Macroeconomics of Financial Markets

ECON 712, Session 1 - Fall 2013

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Week 1


Syllabus and Schedule (subject to change)

- September 17: Financial Frictions and Aggregate Fluctuations.
- September 24: Financial Crises and Bubbles.
- October 1: Financial Crises and Panics.
- October 8: Regulation (Public and Private).
- October 15: Presentations.
Financing Decisions

- A firm can finance its needs by issuing equity, by issuing debt or by using its retained profits.
- Firms face the following financing questions.
  - How much should they borrow?
  - How much retained earning should they use?
  - Does the financial structure affect the cost of financing?
Modigliani Miller - Irrelevant Questions


  "...the market value of the firm - debt plus equity - depends only on the income stream generated by its assets. It follows, in particular, that the value of the firm should not be affected by the share of debt in its financial structure or by what will be done with the returns paid out as dividends or reinvested (profitably)."

- It is irrelevant how the firm finance itself
Modigliani Miller - Irrelevant Questions

- Modigliani-Miller Theorem is composed by three propositions.
  - MM I: The firm’s market value is independent of its capital structure (debt-equity ratio).
  - MM II: The firm’s market value is independent of its dividend policy.
  - MM III: The firm’s weighted average cost of capital (WACC) is independent of its capital structure.

- Firms are indifferent between going to the capital market themselves, issuing bonds or ask for a loan to intermediaries.

- Financial intermediaries do not play any role.
Modigliani-Miller Timing

Borrower and lender write financial contract

Observable shock $S$ determines output

Contract enforced. Payment to B and L contingent on $S$
Definitions

- Assume a firm’s cash flow next period is a random variable $x$.
  - Unlevered firm: Only issue stocks $S_U$
    - Value $V_U = S_U$.
    - Costs of stocks: $r_0 = \frac{E(x)}{\text{Assets}} = \frac{E(x)}{S_U}$
  - Levered firm: Issue stocks $S_L$ and bonds $B_L$
    - Value $V_L = S_L + B_L$.
    - Cost of debt: $r_b$.
    - Repayment of Debt: $R = r_b B_L$
    - Costs of stocks: $r_s = \frac{E(x) - R}{S_L}$.
Modigliani-Miller I

- MMI: Independence of capital structure, \( V_U = V_L \).
- Assume two identical firms with different capital structures and an investor deciding between
  - Buy a fraction \( k \) of stocks in the unlevered firm.
    Gains: \( kE(x) \)  
    Costs: \( kS_U \)
  - Buy a fraction \( k \) of stocks in the levered firm and a fraction \( k \) of bonds.
    Gains: \( k(E(x) - R) + kR \)  
    Costs: \( k(S_L + B_L) \)
- Since gains are the same, costs should be the same, then \( V_U = V_L \).
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- No arbitrage, or the ”law of one price” argument
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- Since gains are the same, costs should be the same, then $V_U = V_L$.
- **No arbitrage, or the ”law of one price” argument**
- **If you cut up a pizza, you have more slices but not more pizza!**
Definitions

- Assume a firm’s cash flow next period is $x$, which can be reinvested to generate a random variable $y$.
  - Firm pays dividends: Value $V_D = S_D$.
  - Firm reinvest profits in best option: Value $V_R = S_R$. 

Modigliani-Miller II

- **MMII:** Independence of dividend policy, $V_D = V_R$.
- Assume two identical firms with different dividend policies and an investor deciding between
  - Buy a fraction $k$ of stocks in the firm that reinvest in the best option.
    - **Gains:** $k[x + E(y) - x]$
    - **Costs:** $kS_R$
  - Buy a fraction $k$ of stocks in the firm that pays dividends and reinvest those dividends in the best option (at a cost $P$).
    - **Gains:** $k[x + E(y) - P]$
    - **Costs:** $kS_D$
  - With competitive markets, $P = x$. Since gains are the same, costs should be the same, then $V_D = V_R$. 

The gains from buying a stock include future profits from the best investment opportunity.

