.8	41.5	41.9	43.3
58	First Horizon Corporation	FHN	39.0	36.2	40.6	46.6	48.1
59	Ameris Bancorp	ABCB	38.5	38.6	44.2	50.1	49.7
60	Popular, Inc.	BPOP	38.5	34.6	38.7	40.9	44.5
61	Home Bancshares, Inc. (Conway, AR)	HOMB	38.5	38.7	38.9	39.4	43.1
62	Cadence Bank	CADE	37.6	41.0	50.2	52.7	55.6
63	Pinnacle Financial Partners, Inc.	PNFP	37.6	35.7	41.9	43.2	41.4
64	U.S. Bancorp	USB	37.4	37.6	36.5	36.9	37.5
65	Cathay General Bancorp	CATY	36.9	34.4	43.2	47.0	46.8
66	Columbia Banking System, Inc.	COLB	36.7	36.7	40.3	44.8	46.4
67	Valley National Bancorp	VLY	36.4	34.9	42.6	50.5	47.0
68	Bank OZK	OZK	35.7	38.4	52.3	46.1	40.3
69	Enterprise Financial Services Corp	EFSC	35.7	33.7	46.6	46.5	42.2
70	Pacific Premier Bancorp, Inc.	PPBI	35.2	28.4	30.9	37.7	41.6
71	TowneBank	TOWN	34.8	33.6	39.2	43.2	44.9
72	Zions Bancorporation, National Association	ZION	34.3	28.3	33.0	37.8	38.2
73	FB Financial Corporation	FBK	34.1	32.7	35.5	48.6	48.1
74	Independent Bank Group, Inc.	IBTX	33.8	30.7	35.9	38.3	35.2
75	JPMorgan Chase & Co.	JPM	32.0	29.4	29.8	31.1	30.3
76	Bank of America Corporation	BAC	30.8	29.0	30.8	31.8	31.2
77	Dime Community Bancshares, Inc.	DCOM	30.6	29.1	23.2	28.4	29.0
78	Farmers & Merchants Bank of Long Beach	FMBL	30.6	29.1	33.0	37.6	38.4
79	Cullen/Frost Bankers, Inc.	CFR	30.3	29.0	31.9	36.3	35.6
80	Eagle Bancorp, Inc.	EGBN	30.2	37.3	41.3	42.7	37.1
81	Hope Bancorp, Inc.	HOPE	30.0	30.4	35.2	45.1	50.6
82	BankUnited, Inc.	BKU	29.2	28.5	32.0	36.7	35.0
83	Comerica Incorporated	CMA	28.7	24.1	31.5	32.2	32.0
84	Hilltop Holdings Inc.	HTH	28.6	20.0	29.4	34.0	36.9
85	W.T.B. Financial Corporation	WTBF.B	28.0	26.0	27.2	32.7	35.4
86	BOK Financial Corporation	BOKF	26.1	25.5	31.2	34.8	34.7
87	Western Alliance Bancorporation	WAL	23.2	19.0	20.8	26.2	27.5
88	Texas Capital Bancshares, Inc.	TCBI	20.8	14.3	18.2	20.4	22.8
89	East West Bancorp, Inc.	EWBC	20.5	20.1	22.6	32.2	26.5
90	CVB Financial Corp.	CVBF	20.4	18.9	20.5	26.6	28.8
91	First Republic Bank	FRC	19.8	14.4	18.7	23.6	22.7
92	First Foundation Inc.	FFWM	18.9	20.0	22.4	22.1	22.1
93	UMB Financial Corporation	UMBF	17.7	16.0	20.5	28.6	30.4
94	ServisFirst Bancshares, Inc.	SFBS	16.2	15.1	17.4	19.9	20.4
95	Citigroup Inc.	C	15.0	15.9	16.6	16.8	15.0
96	Signature Bank	SBNY	6.2	4.8	7.4	11.5	11.6
97	State Street Corporation	STT	4.3	4.5	4.7	2.7	0.4
98	Northern Trust Corporation	NTRS	4.0	4.5	5.6	7.5	6.8
99	SVB Financial Group	SIVB	2.7	2.3	2.3	3.5	4.0
100	The Bank of New York Mellon Corporation	BK	2.3	2.9	4.2	3.3	5.0

Source: S&P Global Market Intelligence.

