A Theory of Bank Liquidity Requirements

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- Banks invest in **liquid assets** to manage **liquidity risk**

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- Banks manage loan risk; moral hazard similar to Holmstrom and Tirole (1997)
- They can hold cash— risk-free asset & unaffected by risk management
- Their equity/balance-sheet size inversely related to the non-bank sectors' (Gorton and Huang (2004))

Key insights

1. **What are the costs and benefits of cash for banks?**
   - **Benefits**: avoids inefficient risk taking $\rightarrow$ reduces loans' credit risk
   - **Costs**: foregone investment in loans and/or exposure to fire-sale

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   - It is not when raising cash involves fire-sales $\rightarrow$ **fire-sale externality**
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2. **Is the competitive equilibrium socially optimal?**
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   - Investment in cash inefficiently low + banking sector inefficiently large
3. **If not, what is an optimal regulation?**
   - Liquidity regulation needs to be complemented with a tax on the banking sector (e.g., risk-weighted capital requirements)

Literature Review

This paper relates mainly to three strands of the literature:

- **Banks' liquidity holdings and potential rationale for regulation**
  e.g., Gorton and Huang (2004); Farhi et al. (2009); Perotti and Suarez (2011); Malherbe (2014); Vives (2014); Diamond and Kashyap (2016); Walther (2016); Carletti et al. (2020); Kara and Ozsoy (2020).

- **Welfare implications of fire-sales**
  e.g., Lorenzoni (2008); Stein (2012); Dávila and Korinek (2018); Kara and Ozsoy (2020); Biais et al. (2020)

- **Debt as a disciplining device**
  e.g., Calomiris and Kahn (1991); Diamond and Rajan (2001)

Outline

1. **Model setup**
2. **Equilibrium characterization**
3. **Welfare analysis**
4. **Policy implications**

The model

Model setup

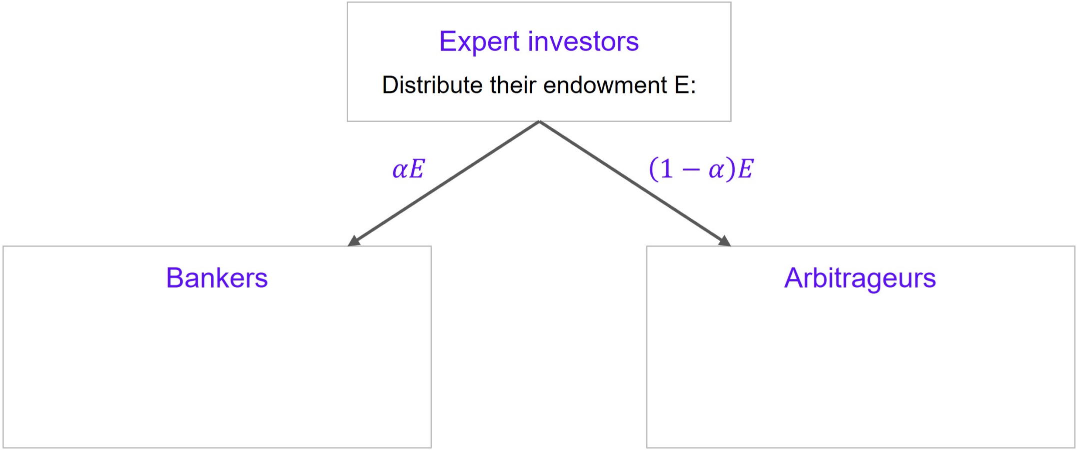
- **Three dates** $(t \in \{0, 1, 2\})$
- **Non-contractible aggregate states**: good $(s = g)$ and bad $(s = b)$
- Storage technology (**cash**) available at t and yields a unit return at $t + 1$
- **Two types of risk-neutral agents** each of size one:
  - → **Expert investors**: own the productive technology in the economy
  - → **Depositors:** outside option - cash; lend to expert investors

Model setup

Expert investors

Distribute their endowment E:

Model setup


Expert investors
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αE
$(1-\alpha)E$
Bankers
Arbitrageurs