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Macroeconomics of Financial Markets
Modigliani-Miller II

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  - With competitive markets, \( P = x \). Since gains are the same, costs should be the same, then \( V_D = V_R \).
  - **The gains from buying a stock include future profits from the best investment opportunity.**
Modigliani-Miller III

- MMIII: Independence of WACC on capital structure.
- Developing the equation for $r_s$

$$
s = \frac{E(x) - R}{S_L} = \frac{E(x)}{S_L + B_L} \frac{S_L + B_L}{S_L} - \frac{r_b B_L}{S_L} = r_0 + (r_0 - r_b) \frac{B_L}{S_L}
$$
Modigliani-Miller III

- MMIII: Independence of WACC on capital structure.
- Defining

\[
WACC = r_s \frac{S_L}{V_L} + r_b \frac{B_L}{V_L}
\]

- WACC is constant, independent of \( \frac{B_L}{S_L} \)

\[
WACC = \left[ r_0 + (r_0 - r_b) \frac{B_L}{S_L} \right] \frac{S_L}{V_L} + r_b \frac{B_L}{V_L}
\]

\[
= r_0 \frac{S_L}{V_L} + r_0 \frac{B_L}{V_L}
\]

\[
= r_0
\]
Modigliani-Miller III

Cost of Capital

Debt/Equity
Modigliani-Miller - Main Assumptions

- Implicit Assumptions
  - No transaction costs (In the US, for firms it is easier to borrow).
  - No differential taxation of debt and equity. (In the US, for individuals taxes on equity (dividends) are higher than taxes on debt (interests)).
  - No bankruptcy costs (this affects risky debt).
  - No Moral hazard: Managers maximize the value of the firm.
  - No Adverse selection: Information is symmetric.
Modigliani-Miller - Main Assumptions

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- Then, the study of financial intermediaries should deal with these frictions.
Why Do Financial Intermediaries Exist?

- Households with savings can lend to nonfinancial firms directly in stock or bond markets.
- Still the direct contact between households and firms are dominated by intermediaries (securities are traded via intermediaries).
- An organizational structure (bank) should then beat the market in some respect!
Modigliani-Miller

Borrower and lender write financial contract.

Observable shock $S$ determines output.

Contract enforced. Payment to B and L contingent on $S$. 
Liquidity Provision

Borrower and lender write financial contract

Observable shock $S$ determines output

Contract enforced. Payment to B and L contingent on $S$

Liquidity shock to L and/or E.
Incomplete Contracts and Commitment

Borrower and lender write financial contract

Observable shock $S$ determines output

Contract enforced. Payment to B and L contingent on $S$

Incomplete contracts

Liquidity shock to L and/or E.

Limited contract enforcement
Costly State Verification

Borrower and lender write financial contract

Observable shock S determines output

Contract enforced. Payment to B and L contingent on S

Incomplete contracts

Liquidity shock to L and/or E.

Unobservable shock and Costly state verification

Limited contract enforcement
Information Asymmetries

Borrower and lender write financial contract

Incomplete contracts

Adverse Selection: Asymmetric Information about the quality of the project

Observable shock S determines output

Liquidity shock to L and/or E.

Moral Hazard: B may take hidden actions

Contract enforced. Payment to B and L contingent on S

Unobservable shock and Costly state verification

Limited contract enforcement

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Macroeconomics of Financial Markets
Macro Implications

- **External Finance Premium.**
  - Wedge between internal returns to project and external pledgable returns. Positive NPV projects are not financed.

- **Credit Constraints.**
  - Not all NPV projects are financed.
  - Projects may not be financed up to efficient scale.
  - Credit rationing.
Open Questions

- How important are these frictions?
- Which friction is more important?
- Are frictions relevant for economic development and fluctuations?
- Is there something governments can do to mitigate the macro effects of financial frictions?
Why Do Financial Intermediaries Exist?

- Liquidity Provision.
- Delegation of Information and Monitoring Processing.
  - Incompleteness.
  - Limited Enforcement.
- Commitment Mechanism.
  - Moral Hazard.
  - Adverse Selection.
What is liquidity?

- Option to turn your investment into cash right now if you need.
What is liquidity?