But most SVB accounts were > $250, 000 so not FDIC insured (zoom)

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77	Dime Community Bancshares, Inc.	DCOM	30.6	29.1	23.2	28.4	29.0
78	Farmers & Merchants Bank of Long Beach	FMBL	30.6	29.1	33.0	37.6	38.4
79	Cullen/Frost Bankers, Inc.	CFR	30.3	29.0	31.9	36.3	35.6
80	Eagle Bancorp, Inc.	EGBN	30.2	37.3	41.3	42.7	37.1
81	Hope Bancorp, Inc.	HOPE	30.0	30.4	35.2	45.1	50.6
82	BankUnited, Inc.	BKU	29.2	28.5	32.0	36.7	35.0
83	Comerica Incorporated	CMA	28.7	24.1	31.5	32.2	32.0
84	Hilltop Holdings Inc.	HTH	28.6	20.0	29.4	34.0	36.9
85	W.T.B. Financial Corporation	WTBF.B	28.0	26.0	27.2	32.7	35.4
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87	Western Alliance Bancorporation	WAL	23.2	19.0	20.8	26.2	27.5
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96	Signature Bank	SBNY	6.2	4.8	7.4	11.5	11.6
97	State Street Corporation	STT	4.3	4.5	4.7	2.7	0.4
98	Northern Trust Corporation	NTRS	4.0	4.5	5.6	7.5	6.8
99	SVB Financial Group	SIVB	2.7	2.3	2.3	3.5	4.0
100	The Bank of New York Mellon Corporation	BK	2.3	2.9	4.2	3.3	5.0

A “bank run via whatsapp”

One account of the run https://twitter.com/torrenegra/status/1634573234187407369?s=20

Alexander Torrenegra
@torrenegra

Silicon Valley Bank was the main bank for two of our companies, my personal savings, and my mortgage. This is how things unfolded for us:

Between 2013 and 2023, all good.

Thursday, 9 AM: in one chat with 200+ tech founders (most in the Bay Area), questions about SVB start to show up.

10 AM: some suggest getting the money out of SVB for safety. Only upside. No downside.

10:50 AM: I read the messages in a bathroom break. Immediately cancel the meeting I had. Ask my wife, Tania, to wire all of our personal money out to other banks. Call my teams. Ask them to do the same. One of them, at the dentist, has to stop the procedure and run home.

11:10 AM: We can't get the money out of any of the accounts. For our personal savings, we don't have other bank accounts readily available. For one of the companies, the permissions are not set up to allow such a significant exit of money. We can only get half of the money out. We wire it to Ameritrade, as we don't have any other bank account set up. For the 2nd company, the banking credentials had been changed. I cannot log in.

11:15 AM: Tania gets a hold of another bank we were already talking to, UBS. Ask them to open a bank account pronto.

11:20 AM: I change the permissions for the 1st company. We request another wire out to Ameritrade for the remaining money from that company. We have to wait for the wires to get out.

11:25 AM: After a long wait, I get a hold of an SVB agent. They reset my credentials for the 2nd company.

~12:00 PM: All of my chats with tech founders in the US light on fire with what’s happening. Obviously, we have a bank runoff. Surreal.

