The Macroeconomics of Imperfect Capital Markets

Anton Korinek

University of Maryland

Lecture 13: Financial Innovation

Financial Innovation

1. **Meaning**
   - innovation = creation of new securities (risk-sharing devices) or reduction in cost of trading securities
   - concept only useful under incomplete markets
   - amount of financial innovation over past 3 decades tremendous
2. **Driving Forces**
3. **Welfare Effects**

Financial Innovation

1. **Meaning**
2. **Driving Forces**
    - better risk-sharing
    - speculation
    - tax minimization
    - rent extraction
3. **Welfare Effects**

Financial Innovation

1. **Meaning**
2. **Driving Forces**
3. **Welfare Effects**
   - welfare theorem: financial innovation only raises welfare unambiguously if it restores first-best equilibrium
   - in presence of market imperfections, financial innovation may reduce welfare:
     - under incomplete markets: create pecuniary externalities
     - under belief disagreements: increase speculation
     - under agency problems: increase moral hazard
     - under risk-shifting: increase bailouts
     - ...

Optimal Security Design

Allen and Gale (RFS, 1988): Optimal Security Design

- market structure is endogenous to incentives to create securities
- study optimal design of a firm's securities given costly issuance

Main insights:

- firm should split income stream such that payoffs are allocated to the agents who value them most
- debt and equity not generally optimal
- equilibrium constrained efficient

Model Setup

Structure of Model:

- 2 dates: $t = 0, 1$
- states of nature $s \in S$ with probabilities π_s
- $j \in J$ types of firms (continuum each)
- $i \in I$ types of consumers (continuum each)
- single consumption good

Firms (Producers)

Firms (producers) defined by two elements:

1. Security set:
   - production plan $y_j \in Y_j$ where $y_j = \{y_j(s)\}$ is output in state s
   - financial structure $e \in E_j$ consisting of $k \leq 2$ securities
   - described by dividends $r^k(e) \geq 0$ s.t. $r^1(e) + r^2(e) = y_j$
   - trade in market at value $v^k(e)$
   - total firm market value $MV(e) = \sum_k v^k(e)$
2. Cost function:
   - function $C_j(e)$ captures cost of inputs and security issuance null set satisfies $C(0) = 0$

Firm objective:

$$\max_{e \in E_j} MV(e) - C_j(e)$$

Consumers

Setup of Consumers:

- denote Ω set of all possible consumption bundles
- $x \in \Omega$ can be written $x = \left(x^0, x^1\right)$ where $x^1 = \left\{x^1(s)\right\}$
- Consumer i is characterized by two elements:
- utility function $U_i(x)$
- endowment $w_i \in \Omega$
- budget constraints:

$$\begin{aligned} x^0 &= w_i^0 - \alpha v \\ x^1 &= w_i^1 + \alpha r \end{aligned}$$

  yields consumption as a function of $x = \xi_i(\alpha, v)$
- optimization problem:

$$\max_{e \in E_j} U_i(\xi_i(\alpha, v)) \quad \text{s.t.} \quad \xi_i(\alpha, v) \geq 0$$

Example 1

Example with Debt and Equity:

- two states of nature $s = 1, 2$ with probabilities $\frac{1}{2}$
- one type of firm with production set $Y = \{0, \bar{y}\}$
  where $\bar{y}(1) = 1$ and $\bar{y}(2) = 2$
- issue up to two securities at cost $c_1 + c_2$
- two types of consumers: n is risk-neutral, a is risk-averse
  $\rightarrow U_n = x^0 + E\left[x^1\right]$ and $U_a = x^0 + E\left[V\left(x^1\right)\right]$ with $V' > 0 > V''$
  for example: assume $V(x) = 2\ln(1+x)$
- define marginal utility of type i as $\mu_{is}\left(x^i\right) = p_{is}\left(x^i\right)/\pi_s$

Example 1, Case (a)