- Option to turn your investment into cash right now if you need.
- Condition: The price at which you can turn the asset into cash is known in advance and does not vary much with how many other people are trying to do the same at the same time.
Main ideas

- Banks transform illiquid assets into liquid liabilities.
- Banks can improve on a competitive market by providing better risk sharing among people with different liquidity needs.
- Key: Asymmetric information about those needs.
- Bank runs: Undesirable equilibrium with real economic consequences (termination of productive investments).
- Contracts that may prevent bank runs:
  - Suspension of convertibility.
  - Deposit insurance (works even with aggregate uncertainty).
  - Lender of last resort.
Model

- Single homogeneous good. Endowments and technology

<table>
<thead>
<tr>
<th>T=0</th>
<th>T=1</th>
<th>T=2</th>
</tr>
</thead>
<tbody>
<tr>
<td>−1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>−1</td>
<td>0</td>
<td>$R &gt; 1$</td>
</tr>
</tbody>
</table>

- The agent may want to consume at $T = 1$ or $T = 2$, not both.

- $Pr(type \ T = 1) = t$ at $T = 0$.

- Assumptions
  - The type is unknown at $T = 0$ (idiosyncratic risk).
  - At $T = 1$ the agent privately observes his type (uninsurable risk).
  - $t$ is known (NO aggregate risk).
**Competitive markets**

- $U(c_1, c_2; \Theta) = t\ln(c_1) + (1 - t)\rho \ln(c_2)$ where $1 \geq \rho > \frac{1}{R}$

  (discounting does not overturn the gains from technology maturity)

- Economy-wide resource constraint for unit mass of agents:

  $$1 = tc_1 + (1 - t)\frac{c_2}{R}$$

- In competitive markets, the solution is autarky:

  $c_1^1 = 1$, $c_2^1 = 0$ and $c_1^2 = 0$, $c_2^2 = R$

- No insurance. No agent would report to be late consumer.
Social optimum

- The society can do it better if there is an insurance mechanism.
- The planner maximizes $U(c_1, c_2; \Theta)$ s.t. resource constraint.
- After some boring algebra

$$
c_1^* = \frac{1}{t + (1 - t)\rho} > 1
$$

$$
c_2^* = \frac{R}{(1 - t) + \frac{t}{\rho}} < R
$$

Since $\rho R > 1$ and defining $r_1 = c_1^*$ and $r_2 = c_2^*$

$$
R > r_2 > r_1 > 1
$$
Social optimum

- Benefit of liquidity: Turn the agent's wealth into readily-spendable in the event the agent discovers he or she needs it.
Decentralization with Banks

- Competitive "bank" liquidity providers intermediaries that set the following interest rates:

\[ r_1 = c_{1}^{*} = \frac{1}{t + (1 - t)\rho} > 1 \]

\[ r_2 = \rho R r_1 > r_1 \]
Sequential Withdrawing

- Assume a sequential withdrawal rule:

\[
V_1(f_j, r_1) = \begin{cases} 
  r_1 & \text{if } f_j < \frac{1}{r_1} \\
  0 & \text{if } f_j \geq \frac{1}{r_1}
\end{cases}
\]

\[
V_2(f, r_1) = \begin{cases} 
  \frac{(1-r_1 f)R}{(1-f)} & \text{if } f < \frac{1}{r_1} \\
  0 & \text{if } f \geq \frac{1}{r_1}
\end{cases}
\]

- The optimal situation is feasible and an equilibrium
  - If \( f = t \) and \( r_1 = c_1^1 \), then \( tr_1 < 1 \) (feasible)
  - If \( f = t \), \( V_2(t, c_1^1) = c_2^2 > c_1^1 \) (types 2 withdraw at \( T = 2 \))
Multiple Equilibria

- Sequential withdrawing induces multiple equilibria.
- Problem for two type two marginal depositors, A and B.
- Two equilibria
  - Good Equilibrium: Social optimum. better than autarky.
  - Bad Equilibrium: Bank run. worse than autarky.