SVB's other big problem: unhedged interest rate risk

Recall typical bank balance sheet from EC1B1

- Banks borrow from depositors (and others) and make loans
- Example bank balance sheet:
  - 10 to 1 leverage ratio

Assets	Liabilities
$1,000 of Loans	$900 of Deposits
	$100 of Equity capital

But SVB also held large chunk of other assets: long-term fixed income securities

- e.g. 10-year government bonds
- rising interest rate $\Rightarrow$ prices of such assets fall
- SVB did not hedge this interest rate risk appropriately

Like all banks, SVB was also very leveraged

Leverage and Risk

- Leverage increases risk
- Say value of assets falls by 2%
- How much does net worth fall if:
  - If leverage ratio is 10 to 1?
    - Net worth falls by 20%
  - If leverage ratio is 20 to 1:
    - Net worth falls by 40%
  - If leverage ratio is 50 to 1:
    - Net worth falls all the way to zero!

Summary: run on Silicon Valley Bank

Two key features made SVB particularly vulnerable

1. large runnable deposit base

2. big interest rate risk

SVB was special ... but definitely not alone $\Rightarrow$ will have to wait and see

2008 Financial Crisis: Some Facts

2008 financial crisis: some facts

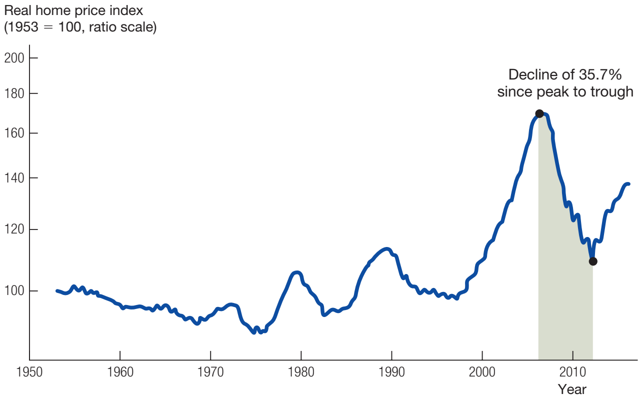
- Will show you data for U.S.
    - purely because many nice graphs are available
- UK and many other advanced economies look similar
    - though some not as extreme

Housing price boom and bust in lead up to crisis

After rising sharply in the years up to 2006, housing prices fell dramatically.

FIGURE 10.1

A Bursting Bubble in U.S. Housing Prices?

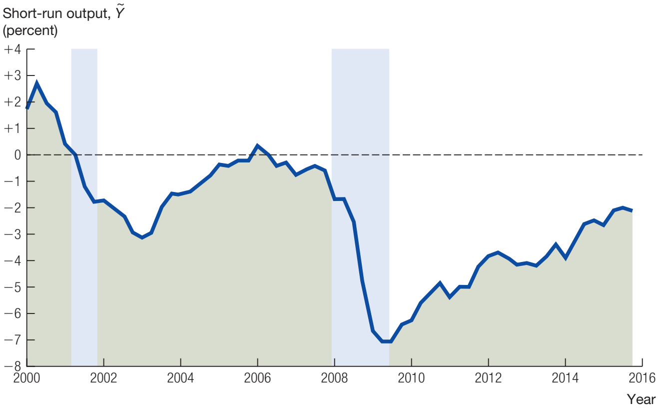


Source: Robert Shiller, www.econ.yale.edu/~shiller/data/Fig2-1.xls.

A very large drop in GDP ...

FIGURE 10.7

U.S. Short-Run Output, $\tilde{Y}$



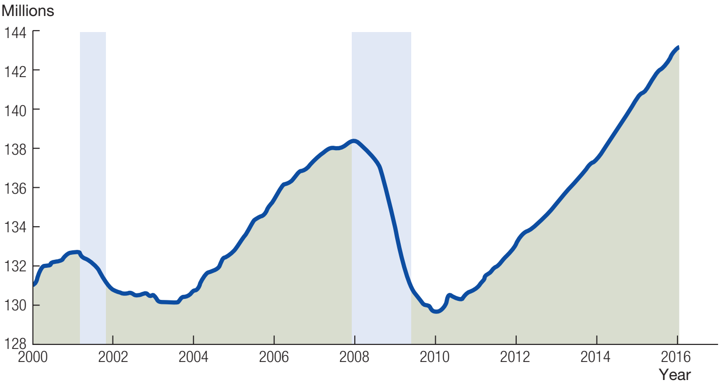
Source: The FRED database and author's calculations.