Example with Debt and Equity: (a) assume $c_1 = 0$

- all firms operate and issue at least one security
- if c_2 is large, they issue only equity: $r^1(s) = \bar{y}(s) \forall s$
- if both agents hold security then state price $\mu_s = \mu_{ns} = 1$
- value of one-security firm is $\sum_s \pi_s \mu_s \bar{y}(s) = 1.5$
- also: in given example, $\sum_s \pi_s \mu_{as} = 1.057$
  $\rightarrow$ risk-averse consumers would value debt more

$\rightarrow$ if c_2 is small enough, some firms issue equity and debt: in fact, it is optimal to issue maximum debt possible $r^2(s) = 1$

$\rightarrow$ in equilibrium there will be three securities: equity of both types of firms and debt

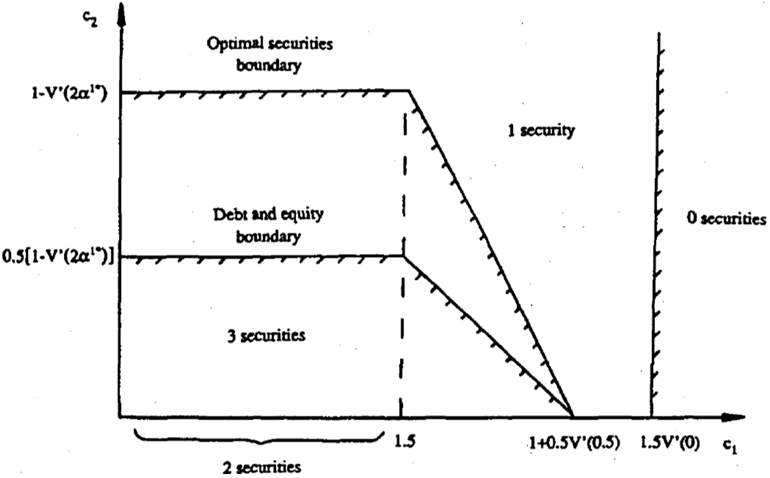
Claim	Payoff $s = 1$	Payoff $s = 2$	Price
r^1	1	1	1.057
r^2	0	1	0.500

Example 1, Case (b)

Example with Debt and Equity, (b) assume $c_1 > 0$:

- firms operate only if $c_1 < 1.5V'(0)$
- as c_1 declines below that level,
  - firms initially issue only equity
  - only risk-averse consumers buy equity since $\mu_{as} > 1$
  - as c_1 falls, more and more firms operate
- once μ_{as} has declined enough, risk-neutral consumers enter
- at $c_1 = 1.5$, all firms invest and are held by risk-neutral consumers

Optimal Security Issuance: Example



Example 2, Case (a)

Example with Unrestricted Securities, (a) assume $c_1 = 0$:

- all firms operate and issue at least one security
- if c_2 is large, they issue only equity: $r^1(s) = \bar{y}(s)\,\forall s$
- but $\mu_{a1} > \mu_{n1} = \mu_{n2} > \mu_{a2}$:
  risk-averse agents value state 1 more/state 2 less
  $\rightarrow$ debt is not an efficient security

$\rightarrow$ it is optimal to create securities that cater to investor types

$\rightarrow$ provide payoffs from each state of nature to investor who values it most

$\rightarrow$ pure contingent claims = very general result

Claim	Payoff $s = 1$	Payoff $s = 2$	Price
r^1	1	0	0.614
r^2	0	2	1.000

Example 2, Case (b)

Example with Unrestricted Securities, (b) assume $c_1 > 0$:

- firms operate only if $c_1 < 1.5V'(0)$
- as c_1 declines below that level,
  - firms initially issue only equity
  - only risk-averse consumers buy equity since $\mu_{as} > 1$
  - as c_1 falls, more and more firms operate
- optimal securities boundary is higher than debt and equity boundary because payoff allocation more efficient

Speculation and Risk-Sharing

Simsek (QJE, 2013): Speculation and Risk-Sharing with New Financial Assets

- If agents have different beliefs, trade for risk-sharing AND speculation
- new financial assets increase speculation
- outcomes involve greater portfolio risks
- macro economy experiences greater volatility

Financial Innovation for Rent Extraction

Korinek (2013): Financial Innovation for Rent Extraction

Motivation: losses during crises magnified by financial innovation:

- Numerous "innovations" to leverage FDIC-bailouts:
  - rise of repos
  - effective seniority through short-term liabilities
  - ...
- "Innovative" types of mortgages
- "Innovations" to circumvent capital adequacy requirements
- Role of CDSs in the demise of AIG
- ...