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Multiple Equilibria

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<td>( \frac{r_1}{2}, \frac{r_1}{2} )</td>
<td>( r_1, 0 )</td>
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<td>Withdraw in 2</td>
<td>( 0, r_1 )</td>
<td>( r_2, r_2 )</td>
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Suspension of convertibility

- Eliminates bank runs **ONLY when** \( t \) **is known**.
- It eliminates incentives to type 2 agents to withdraw at \( T = 1 \)

\[
V_1(f_j, r_1) = \begin{cases} 
    r_1 & \text{if } f_j < \hat{f} \\
    0 & \text{if } f_j \geq \hat{f}
\end{cases}
\]

\[
V_2(f, r_1) = \begin{cases} 
    \frac{(1-r_1f)R}{(1-f)} & \text{if } f < \hat{f} \\
    \frac{(1-r_1\hat{f})R}{(1-\hat{f})} & \text{if } f \geq \hat{f}
\end{cases}
\]

such that \( \hat{f} \in \left[ t, \frac{R-r_1}{r_1(R-1)} \right] \)

- Optimal risk sharing is a unique NE in dominant strategies.
Suspension of convertibility

- **When** *t* **is unknown** (for example, following a stochastic process), the unconstrained optimum is not achievable.

- With sequential withdrawing, there is a distortion of the consumption of type 2 agents that comes from market clearing.

- Even when first best is not achievable, the result is better than without suspension.
Deposit Insurance

- This works even when \( t \) is unknown.
- Key: The government should tax ending \( T = 1 \), after observing \( f \).
- Then, if withdrawn at \( T = 1 \) is \( f \), set taxes such that the people who withdrew get \( c_1(f) \).

\[
\hat{V}_1(f) = \begin{cases} 
  c_1(f) & \text{if } f \leq \bar{t} \\
  1 & \text{if } f > \bar{t}
\end{cases}
\]

- Implemented by the following proportional taxes

\[
\tau(f) = \begin{cases} 
  1 - \frac{c_1(f)}{r_1} & \text{if } f \leq \bar{t} \\
  1 - \frac{1}{r_1} & \text{if } f > \bar{t}
\end{cases}
\]
Deposit Insurance

- Taxes are plowed back into banks, to pay withdrawals at $T = 2$. Then

$$\hat{V}_2(f) = \begin{cases} 
  c_2^2(f) = \frac{(1-c_1^1(f)f)R}{(1-f)} > c_1^1(f) & \text{if } f \leq \bar{t} \\
  \frac{(1-f)R}{(1-f)} = R > 1 & \text{if } f > \bar{t}
\end{cases}$$

- Then unique dominant strategy equilibrium is $f = t$ (the realization of $t$), which delivers the unconstrained social optimum.
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- Many other tax schedules make it!!!
Deposit Insurance

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- Only a government can make the credible promise of providing insurance. In equilibrium the promise need not be fulfilled.

- Same result with lender of last result.
Deposit Insurance

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- **CHICKEN MODEL!!!**
Final remarks - Decentralization by firms!

- Assume a firm can commit to pay dividends

\[ D_1 = tr_1 \quad \text{and} \quad D_2 = R(1 - tr_1) \]

- Assume consumers can trade these dividends.

- The firm can implement the first best!!! without bank runs!!!
Final remarks - Not an aggregate story!

- Financial crises occur when depositors at many or all of the banks in a region or country attempt to withdraw their funds simultaneously.
- However this is not a story of contagion!
Final remarks - What fuels bank runs?

- Bank runs are self-fulfilling in nature.
- Are they random events or natural results of business cycles?
- Calomiris and Gorton (91) and Lindgren et al. (96) found there is no support for the "sunspots" view of bank runs.
- They also found evidence deposit insurance and lender of last resort are in fact effective in avoiding bank runs.
- Support for the application of Global Games
Final remarks - What fuels bank runs?