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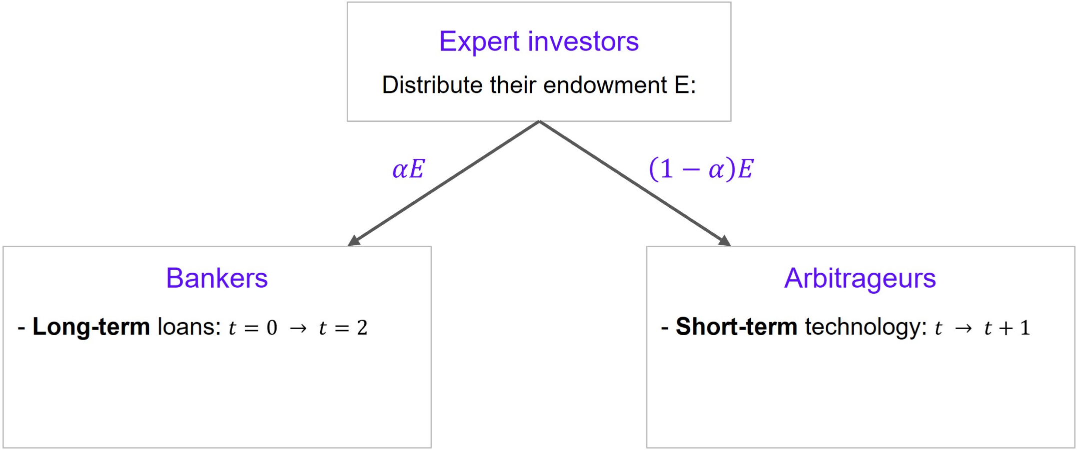
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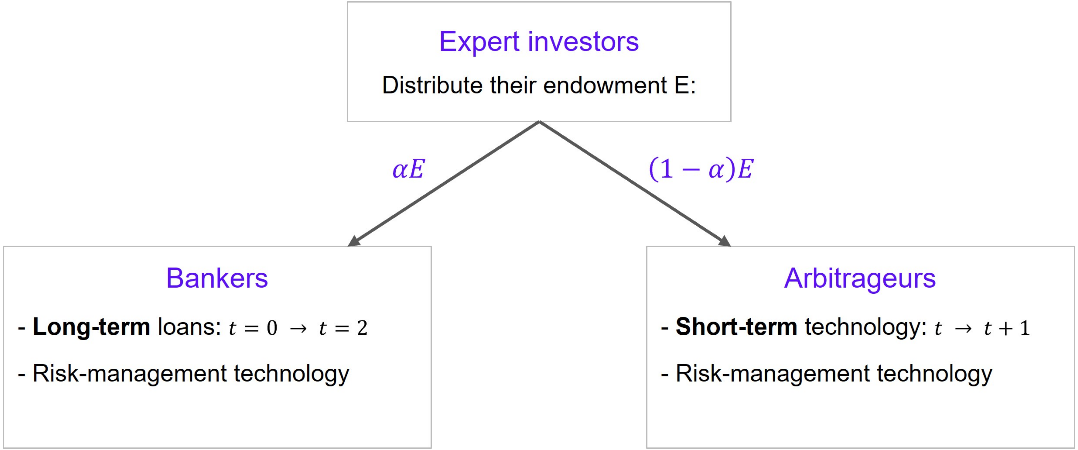
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- **Can** raise funds from depositors

Arbitrageurs

- **Short-term** technology: $t \rightarrow t + 1$
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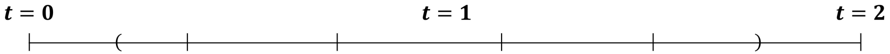
Equilibrium characterization

1. Bankers' optimization problem
2. Arbitrageurs' optimization problem

$\rightarrow$ Competitive equilibrium allocation

Timeline of bankers' decisions



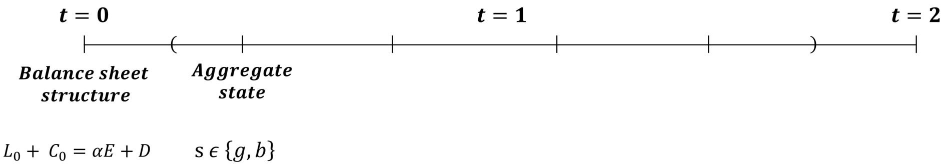
Timeline of bankers' decisions

$t = 0$ $t = 1$ $t = 2$

Balance sheet structure

$L_0 + C_0 = \alpha E + D$

Timeline of bankers' decisions



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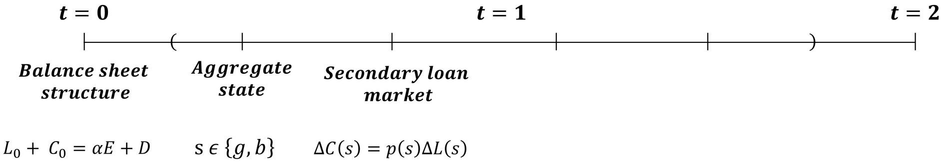

