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## Fire sales, inefficient banking and liquidity ratios

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#### Fire sales: an old phenomenon

- Financial fire sales are periods during which financial institutions are forced to engage in distressed sale of assets to meet their obligations
- Fire sales defined theoretically as *forced sales at a dislocated price* (Schleifer and Vishny 1992)
- Modern financial markets have not invented fire sales (1866 crisis on the money market of Lombard Street)
- During those episodes, liquidity demand by distressed banks cannot be satisfied by sufficient supply of liquidity to buy back assets: collapse of price

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#### Welfare and fire sales

- Are fire sales harmful?
- ► → mere innocuous redistribution effect between sellers and buyers with no impact on welfare in absence of imperfections (Greenwald Stiglitz 1986)
- However, market failures could generate a pecuniary externality: need a good model of banking

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## Literature

- 1. Banking model
  - Diamond and Dybvig (1983), Allen and Gale (1998, 2004, 2005)
- 2. Fire Sales
  - Seminal work by Schleifer Vishny (1992)
  - ► Fire sales: credit constraint: Kiyotaki Moore (1997)
  - Stein (2012): fire sales induce a negative externality in a model where bank are money creator and there is a binding collateral constraint: excessive creation of private money
- 3. Externalities
  - Greenwald Stiglitz (1986), Geanokoplos and Polemarchakis (1986)

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## This paper

- Introduction of a financial intermediary offering illiquid contracts: similar to contractual savings (pension funds, insurance companies)
- General equilibrium analysis of fire sales: understand how both the demand for and the supply of liquidity are determined
- Fire sales are a transfer of money within the financial sector that is not neutral with incomplete markets: redistribution between different ex post type of households = insurance problem

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#### Paper at a glance

- Banking model a la Diamond and Dybvig: a shock makes a stochastic proportions of households impatient before assets have matured
- Households can choose between:
  - liquid contract of banks (can withdraw if impatient)
  - illiquid offered by funds (cannot withdraw early but higher return - riskier)
- Financial sectors composed of banks and funds which interact on market of assets: banks sell assets to funds
- Welfare loss arises that goes through the price, no deadweight loss of asset sales

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## Contribution- 1

- Uncover an externality of fire sales new in the literature by building a model of supply and demand of liquidity - Takes 2 forms:
  - 1. Banks invest too much in assets (Banks' choice)
  - 2. Inefficient size of banking sector (HH choice)
- Crucially, no mixed equilibrium (Allen Gale 2004):
  - Sales of assets between different sectors
  - In my setting, mixed equilibrium not necessary to have an equilibrim
- Motivate a pecuniary externality in a setting with:
  - 1. No collateral constraint (different from Stein 2010)
  - 2. Ex ante identical households (different from Allen Gale 2004)

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## Intuition behind welfare loss of fire sales

- Fire sales are a redistribution between the two sectors offering contracts of different liquidity (banks and funds)
- In fine, transfer through price effect of price sales implies a transfer of wealth between households needing liquidity and households who can postpone withdrawals
- Externality arises because agents do not take into account their impact on fire sale prices and hence on the transfer operated by fire sales
- Cost of fire sales = inefficient insurance of risk of becoming impatient i.e. against idiosyncratic liquidity risk

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#### Contribution- 2

- Provide an assessment of liquidity ratios in general equilibrium setting
- Reduce inefficiency in bank's choice
- But can worsen inefficiency in HH's choice
- Tax on deposits and subsidy of illiquid contracts of funds

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#### Take-away results

- 1. Banks take on too much risk
- 2. Banking sector is too big relative to funds: **illiquid contracts are valuable**
- 3. Liquidity ratios help for the first inefficiency (banks) but can worsen the second one (households)

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#### Content

- $1. \ \mathsf{Model}$
- 2. Inefficiencies
- 3. Policy: liquidity ratios and tax on deposits

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#### Environment

- 3-period banking model: 0, 1 and 2
- Ex ante, 3 agents: banks, funds, ex ante identical households,
   after shock: patient / impatient households
- Households invest in contracts of financial intermediaries which invest for them in assets
- Assets mature in period 2, two types of assets:
  - early assets (done in period 0) return R<sup>E</sup>
  - late assets (done in period 1) return R<sup>L</sup>