After its initial resilience to the financial crisis, the real economy declined sharply. At the bottom of the recession, real GDP was more than 7 percent below potential.

... and employment

FIGURE 10.6

Nonfarm Employment in the U.S. Economy



Source: The FRED database.

Total nonfarm employment peaked in December 2007, the date the recession is said to have started, at more than 138 million. More than 8.4 million jobs were lost by February 2010.

Asset Bubbles

What is a bubble?

- Price of an asset does not reflect its “fundamental value”
- Idea: speculators buy the asset only because they expect its price to rise in the future
- Self-fulfiling expectations: “prices rise because they are expected to rise”
- Now: a simple model of a bubble

A simple asset pricing model

- Asset pays dividends
$$\{y_t\}_{t=0}^{\infty} = y_0, y_1, \ldots$$
- Individuals discount future at $\beta = 1/(1+r)$ satisfying $0 < \beta < 1$

- How will this asset be priced?

- Main example: asset = house
  - dividend y_t = per-period benefit received from owning the house
  - either rent (investment) or benefit from living in house (owner-occupied)
  - will sometimes say “rent” instead of “dividend”

A difference equation for pricing the asset

- **Claim:** the asset price p_t must satisfy the difference equation

$$p_t = y_t + \beta p_{t+1} \tag{$*$}$$

  In words: price today = dividend + discounted price tomorrow
- **Intuition:** arbitrage – see supplement
- **Claim:** A solution to the difference equation $(*)$ is

$$p_t = \sum_{j=0}^{\infty} \beta^j y_{t+j} = y_t + \beta y_{t+1} + \beta^2 y_{t+2} + \beta^3 y_{t+3} \ldots \tag{$**$}$$

  In words: Price = present discounted value (PDV) of future dividends
- **Example:** constant dividend $y_t = \bar{y}$ for all t (using $\sum_{j=0}^{\infty} \beta^j = 1/(1-\beta)$)

$$p_t = \frac{\bar{y}}{1-\beta}$$

- Is this a bubble? No
- PDV of future dividends = correct notion of fundamental value

A difference equation for pricing the asset

- Recall: the asset price p_t must satisfy the difference equation

$$p_t = y_t + \beta p_{t+1} \tag{$*$}$$

  with one solution given by

$$p_t = \sum_{j=0}^{\infty} \beta^j y_{t+j} = y_t + \beta y_{t+1} + \beta^2 y_{t+2} + \beta^3 y_{t+3} \dots \tag{$**$}$$

- How can bubbles arise?
- **Key:** asset price p_t in ($**$) is not unique solution to ($*$)
  - equation ($*$) has many more solutions that all correspond to bubbles

A useful case: zero dividends $y_t = 0$

- Asset pricing equation is

$$p_t = \beta p_{t+1}$$

- Obvious solution

$$p_t = 0 = \text{no-bubble solution}$$

- But there is another solution

$$p_t = c \left(\frac{1}{\beta}\right)^t = c\beta^{-t} \quad \text{for a constant } c$$

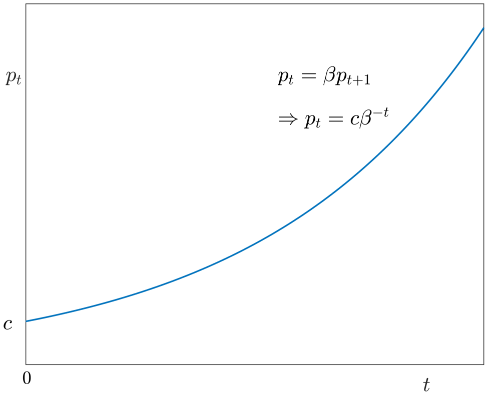
- Verify:

$$p_t = c\beta^{-t} = \beta \underbrace{\left[c\beta^{-(t+1)}\right]}_{p_{t+1}} = \beta p_{t+1}$$