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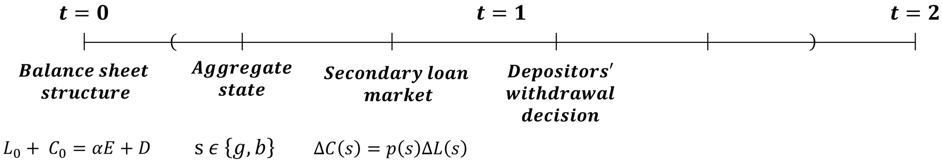

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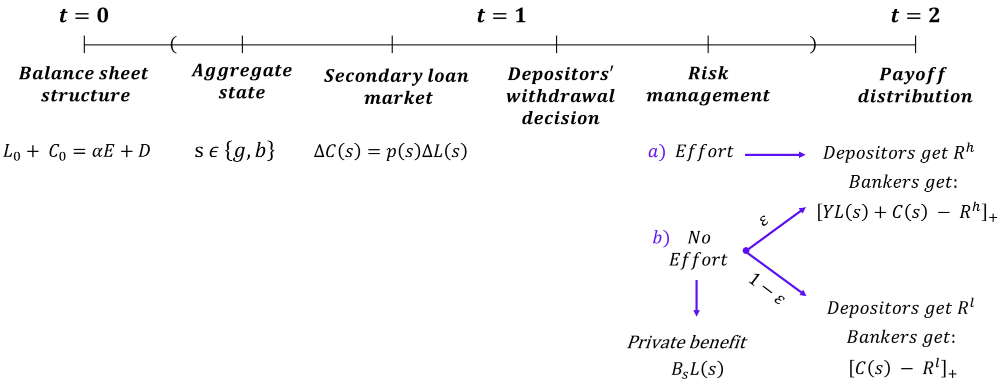

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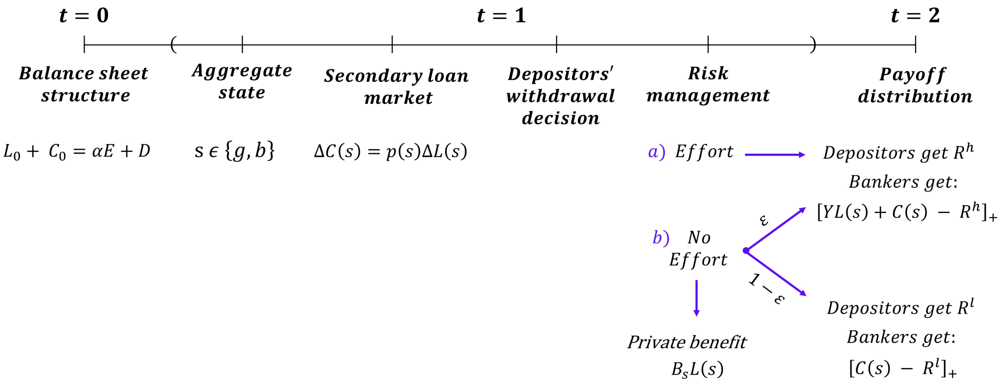
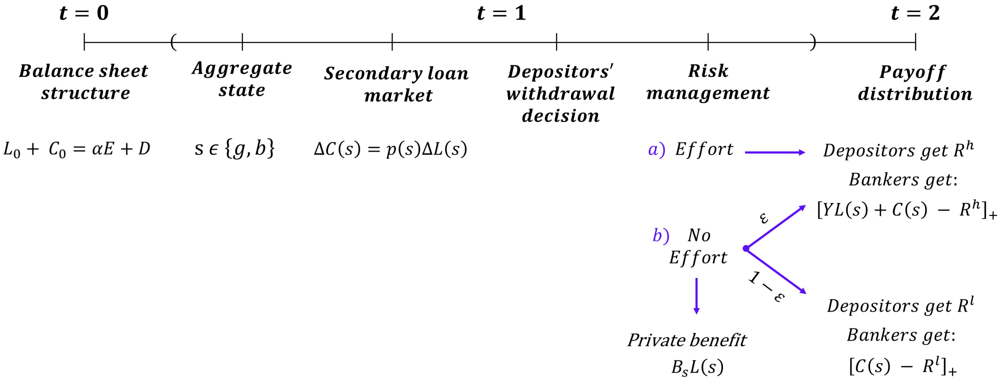