Motivation

Unprecedented losses have led to unprecedented bailouts

- Social desirability of bailouts hotly debated:
  1. bailouts increase ex-post efficiency
  2. bailouts deteriorate ex-ante incentives (“moral hazard”)

  $\Rightarrow$ trade-off between efficiency and incentive effects

- Financial innovation massively deteriorates the balance between efficiency and incentive effects

Further Motivation

Key Considerations

1. study an economy with bankers and households
2. two types of financial market incompleteness:
   - bankers need net worth to intermediate capital
   - incomplete insurance markets between bankers and households
3. analyze two mechanisms to transfer resources between them:
   - financial innovation
   - bailouts

Key Results

1. financial innovation and bailouts are close substitutes:
   - both improve welfare by extending span of feasible transfers
2. if both are present, however, arbitrage opportunities arise
   $\rightarrow$ *financial innovation for rent extraction*
3. macroeconomic implications:
   - large bank profits in good times, large losses in bad times
   - redistribution from households to bankers
   - increased consumption volatility
   - higher output volatility and negative NPV investments
   - increased risk premia
4. delineate policy lessons

Literature

Contribution to the Literature:

- Literature on bailouts and “moral hazard:”
  e.g. Bagehot (1873), ...
- Literature on financial innovation:
  e.g. Allen and Gale (1989, 1991), Simsek (2011), ...
- Literature on rent extraction by financial sector:
  e.g. Akerlof and Romer (1993), Philippon and Reshef (2009), ...

Benchmark Model

Benchmark model:

- two agents: households and bankers $i \in \{h, b\}$
- two states of nature $s \in \{L, H\}$
- two time periods:
  - period 0: collect endowments
  - period 1: execute allocation systems
    $\rightarrow$ determine wealth w_{is} to be carried into next period
  - period 2: production and consumption
- Probabilities and initial endowments:

	$s = L$	$s = H$
probability	$\pi < \frac{1}{2}$	$1 - \pi$
households e_h	e	e
banker e_b	e_L	e_H

Period 1

- **Collect endowments**
- **Apply different allocation systems:**
    - autarky $\mathcal{A}(\cdot)$
    - Walrasian market $\mathcal{M}(\cdot)$
    - production $\mathcal{P}(\cdot)$
    - uncompensated transfers ("bailouts") $\mathcal{B}(\cdot)$
    - compensated transfer rules $\mathcal{T}(\cdot)$
    - combinations, e.g. $\mathcal{M}(\mathcal{P}(\cdot))$, $\mathcal{B}(\mathcal{M}(\cdot))$, $\mathcal{B}(\mathcal{P}(\cdot))$, ...
    - ...

Period 2

Bankers:

- bankers have exclusive access to intermediation technology
- financial friction in period 2 prevents borrowing/lending
- bankers convert financial wealth into capital $k_s = w_{bs}$
  $\rightarrow$ financial wealth of banks is essential

One-Period Firms (zero profit, owned by bankers):

- Cobb-Douglas production function $F(k, \ell) = Ak^\alpha \ell^{1-\alpha}$
- hire capital and labor at marginal product

Households:

- supply $\ell = 1$ unit of labor at market wage ω
- consume at end of period

$$V_h(w_s) = u(w_{hs} + \omega_s) = u(w_{hs} + (1-\alpha)Ak_s^\alpha)$$
$$V_b(w_s) = u(\alpha A k_s^\alpha)$$