- In fact this works for any constant c so there are infinitely many such solutions
- All these solutions are bubble solutions: $p_t \neq$ fundamental value = 0

A pure bubble when the asset pays no dividend $y_t = 0$

When $c > 0$ asset price $p_t = c\beta^{-t}$ grows exponentially (recall $\beta < 1$)



- Buy worthless asset because expect to sell it at higher price tomorrow
- "Prices rise because they are expected to rise"

Putting everything together: positive dividends y_t

- Recall: the asset price p_t must satisfy the difference equation

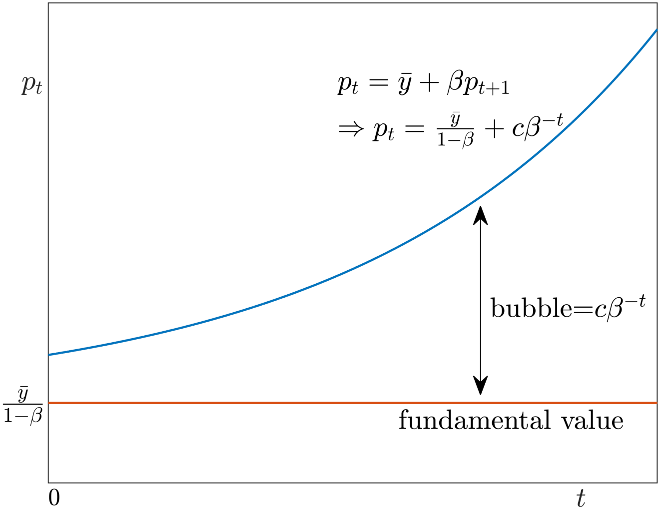
$$p_t = y_t + \beta p_{t+1} \tag{$*$}$$

- **Claim:** general solution to $(*)$ is

$$p_t = \underbrace{\sum_{j=0}^{\infty} \beta^j y_{t+j}}_{\text{fundamental value}} + \underbrace{c\beta^{-t}}_{\text{bubble component}} \qquad \text{for any constant } c$$

- Next slide: graph with constant dividend and hence constant fundamental value

Asset price = fundamental value + bubble component



Asset bubbles: summary

- It's not necessarily true that

$$\text{asset price} = \text{fundamental value} = \text{PDV of dividends}$$

- Instead there can be self-fulfilling bubbles in which

$$\text{asset price} = \text{fundamental value} + \text{bubble component}$$

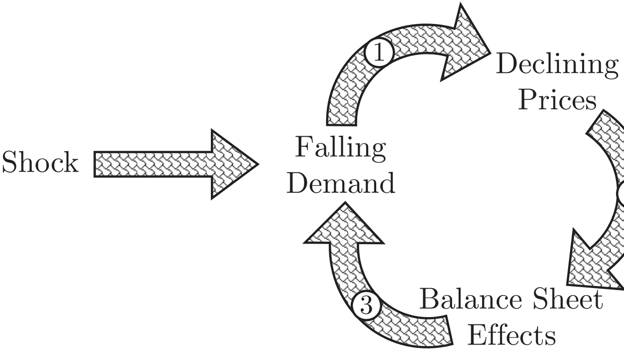
- These bubbles are self-fulfiling in sense that prices rise because they are expected to rise

- For more on bubbles, see survey by Brunnermeier (2008) "Bubbles" in the The New Palgrave Dictionary of Economics

  https://link.springer.com/referenceworkentry/10.1057/978-1-349-95121-5_44-2

Financial Frictions and Amplification

The idea in a nutshell: “financial doom loop”