When effort is observable $\rightarrow$ effort is always exert (NPV$>$0)

Timeline of bankers' decisions



When effort is not observable → state dependent Moral Hazard $(B_g < B_b)$

Timeline of bankers' decisions

$t = 0$			$t = 1$		$t = 2$
Balance sheet structure	***Aggregate state***	***Secondary loan market***	***Depositors' withdrawal decision***	***Risk management***	***Payoff distribution***

$L_0 + C_0 = \alpha E + D$

Good state $s = g$

$\Delta C(g) = \Delta L(g) = 0$

a) *Effort is always exerted* → *Depositors get* R^h; *Bankers get:* $[YL_0 + C_0 - R^h]_+$

Bad state $s = b$

$\Delta C(b) = \underbrace{(1-z)Y}_{p(b)} \Delta L(b)$

a) *Effort* → *Depositors get* R^h; *Bankers get:* $[YL(b) + C(b) - R^h]_+$

b) *No Effort* → *Private benefit* $B_b L(b)$

- with probability ε: *Depositors get* R^h; *Bankers get:* $[YL(b) + C(b) - R^h]_+$
- with probability $1 - \varepsilon$: *Depositors get* R^l; *Bankers get:* $[C(b) - R^l]_+$

Moral hazard problem

Incentive compatibility constraint :

$$\underbrace{\left[YL(b) + C(b) - R^h\right]_+}_{\text{Effort is exerted}} \geq \underbrace{\varepsilon \left[YL(b) + C(b) - R^h\right]_+ + (1-\varepsilon) \left[C(b) - R^l\right]_+ + B_b L(b)}_{\text{Effort is not exerted}}$$

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- Bankers issue a **demandable debt contract** with $R^h = D$ and $R^l = C(b)$

Moral hazard problem

Incentive compatibility constraint:

$$D \;\leq\; \mathcal{P}_b L(b) \;+\; C(b)$$

where $\mathcal{P}_b \equiv Y - \frac{B_b}{1-\varepsilon}$ is the **pledgeable loan income**

Moral hazard problem

Incentive compatibility constraint:

$$D = \frac{\mathcal{P}_b}{1-\mathcal{P}_b}\alpha E \; + \; C_0 \; + \; \frac{1}{1-\mathcal{P}_b}\left(1 - \frac{\mathcal{P}_b}{(1-z)Y}\right)\Delta C(b)$$

After substituting the $L_0 + C_0 = \alpha E + D$ and $\Delta L(b) = \underbrace{\frac{1}{(1-z)Y}}_{\frac{1}{p(b)}} \Delta C(b)$

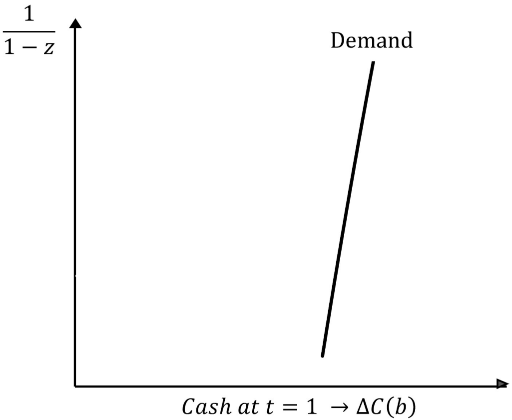
Bankers' optimization problem

Bankers take price $\frac{1}{1-z}$ as given, and chose D , C_0 and $\Delta C(b)$ to maximize:

$$\underbrace{Y\alpha E}_{\text{Payoffs from direct investment}} + \underbrace{(Y-1)\,D}_{\text{Payoffs from issuing debt}} - \underbrace{\underbrace{(Y-1)C_0}_{\text{Forgone payoffs}} - \underbrace{(1-q)\left(\frac{1}{1-z}-1\right)\Delta C(b)}_{\text{Expected fire-sale cost}}}_{\text{Total cost of investing in cash at } t=0 \text{ and } t=1}$$

Subject to $D \leq \alpha \bar{D}$ and the binding incentive compatibility constraint.