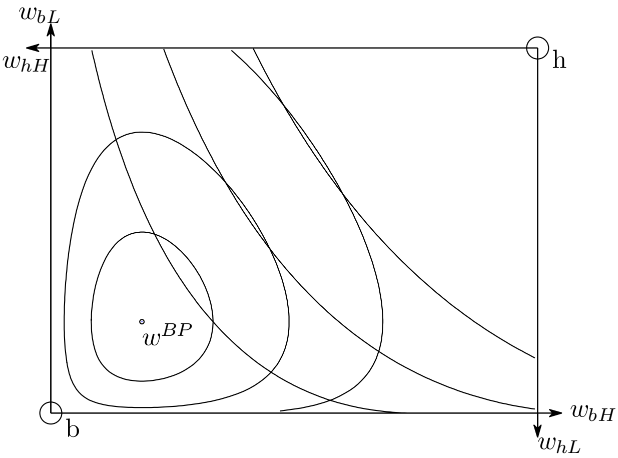
Autarky

Autarky equilibrium:

- Beginning-of-period 2 wealth = endowment
- Banker utility is $U_b^{\mathcal{A}} = E[V_b(w_s)] = E[u(\alpha A e_{bs}^{\alpha})]$
- Household utility $U_h^{\mathcal{A}} = E[V_h(w_s)] = E[u(e_{hs} + (1-\alpha) A e_{bs}^{\alpha})]$

Autarky

Autarky equilibrium in Modified Edgeworth box



Walrasian Market

Introduce Walrasian market to trade across $s = L, H$ in period 1:

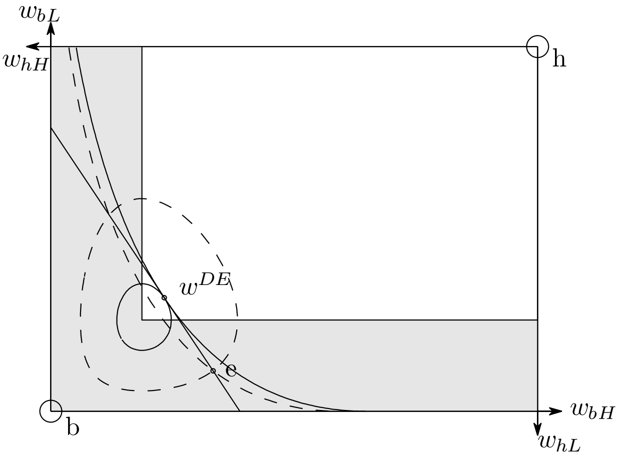
- each agent demands w_{is} state s goods at price p_s (define $p_H = 1$ numeraire)
- optimality conditions of bankers and households imply

$$MRS_b = \frac{V_b'(w_{bH})}{V_b'(w_{bL})} = \frac{1}{p_L} = \frac{V_h'(w_H)}{V_h'(w_L)} = MRS_h$$

- resulting levels of utility $U_b^{\mathcal{M}}$ and $U_h^{\mathcal{M}}$

Walrasian Market

Decentralized Equilibrium: trade $w_{bs}^{\mathcal{M}}$ units



Transfer Allocation

Transfers:

- assume no markets are open in period 1
- observe that $\partial\omega/\partial k > 0$,
  at $k = 0$, $\partial\omega/\partial k = \infty$

Lemma (Pareto-Improving Bailouts)

A planner who maximizes household welfare finds it ex-post optimal to provide transfers to bankers as long as $k < \hat{k}$ which is defined by

$$F_{kl}(\hat{k}, 1) = \alpha(1-\alpha)A\hat{k}^{\alpha-1} = 1$$

Transfer Allocation

Transfers:

- For given w_{bs}, bankers receive a transfer $t_s = \hat{k} - w_{bs}$ up to a maximum $\bar{t} = w_{hs}$