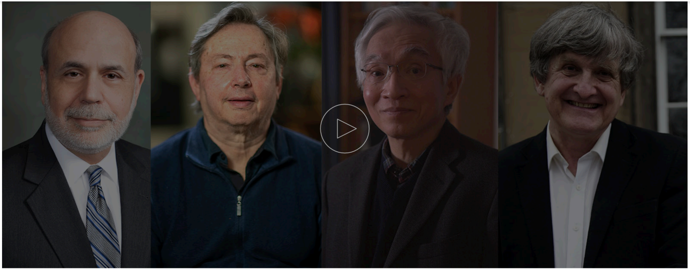
- Sometimes people call this “financial doom loop” or “diabolic loop”
- An “LSE idea”: Key work by Nobu Kiyotaki and John Moore written while both were at LSE (John Moore still is)

Watch the interviews here, particularly John Moore’s

BBVA Foundation

FRONTIERS OF KNOWLEDGE AWARDS

Nominate Eng



Ben Bernanke, Mark Gertler, Nobuhiro Kiyotaki and John Moore

In Economics, Finance and Management

The Frontiers of Knowledge Award goes to Bernanke, Gertler, Kiyotaki and Moore for establishing the nature of the linkage between the financial sector and the real economy and how it operates to amplify crises

https://www.frontiersofknowledgeawards-fbbva.es/noticias/

the-frontiers-of-knowledge-award-goes-to-bernanke-gertler-kiyotaki-and-moore-for-establishing-the-nature-of-the-linkag

Plan for this part of lecture notes

1. Preliminaries: Borrowing and Saving in a Small Open Economy
2. Preliminaries: Consumption Based Asset Pricing
3. Borrowing and Saving with a "Collateral Asset": Financial Amplification

Here:

- due to time constraints only provide overview
- see supplement for more detailed version (examinable)

Borrowing and Saving in a Small Open Economy

- "Small open economy": household can borrow and lend at a fixed world interest rate r^*
- Consumers solve

$$\max_{c_1, c_2, d_1} \; u(c_1) + \beta u(c_2) \quad \text{s.t.}$$

$$c_1 = y_1 + d_1$$

$$c_2 + d_1(1 + r^*) = y_2$$

$$d_1 \leq \kappa y_1, \qquad \kappa \geq 0$$

- Note: d_1 is debt, i.e. how much household borrows in period 1
- Note presence of borrowing constraint $d_1 \leq \kappa y_1$
  - borrow up to fraction (or multiple) κ of first-period income y_1
  - κ parameterizes quality of credit markets
  - $\kappa = \infty$: can borrow as much as you'd like (no constraint
  - $\kappa = 0$: cannot borrow at all

Unconstrained solution $\kappa = \infty$

- Can write present-value budget constraint

$$c_1 + \frac{c_2}{1+r^*} = y_1 + \frac{y_2}{1+r^*} \equiv y^{PDV}$$

- Optimality condition = standard Euler equation

$$u'(c_1) = \beta(1+r^*)u'(c_2)$$

- Assumption: $\beta(1+r^*) = 1$

- Then unconstrained solution is

$$c_1^u = c_2^u = \frac{1+r^*}{2+r^*}y^{PDV}, \qquad d_1^u = c_1^u - y_1 = \frac{y_2 - y_1}{2+r^*}$$

where u-subscript stands for "unconstrained"

Solution with borrowing constraint $d_1 \leq \kappa y_1$ with $\kappa < \infty$

Case 1: $d_1^u \leq \kappa y_1$ **(loose constraint)**

- can obtain unconstrained allocation (c_1^u, c_2^u, d_1^u)
- $=$ optimal choice and constraint will never bind

Case 2: $d_1^u > \kappa y_1$ **(binding constraint)**

- cannot obtain unconstrained allocation (c_1^u, c_2^u, d_1^u)
- household will borrow as much as it can $d_1 = \kappa y_1$ and consumption is

$$c_1 = (1 + \kappa) y_1, \quad c_2 = y_2 - \kappa y_1 (1 + r^*)$$

- $c_1 < c_1^u = c_2^u < c_2$, i.e. can no longer smooth consumption perfectly
- borrowing constraint makes them strictly worse off