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## Liquidity shock

- Liquidity shock hits consumers' preferences in period 1 before asset maturation
- Idiosyncratic: households do not know their type ex ante
  - Impatient only care about middle period consumption, cannot postpone consumption until asset maturation
  - Patient wait for asset maturation in last period to consume: lucky outcome
- Aggregate: size of the shock (number of impatient) is stochastic

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## Model ingredients

- Before liquidity shock, households allocate wealth between banks and funds
- Liquid contracts of banks: canwith draw if hit by liquidity shock
- Illiquid contracts of funds: cannot withdraw if hit by liquidity shock: riskier investment for HH
- If liquidity shock too high, banks can sell assets to funds who have cash
- Fire sales when price of assets sold by banks to funds falls below fundamental value

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# Timing

#### 1. Period 0

- 1.1 Households allocate D to liquid contracts of banks and K to illiquid contracts of funds
- 1.2 Banks and funds invest in reserves  $(L^B, L^F)$  and in early assets  $(S^B, S^F)$  and banks decide fixed rate to pay impatient households  $\overline{c}$

#### 2. Period 1

- 2.1 Shock realized: proportion  $\theta$  of households impatient withdraw from banks  $\theta \overline{c} D$
- 2.2 Banks can sell assets to funds if needed remaining cash of banks and funds invested in early assets
- 2.3 Banks default if ICC not respected
- 3. **Period 2**: early and late assets mature, funds' profits (and banks' if no default before) realized and shared between  $1 \theta$  patient (patient no longer care about consumption)

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## Micro imperfections

- 1. Incomplete markets: generates the externality
  - Missing markets: no Arrow securities allowing banks to insure against aggregate liquidity shock
  - Funds and banks cannot raise new cash in period 1
- 2. Asymmetry of information between bank and depositors: imperfections innocuous
  - Depositor type (patient/impatient) is private information
  - Contract cannot be made contingent upon the type
  - Bank run possible: need incentive compatible contract

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#### Probability of default

Bank defaults when incentive compatibility constraint no longer verified:

$$heta \overline{c} D + (1- heta) \overline{c} D rac{P( heta)}{R^E} \leq L^B + S^B P( heta)$$

• Gives the default threshold: 
$$\overline{\theta}$$

• 
$$(1 - \overline{ heta})$$
 is the probability of default

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#### Fundamental price

Price that makes funds indifferent between holding early assets sold by banks or investing in new late assets

$$P^F = rac{R^E}{R^L}$$

 Ratio btw marginal return of buying back early assets and marginal return on investing in new assets projects

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#### Fire sales

# Theorem

For high liquidity shock and  $R^E$  sufficiently high compared to  $R^L$ , price falls to cash in the market price when banks default.

 Market clearing: demand of liquidity by banks = supply by funds

$$P^* = \frac{L^F}{S^B}$$

- Discontinuity in the price at bankruptcy price P\*
- ▶  $P^*$  decreases with  $S^B$  and with  $D(L^F = E D S^F)$

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#### Externality takes two forms

- 1. In banks' choice
- 2. In households' choice

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#### Externality lies in choice of $S^B$

- ▶ The 2 f.o.c. wrt to  $\overline{c}$  and  $L^B$  are identical in both economies, only the f.o.c. wrt to  $S^B$  differs
- Bank does not internalize the effect on its choice of S<sup>B</sup> on bankruptcy price P<sup>\*</sup> = L<sup>F</sup>/S<sup>B</sup>
- Choosing more S<sup>B</sup> in period 0 implies a lower bankruptcy price, and has an impact on:
- 1. Probability of default
- 2. Payment banks can make to depositors in case of default

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## Impact of choice of S on probability of default

 Decentralized bank does not internalize the impact of its choice of S<sup>B</sup> on bankruptcy price

$$\frac{\partial \theta^*}{\partial S^B_{dec}} = \frac{R^E P^*_{dec}}{\overline{c}_{dec} D_{dec} (R^E - P^*_{dec})}$$