$\rightarrow$ floor to banker utility $V_b(\hat{k})$

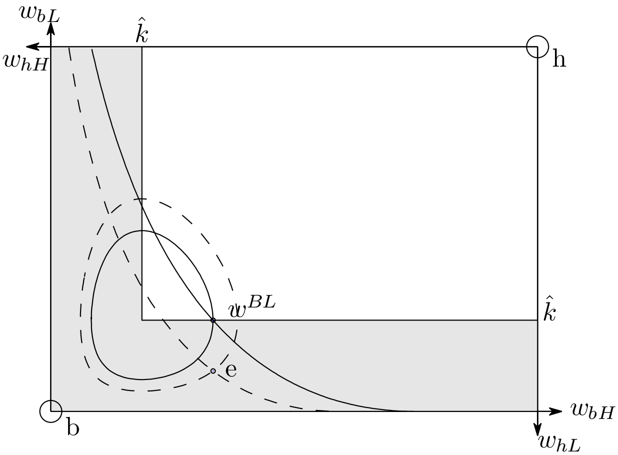
$\rightarrow$ utility of consumers increased
$V_h(w_{hs} - t_s + (1-\alpha)A\hat{k}^\alpha) > V_h(w_{hs})$

Lemma (Pareto-Improving Bailout)

A bailout rule that ensures $k_s \geq \hat{k}$ leads to an ex-post Pareto improvement.

Uncompensated Transfers

Bailout Transfer Rule with $\hat{k}$



Combining Walrasian Market and Transfers

Assume a Walrasian market *followed by* a transfer rule $\hat{k}$
(and assume households cannot commit not to bail out)

Focus on symmetric equilibria

Banker can follow two strategies:

1. **Insurance regime:** trade in the market to optimally insure
2. **Rent extraction regime:** trade to maximize transfers

$\rightarrow$ choose strategy that maximizes utility

Note: insurance regime replicates the DE allocation

Combining Walrasian Market and Transfers

Rent Extraction Regime:

Bankers have incentive to sell claims against state L:

- until the endowment of households is exhausted $(w_{bH}, w_{hH}) = (e + e_H, 0)$
- at the prevailing market price $p_L^{RE} = \frac{V_h'(e+e_L-\hat{k})}{V_h'(0)}$
- and obtain utility $U_b^{RE} = \pi V_b(\hat{k}) + (1-\pi) V_b(e + e_H)$

Proposition (Rent Extraction)

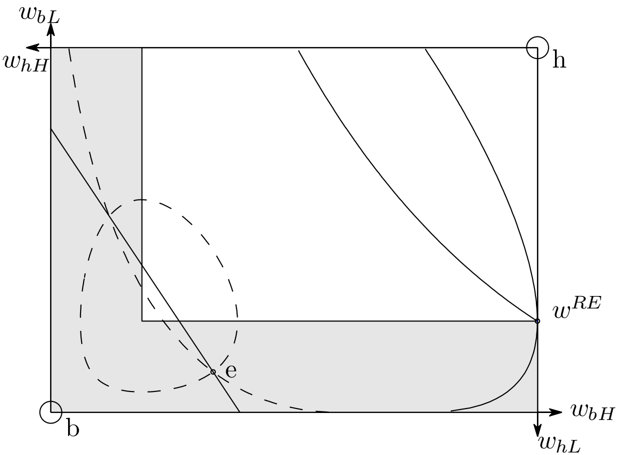
1. Bankers choose the rent extraction regime if $U_b^{RE} > U_b^{DE}$.

2. The rent extraction regime is more likely the lower (i) banker endowment, (ii) the probability π of state L and (iii) the higher the endowment e of households

3. In the rent extraction regime, bankers increase period 2 output volatility and the risk premium p_L.

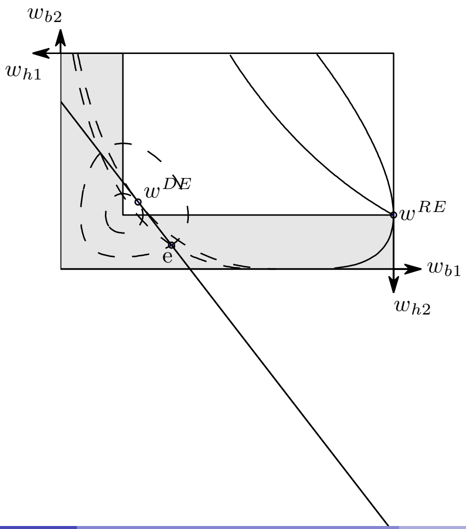
Rent Extraction

Rent Extraction Equilibrium



Rent Extraction

Rent Extraction Equilibrium (zoomed out)