A credit crunch $\kappa \downarrow$

- Recall

$$c_1 = (1+\kappa)y_1, \quad c_2 = y_2 - \kappa y_1(1+r^*)$$

- Therefore $\kappa \downarrow \Rightarrow c_1 \downarrow$ and $c_2 \uparrow$

- Even worse consumption smoothing $\Rightarrow$ welfare falls more

Consumption-based asset pricing

- Now: no borrowing and lending but households can invest in an asset a_t
  - buy asset at price p_1 in period 1
  - asset pays a dividend D in period 2
  - asset is in fixed supply $a_0^s = a_1^s = 1$, i.e. there is one unit of the asset
- Households solve

$$\max_{c_1, c_2, a_1} u(c_1) + \beta u(c_2) \quad \text{s.t.}$$

$$c_1 + p_1 a_1 = y_1 + p_1 a_0$$

$$c_2 = y_2 + D a_1$$

- In equilibrium $a_0 = a_1 = 1$ and hence already know (^{e} for "equilibrium")

$$c_1^e = y_1, \quad c_2^e = y_2 + D$$

- Only question: **what is the equilibrium asset price p_1?**
  - note similarity to finding equilibrium r in last part of lecture 4

Equilibrium asset price

- Optimality condition

$$p_1 u'(c_1) = \beta D u'(c_2)$$

- But we already know that in equilibrium

$$c_1^e = y_1, \qquad c_2^e = y_2 + D$$

- Therefore equilibrium asset price is

$$p_1 = \frac{\beta u'(c_2^e)}{u'(c_1^e)} D = \frac{\beta u'(y_2 + D)}{u'(y_1)} D$$

- Example: log utility $u(c) = \log c$

$$p_1 = \frac{\beta c_1^e}{c_2^e} D$$

- Note: rather than asking "given prices, what is consumption?" we asked "given consumption, what is the price?"

Equilibrium asset price p_1 is depressed when c_1 is low

- Equilibrium asset price

$$p_1 = \frac{\beta u'(c_2^e)}{u'(c_1^e)} D = \frac{\beta u'(y_2 + D)}{u'(y_1)} D$$

- Example: log utility $u(c) = \log c$

$$p_1 = \frac{\beta c_1^e}{c_2^e} D = \frac{\beta y_1}{y_2 + D} D$$

- Interesting feature: p_1 is low when $c_1^e = y_1$ is low and marginal utility $u'(c_1^e)$ is high

- Intuition: don't want to buy asset if you're starving $\Rightarrow$ low asset price

- This will be key feature of model we want to get to

Borrowing and saving with collateral asset: financial amplification

- Now combine elements from two preliminaries
  - borrowing and saving in small open economy
  - consumption-based asset pricing

- Key new ingredient = collateral constraint: borrowing constraint in which amount of debt d_1 is constrained by value of its assets

- Here: assume

$$d_1 \leq \kappa p_1 a_0$$

- Idea: can borrow against value of existing assets (in case of housing: "houses as ATMs", i.e. HELOC = home equity line of credit)

- Alternative formulation: $d_1 \leq \kappa p_1 a_1$ – see supplement

Borrowing and saving with collateral asset: financial amplification

- Households solve:

$$\max_{c_1, c_2, a_1, d_1} \; u(c_1) + \beta u(c_2) \quad \text{s.t.}$$

$$c_1 + p_1 a_1 = y_1 + p_1 a_0 + d_1$$

$$c_2 + d_1(1 + r^*) = y_2 + D a_1$$

$$d_1 \leq \kappa p_1 a_0$$

- Asset is still in fixed supply: $a_0^s = a_1^s = 1$
- Unconstrained solution: see supplement
- As before, two cases: loose constraint and binding constraint
- Here: focus on binding constraint

Equilibrium with binding constraint

- Borrow as much as possible, imperfect consumption smoothing

$$d_1 = \kappa p_1 a_0 = \kappa p_1, \quad c_1 = y_1 + \kappa p_1, \quad c_2 = y_2 + D - \kappa p_1(1 + r^*)$$