Cash market at $t = 1$



Arbitrageur's optimization problem

Arbitrageurs' maximisation problem in the bad state:

$$\max_{K(b),A(b)} \quad \overbrace{G\left(K(b)\right)}^{\text{Productive technology}} \quad + \quad \overbrace{YA(b)}^{\text{Purchased loans}}$$

$$s.t \quad (1-\alpha)E \; = \; K(b) \; + \; (1-z)YA(b)$$

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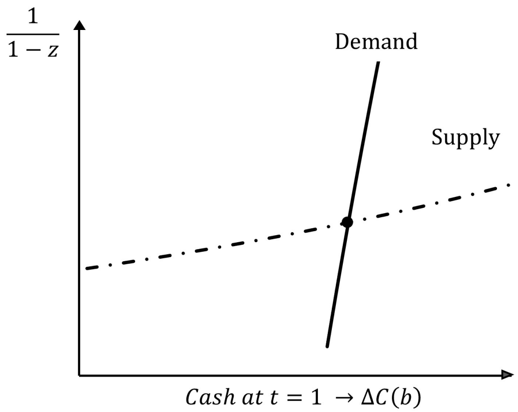
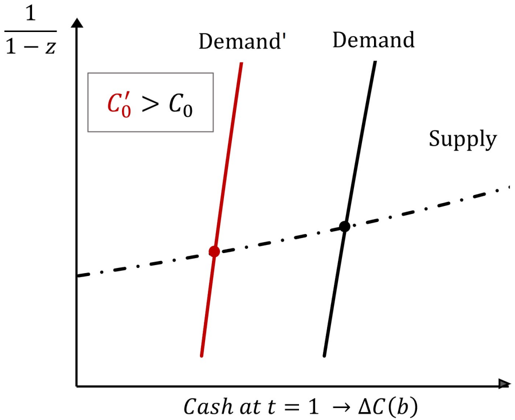
The first-order condition $\rightarrow G'\left((1-\alpha)E - \overbrace{(1-z)YA(b)}^{\text{Cash supply}}\right) = \frac{1}{1-z}$