Mixed Strategy Rent Extraction

Note: symmetric equilibrium leaves money on the table

Mixed-Strategy Equilibrium:

Bankers may find it optimal to split into two groups

1. group $\sigma = L$ of mass n_L extracts transfers in state $s = L$
2. group $\sigma = H$ of mass n_H extracts transfers in state $s = H$

In mixed strategy equilibrium,

- rent extraction such that $w_b(L) = (\hat{k}, e + e_L - \hat{k} \cdot n_H/n_L)$ and $w_b(H) = (e + e_H - \hat{k} \cdot n_L/n_H, \hat{k})$ whereas $w_h = (0, 0)$
- masses n_L and n_H are chosen such that $U_{b(L)} = U_{b(H)}$

Proposition (Mixed Strategy Rent Extraction)

In a mixed strategy rent extraction equilibrium bankers bet with each other and with households to extract the maximum possible surplus in all states of nature.

Market Structure and Financial Innovation

Assume bankers can create market between $s = L, H$ at a fixed cost f (see e.g. Allen and Gale, 1988, 1991)

Proposition (Financial Innovation for Rent Extraction)

Bankers are willing to pay a higher fixed cost f to create a market if they do so for rent extraction than if they do so for insurance.

Note: financial innovation directed at creating an arbitrage opportunity

- bailout $\approx$ Arrow-Debreu security at zero (underpriced) cost
- traded securities sell at a positive price

$\rightarrow$ modern financial markets extremely efficient at arbitrage

Market Structure and Financial Innovation

Proposition (Incentives for Beneficial Innovation)

If a market to insure a given state of nature does not exist, bailouts reduce the incentives of bankers to create a market.

Intuition:

- bailouts are substitutes for markets
- less incentive to create a market if substitute already exists

→ bailouts increase incentives for “bad” innovation
→ reduce incentives for “good” innovation

Production Economy

Allow bankers access to production technology:

- concave production possibilities frontier $G(e_{bL}, e_{bH}) = 0$
- only bankers have access to technology
- in optimal allocation, bankers pick (e_{bL}, e_{bH}) s.t.

$$MRT_b = \frac{V_b'(e_{bL})}{V_b'(e_{bH})} = \frac{\pi}{1-\pi}$$

- expected level of profits $U_b^{\mathcal{P}}$ and of household utility $U_h^{\mathcal{P}}$

Combining PPF and Walrasian market:

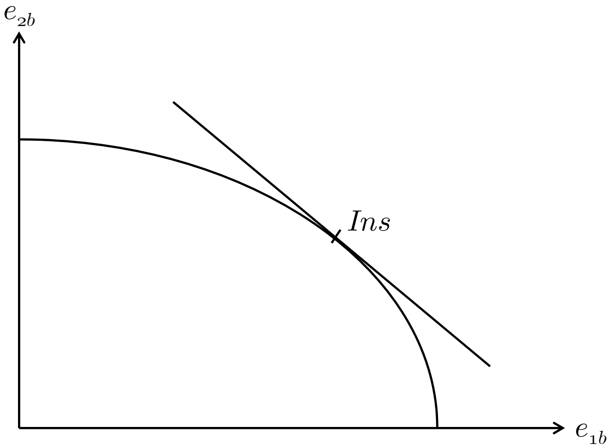
- optimality implies

$$MRT_b = MRS_b = \frac{V_b'(e_{bL})}{V_b'(e_{bH})} = p_L = \frac{V_h'(w_{hL})}{V_h'(w_{hH})} = MRS_h$$

- expected level of profits $U_b^{\mathcal{MP}}$ and of household utility $U_h^{\mathcal{MP}}$