- Equilibrium asset price determined by

$$p_1 = \frac{\beta u'(c_2)}{u'(c_1)} D = \frac{\beta u'(y_2 + D - \kappa p_1(1 + r^*))}{u'(y_1 + \kappa p_1)} D$$

- Key feature again: equilibrium asset price p_1 is depressed when c_1 is low

- To solve this neatly change utility slightly: log-linear utility

$$u_1(c_1) + \beta u_2(c_2), \quad u_1(c_1) = \log c_1, \quad u_2(c_2) = c_2$$

- Also assume $\kappa\beta D < 1$

Equilibrium with binding constraint and log-linear utility

- With log-linear utility equilibrium price satisfies

$$p_1 = \beta D c_1$$
$$c_1 = y_1 + \kappa p_1$$

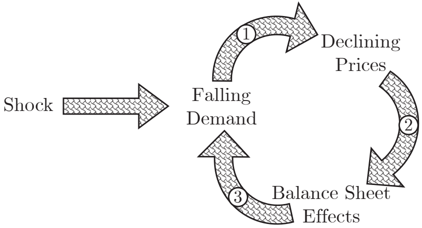
- Solving for p_1 and c_1

$$p_1 = \frac{\beta D y_1}{1 - \beta D \kappa}, \qquad c_1 = \frac{y_1}{1 - \beta D \kappa}$$

- Equilibrium features financial amplification
- Suppose $y_1 \downarrow$. Unsurprisingly $c_1 \downarrow$
- But key: c_1 may fall by a lot more than y_1!

$$\frac{\partial c_1}{\partial y_1} = \frac{1}{1 - \beta D \kappa} > 1 \quad \Rightarrow \quad \text{multiplier effect}$$

Intuition: “financial doom loop”



- Key equations

$$p_1 = \beta D c_1 \tag{1}$$

$$c_1 = y_1 + \kappa p_1 \tag{2}$$

- Mechanism: $y_1 \downarrow \Rightarrow$ consumption $c_1 \downarrow$ from (2) $\Rightarrow$ asset demand $\downarrow$ (“don’t want to buy asset when starving”) $\Rightarrow$ asset price $p_1 \downarrow$ from (1) $\Rightarrow$ tighter collateral constraint $\Rightarrow c_1 \downarrow$ from (2) $\Rightarrow p_1 \downarrow$ from (1) and so on...

Importance of house prices during the financial crisis

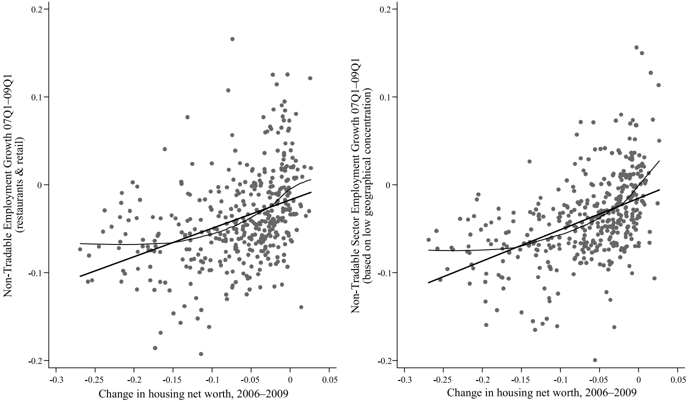


FIGURE 1.—Non-tradable employment and the housing net worth shock. This figure presents scatter-plots of county-level non-tradable employment growth from 2007Q1 to 2009Q1 against the change in housing net worth from 2006 to 2009. The left panel defines industries in restaurant and retail sector as non-tradable, and the right panel defines industries as non-tradable if they are geographically dispersed throughout the United States. The sample includes counties with more than 50,000 households. The thin black line in the left panel is the non-parametric plot of non–tradable employment growth against change in housing net worth.

Source: Mian and Sufi (2014) “What Explains the 2007-2009 Drop in Employment?”