Cash market at $t = 1$

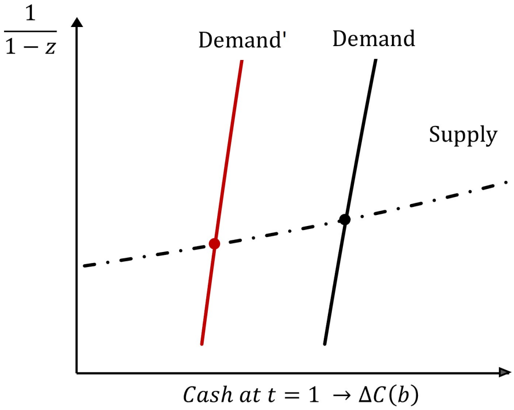


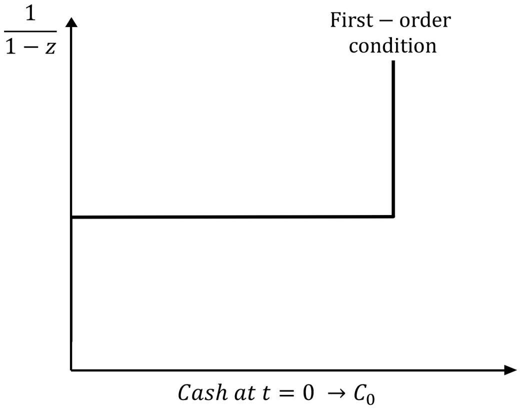
Cash market at $t = 1$ and at $t = 0$



Cash market at $t = 1$ and at $t = 0$

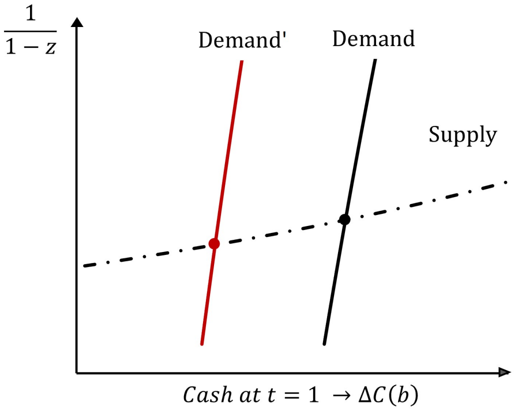
Equ.

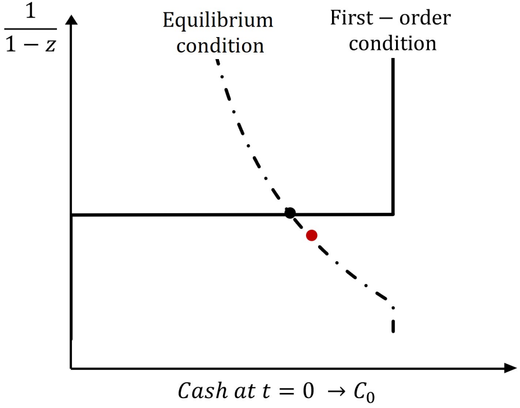




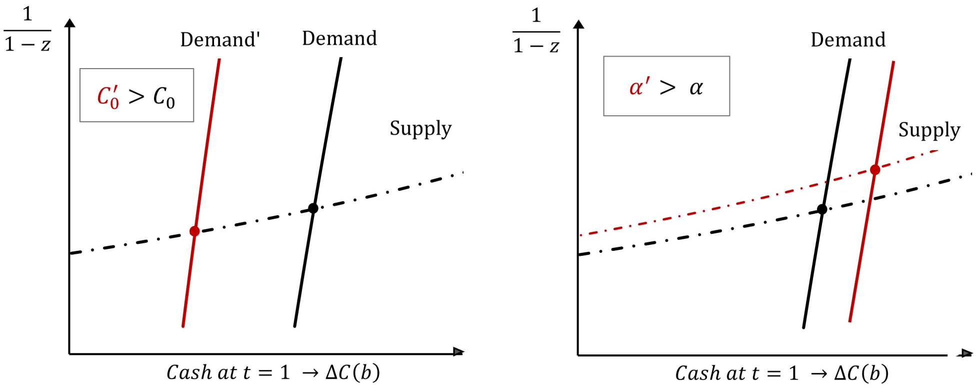
Cash market at $t = 1$ and at $t = 0$

Equ.





Cash market at $t = 1$ and at $t = 0$ ⏩ Equ.



Welfare analysis

Constrained-efficient allocation

Equations

The social planner's (SP) optimization problem:

$$\underset{\alpha,D,C_0}{Max} \quad \Pi_0^{Experts} \quad \rightarrow \quad \text{Experts' expected profits}$$

$$subject\ to \quad U_{SP}^{Depositors} = U_{CE}^{Depositors}$$

Incentive compatibility constraint $\rightarrow$ determines $\Delta C(b)$

Equilibrium price: $\dfrac{1}{1-z} = F(\ C_0\ ,\ \alpha\ )\ \ where\ F_{C_0} < 0, F_\alpha > 0$

Constrained-efficient allocation

- **The competitive equilibrium is not constraint-efficient**
  - + Experts do not internalize their effect on prices (**pecuniary externality**)
  - + Prices affect the binding incentive compatibility constraint (ICC)
  - = Each expert's effect on prices affect other experts through the ICC

Constrained-efficient allocation

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  - + Experts do not internalize their effect on prices (**pecuniary externality**)
  - + Prices affect the binding incentive compatibility constraint (ICC)
  - = Each expert's effect on prices affect other experts through the ICC
- **The pecuniary externality operates through two channels:**
  - $\rightarrow$ Bankers' demand for cash at $t = 1$ inefficiently high
    - low investment in cash at $t = 0$ + large balance sheet size
  - $\rightarrow$ Arbitrageurs' supply for cash at $t = 1$ inefficiently low
    - Arbitrageurs' balance-sheet size small relative to bankers'