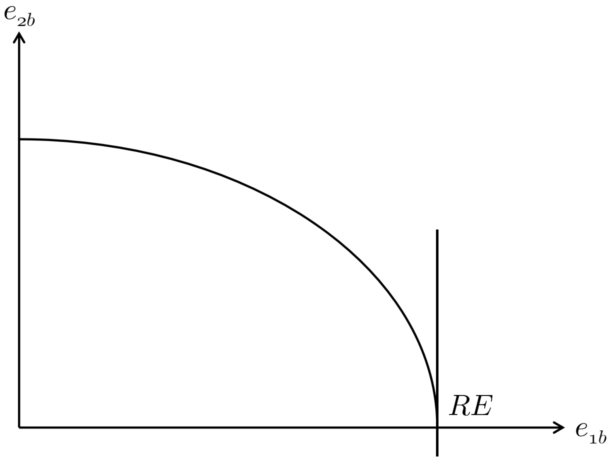
Production Economy

Production Economy – Insurance Regime



Production Economy

Production Economy – Rent Extraction Regime



Rent Extraction with Production

Assume bankers face a concave PPF $F(e_{bL}, e_{bH})$

Proposition (Rent Extraction with Production)

1. In a symmetric rent extraction equilibrium, bankers choose an endowment $e_L = 0$ to maximize e_H.

2. In a mixed-strategy rent extraction equilibrium, bankers reduce aggregate wealth in both states of nature.

$\rightarrow$ massively negative NPV production takes place

Example: housing bubble

Policy Measures against Rent Extraction

Categories:

- Taxes/regulation on state-contingent trades
  $\rightarrow$ very difficult to fine-tune
- Limits on financial innovation
- Limits on bailouts:
  - expropriation: impose losses on owners
    $\rightarrow$ ensures owners do no receive transfer bailout rents in state L
  - limited liability: impose losses on claim holders
    $\rightarrow$ ensures owners cannot shift rents into state H

Taxes/Regulation

Compensated Transfers

Assume the planner provides ex-post Pareto-improving bailouts in state L)
and imposes a compensatory transfer $t_H = -\tau(t_L)$ in state H

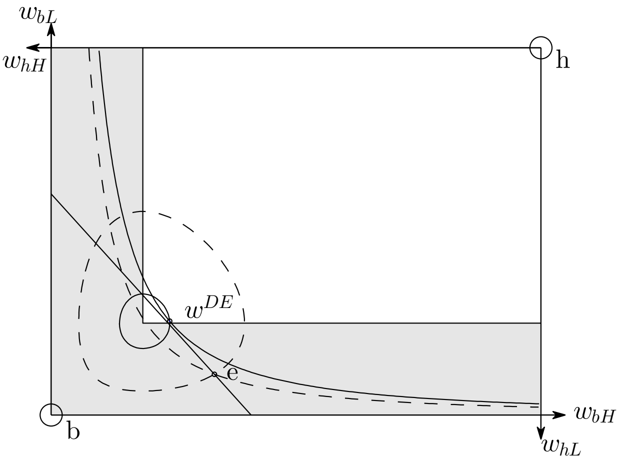
$$\text{where } \tau(0) = 0 \text{ and } \tau'(t_L) \geq 0$$

$\rightarrow$ households receive compensation for transfers

$\rightarrow$ note: $\tau(t_L) = p_L t_L$ replicates decentralized equilibrium

Compensated Transfers

Compensated Transfer Equilibrium



Market Equilibrium Under Compensated Transfers

Rent extraction can be counteracted by charging for expected transfers

$\rightarrow$ find compensation rule $\tau(t_L)$ to restore efficient equilibrium

$\rightarrow$ financial regulation, tax policy, ...

Corollary (Compensated Transfers)

1. If the compensation rule τ is such that $\tau' < p_L^{RE}$, the rent extraction equilibrium will prevail.

2. If the compensation rule τ satisfies $\tau' \geq p_L^{RE}$, the efficient equilibrium can be restored.

Note: $\tau' < p_L^{RE}$ creates an "arbitrage" opportunity

Conclusions

1. Bailouts play a dual role:
   market substitution versus rent extraction
2. Financial innovation shifts the balance of the two
3. Financial innovation is most profitable if directed at rent extraction
4. Rent extraction equilibria:
   - may shift an economy's aggregate surplus to bankers
   - increase volatility and reduce efficiency
   - may lead to massively negative NPV investments
5. Even if regulation makes rent extraction costly, small mispricing may lead to massive rent extraction