Social planner understands that partial derivative is:

$$\frac{\partial \theta^*}{\partial S_{soc}^B} = \frac{R^E P_{soc}^*}{\overline{c}_{soc} D_{soc} (R^E - P_{soc}^*)} \frac{\overline{c_{soc}} D_{soc} - L_{soc}^B - K_{soc}}{R^E S_{soc}^B - K_{soc}}$$

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# Over investment in $S^B$ by decentralized bank

#### Theorem

Banks invest too much in assets, i.e. take on too much risk

▶ The value of the partial derivative of the Lagrangian with respect to  $S^B$  is greater in the decentralized economy than in the constrained efficient economy for a given value of  $S^B$ ,  $S^B = \overline{S}$ .

$$\frac{\partial \mathcal{L}_{dec}}{\partial S^B}(S^B = \overline{S^B}) > \frac{\partial \mathcal{L}_{soc}}{\partial S^B}(S^B = \overline{S^B})$$

► For decentralized bank, increasing S<sup>B</sup> marginally increases the utility more than in constrained social planner problem because neglect impact on price

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#### Inefficiency on households' side

Theorem Households can over invest in banks: banks are too big compared to funds

- Households do not internalize the effect of their choice on the bankruptcy price
- ▶ Fail to realize that bankruptcy price  $P^*$  depends on D and K
  - Neglect the impact on probability of default by banks and on payments by banks in case of default
  - Neglect impact on expected payments by banks

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#### Liquidity ratios

Liquidity ratios constraint whose Lagrange multiplier is μ<sub>2</sub>:

 $S^B \leq \alpha D$  with  $\alpha \leq 1$ 

•  $\mu_2$  enters banks and households' program

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#### Effect of liquidity ratios - Banks choice

Theorem

# Binding liquidity ratios alleviate the inefficiency lying in bank's choice

In the decentralized economy with ratio:

$$\frac{\partial \mathcal{L}_{dec}}{\partial S^B} = \frac{\partial \mathcal{L}_{dec}}{\partial S^B} - \mu_1 - \mu_2$$

In the efficient constraint economy:

$$\frac{\partial \mathcal{L}_{soc}}{\partial S^B} = \frac{\partial \mathcal{L}_{soc}}{\partial S^B} - \mu_1$$

▶  $\Rightarrow \mu_2 > 0$  allows to get the decentralized allocation closer to the constrained efficient allocation

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#### Effect of liquidity ratios - HH choice

$$\max_{D,K} [\max_{\overline{c},L^B,S^B}] + \lambda [E - D - K] = \max_{D,K} U + \mu_1 [D - S^B - L^B] + \mu_2 [\alpha D - S^B]$$

$$\frac{\partial \mathcal{L}^{\mathcal{B}}_{ratio}}{\partial D} = \frac{\partial \mathcal{L}^{\mathcal{B}}_{dec}}{\partial D} + \alpha \mu_2$$

#### Theorem

Imposing  $\mu_2 > 0$  in order to alleviate the inefficiency lying in the bank's choice can worsen the inefficiency lying in the households choice.

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#### Non contingent tax

- Equivalent to a redistribution between types
- Does not require to observe the type

#### Theorem

Any tax  $t \ge 0$  allows to get the choice of households closer to the efficiency and increases welfare.

$$\frac{\frac{\partial \mathcal{L}_{dec}}{\partial D^{i}}}{\frac{\partial \mathcal{L}_{dec}}{\frac{\partial \mathcal{K}^{i}}{t}} \geq 0$$

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## Conclusion

- Pecuniary externality is an inefficient insurance due to transfer btw patient and impatient by price effect of fire sales
- Arises both in banks and HH choice:
  - 1. Banks invest too much in assets and cannot insure depositors optimally against risk of being impatient
  - 2. Banking sector is too big relatively to financial sector because households invest too much in deposits
- Policy needs to take care of two inefficient choices: liquidity ratios can worsen inefficiency in households' choice
- Complementary policy to ratio: redistributive tax to restore optimal insurance