Policy implications

Optimal ex-ante regulation

Ex-ante regulation should boost aggregate investment in liquid assets

1. **Cash/liquidity requirements on banks:**
    - Reduce bankers' demand for cash in the bad state *ceteris paribus*

Optimal ex-ante regulation

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1. **Cash/liquidity requirements on banks:**
   - Reduce bankers' demand for cash in the bad state *ceteris paribus*
2. A tax on bankers' activity or a **risk-weighted capital requirement**
   - Reduces the size of banks' loan portfolio $\rightarrow$ the size of their balance sheet
   - Thereby, boosts the supply of cash at $t = 1$ by arbitrageurs

Both complement each other in the implementation of the second best.

Concluding remarks

- **The key role of cash:**
  - $\rightarrow$ Benefits: avoids inefficient risk taking $\rightarrow$ increases external funding
  - $\rightarrow$ Costs: foregone investment in loans and/or exposure to fire-sale
  - $\rightarrow$ Can be generated in the bad state, when raising more equity is hard
  - $\rightarrow$ Explain the Goodhart's paradox – the last taxi standing analogy ⏩ link

Concluding remarks

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  - → Costs: foregone investment in loans and/or exposure to fire-sale
  - → Can be generated in the bad state, when raising more equity is hard
  - → Explain the Goodhart's paradox – the last taxi standing analogy ⏩ link
- **Regulation** needed if accumulating cash involves asset fire-sales
  - → **Liquidity requirements**, increases banks' liquidity investment
  - → A tax on the banking sector to boost the liquidity provision in the bad state by the non-bank sector (e.g., **risk-weighted capital requirement**)

Thank you!

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Background slides

Goodhart (2008)

“the weary traveller who arrives at the railway station late at night, and, to his delight, sees a taxi there who could take him to his distant destination. He hails the taxi, but the taxi driver replies that he cannot take him, since local bylaws require that there must always be one taxi standing ready at the station.”

⏩ Back

Banker's optimal cash holdings

At $t = 1$, bankers increase their cash holdings to meet ICC:

$$\Delta C(b) = \frac{(1 - \mathcal{P}_b)\left(\alpha\bar{D} - C_0\right) - \mathcal{P}_b \alpha E}{1 - \frac{\mathcal{P}_b}{(1-z)Y}}$$

At $t = 0$, banker choose the initial cash considering its effect on $\Delta C(b)$:

$$\underbrace{(Y - 1)}_{\substack{\text{Cost of raising} \\ \text{cash at } t=0}} - \underbrace{(1 - q)\left(\frac{1}{1 - z} - 1\right)\left[\frac{1 - \mathcal{P}_b}{1 - \frac{\mathcal{P}_b}{(1-z)Y}}\right]}_{\substack{\text{Cost of raising} \\ \text{cash at } t=1}} \;\; \begin{vmatrix} > \\ = \\ < \end{vmatrix} \;\; 0 \;\; \begin{vmatrix} \to C_0 = 0 \\ \to \text{Indifferent} \\ \to \Delta C(b) = 0 \end{vmatrix}$$

Back

The optimal α when effort is not observable

When effort is not observable:

$$Y + \lambda \frac{\mathcal{P}_b}{1 - \mathcal{P}_b} + \xi^{CE} \frac{\bar{D}}{E} = \mathbf{E}_0 \left[G' \left(\left(1 - \alpha^{CE} \right) E - \Delta C(s) \right) \right]$$

where $\lambda = Y - 1 - \xi^{CE}$ is the Lagrangian multiplier of the ICC and $\xi^{CE} \geq 0$ is the Lagrangian multiplier of $D \leq \alpha \bar{D}$.

Note that a necessary condition for a binding ICC is $\frac{\mathcal{P}_b}{1-\mathcal{P}_b} < \frac{\bar{D}}{E}$

We assume this is the case, hence $\alpha^{CE} < \alpha^{FB}$.

Back

First-best

When effort is observable (first-best):

- Bankers' investment in cash zero at any time $\rightarrow C_0^{FB} = \Delta C^{FB}(s) = 0$
- Bankers and arbitrageurs co-exists such that:

$$Y + \xi^{FB}\frac{\bar{D}}{E} = G'\left(\left(1 - \alpha^{FB}\right)E\right)$$

where $\xi^{FB} > 0$ is the Lagrangian multiplier of $D \leq \alpha\bar{D}$.

When effort is not observable:

- Bankers' investment in cash $\rightarrow C_0^{CE}, \Delta C^{CE}(b) \geq 0$
- The size of bankers' balance sheet relatively lower: $\alpha^{CE} < \alpha^{FB}$

Equ.

Constrained-efficient allocation

Back

The social planner's (SP) optimization problem:

$$\left.\begin{aligned} \max_{\alpha,D,C_0} \quad & Y\alpha E + \Big(Y-1\Big)\Big(D-C_0\Big) + qG\Big((1-\alpha)E\Big) \\ & +(1-q)\Big(\Delta C(b) + G\Big((1-\alpha)E - \Delta C(b)\Big)\Big) \end{aligned}\right\} \text{Expert's profits}$$

$$s.t. \quad U^{SP}_{Depositors} = U^{CE}_{Depositors}$$

Incentive compatibility constraint that depends on $\dfrac{1}{1-z}$:

$$\Delta C(b) = \frac{(1-\mathcal{P}_b)(D-C_0) - \mathcal{P}_b \alpha E}{1 - \frac{\mathcal{P}_b}{Y}\frac{1}{1-z}}$$

Equilibrium price: $\dfrac{1}{1-z} = G'\left((1-\alpha)E - \Delta C(b)\right)$

Bankers' optimization problem

Bankers take price $\frac{1}{1-z}$ as given, and chose D, C_0 and $\Delta C(b)$ to maximize:

$$\underbrace{Y\alpha E}_{\text{Payoffs from direct investment}} + \underbrace{(Y-1)\,D}_{\text{Payoffs from issuing debt}} - \underbrace{\underbrace{(Y-1)C_0}_{\text{Forgone payoffs}} - \underbrace{(1-q)\left(\frac{1}{1-z}-1\right)\Delta C(b)}_{\text{Expected fire-sale cost}}}_{\text{Total cost of investing in cash at } t=0 \text{ and } t=1}$$

Subject to the incentive compatibility constraint:

$$D \leq \frac{\mathcal{P}_b}{1-\mathcal{P}_b}\alpha E + C_0 + \frac{1}{1-\mathcal{P}_b}\left(1-\frac{\mathcal{P}_b}{(1-z)Y}\right)\Delta C(b)$$

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Subject to the incentive compatibility constraint (binding):

$$D = \frac{\mathcal{P}_b}{1-\mathcal{P}_b}\alpha E + C_0 + \frac{1}{1-\mathcal{P}_b}\left(1-\frac{\mathcal{P}_b}{(1-z)Y}\right)\Delta C(b)$$

Bankers' optimization problem

Bankers take price $\frac{1}{1-z}$ as given, and chose D, C_0 and $\Delta C(b)$ to maximize:

$$Y \alpha E \; + \; (Y-1) \underbrace{(D - C_0)}_{\text{Net debt}} \; - \; (1-q)\left(\frac{1}{1-z} - 1\right) \Delta C(b)$$

Subject to the incentive compatibility constraint (binding):

$$\overbrace{(D - C_0)}^{\text{Net debt}} \; = \; \frac{\mathcal{P}_b}{1-\mathcal{P}_b} \alpha E \; + \; \frac{1}{1-\mathcal{P}_b}\left(1 - \frac{\mathcal{P}_b}{(1-z)Y}\right) \Delta C(b)$$

Bankers' optimization problem

Bankers take price $\frac{1}{1-z}$ as given, and chose C_0 and $\Delta C(b)$ to maximize:

$$Y\alpha E \; + \; (Y-1)\underbrace{(\alpha\bar{D} - C_0)}_{\text{Net debt}} \; - \; (1-q)\left(\frac{1}{1-z} - 1\right)\Delta C(b)$$

Subject to the incentive compatibility constraint (binding):

$$\overbrace{(\alpha\bar{D} - C_0)}^{\text{Net debt}} \; = \; \frac{\mathcal{P}_b}{1-\mathcal{P}_b}\alpha E \; + \; \frac{1}{1-\mathcal{P}_b}\left(1 - \frac{\mathcal{P}_b}{(1-z)Y}\right)\Delta C(b)$$