<table>
<thead>
<tr>
<th>NBER Cycle Peak-Trough</th>
<th>Panic Date</th>
<th>Percentage Δ (Currency/Deposit)</th>
<th>Percentage Δ Pig Iron</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct. 1873-Mar. 1879</td>
<td>Sep. 1873</td>
<td>14.53</td>
<td>-51.0</td>
</tr>
<tr>
<td>Mar. 1882-May 1885</td>
<td>Jun. 1884</td>
<td>8.80</td>
<td>-14.0</td>
</tr>
<tr>
<td>Mar. 1887-Apr. 1888</td>
<td>No panic</td>
<td>3.00</td>
<td>-9.0</td>
</tr>
<tr>
<td>Jul. 1890-May 1891</td>
<td>Nov. 1890</td>
<td>9.00</td>
<td>-34.0</td>
</tr>
<tr>
<td>Jan. 1893-Jun. 1894</td>
<td>May 1893</td>
<td>16.00</td>
<td>-29.0</td>
</tr>
<tr>
<td>Jun. 1899-Dec. 1900</td>
<td>No panic</td>
<td>2.78</td>
<td>-6.7</td>
</tr>
<tr>
<td>Sep. 1902-Aug. 1904</td>
<td>No panic</td>
<td>-4.13</td>
<td>-8.7</td>
</tr>
<tr>
<td>May 1907-Jun. 1908</td>
<td>Oct. 1907</td>
<td>11.45</td>
<td>-46.5</td>
</tr>
<tr>
<td>Jan. 1910-Jan. 1912</td>
<td>No panic</td>
<td>-2.64</td>
<td>-21.7</td>
</tr>
</tbody>
</table>
Final remarks - Moral Hazard!

- In the presence of portfolio choices, both deposit insurance and bailouts may introduce distortions through moral hazard.
- Question: Is there a combination of tools that prevents bank runs and maintains potential punishments to bank managers?
Final remarks - Extensions

- This paper has been extended to:
  - Currency crises
  - Liquidity needs by firms
  - Design of bailouts and bankruptcy laws.
Final remarks - Some questions

- Why do people deposit in the first place?
  - In fact, they only deposit if the "bank run" probability is low.

- Why does an intermediary appear in the first place?
  - A monopolist could profit while achieving the first best.
Final remarks - Some (killing) questions

- How about not having sequential withdrawing?
  - Not robust to mechanism design.

- How about issuing equity to decentralize?
  - Optimum without banks...and without bank runs.

- What if ex post trading is allowed?
  - NO EQUILIBRIUM.
Final remarks - Criticisms

- **Bank runs**: Artifact of sequential withdrawing.
- Green and Lin (00): Bank runs are not robust to a mechanism design approach.
Final remarks - Criticisms

- Decentralizing without banks implements the first best without runs!
  Condition: Segmented markets.
  - Assume a firm can commit to pay the following dividends
    \[
    D_1 = tr_1 = tc_1^* \quad \text{and} \quad D_2 = R(1 - tr_1) = (1 - t)c_2^*
    \]
  - Note the firm promises the Arrow state price of early consumption \((tc_1^*)\) and of late consumption \(((1 - t)c_2^*)\).
  - Assume consumers can trade these dividends in period 1 (only among participants, or segmented markets). At which price?
Final remarks - Criticisms

At the Arrow prices after uncertainty has been resolved.

\[ P = \frac{c_1^*}{c_2^*} = \frac{\text{Supply from late in } t=1}{\text{Supply from early in } t=2} = \frac{(1 - t)D_1}{tD_2} = \frac{(1 - t)r_1}{R(1 - tr_1)} \]

This is feasible and implements first best,

- Early consumers consume
  \[ tr_1 + \frac{(1 - t)tr_1}{t} = r_1 = c_1^* \]

- Late consumers consume
  \[ R(1 - tr_1) + \frac{tR(1 - tr_1)}{(1 - t)} = R(1 - tr_1) = r_2 = c_2^* \]
Final remarks - Extensions and Critics

- Jacklin critique (87): In fact, the whole justification of banks is just an artifact of trading restrictions and no secondary markets!

- Assume a single individual does not deposit in the bank (or does not buy dividends in the firm above).
  - If late consumer: Hold the asset and consume,
    \[ R > c_2^* \]
  - If early consumer: Buy the asset at a price \( P \).
    \[ RP = R \frac{(1-t)r_1}{R(1-tr_1)} > r_1 = c_1^* \]
  - If trade at \( t=1 \) is feasible there are incentives to not participate!
In next lectures

- Sequential withdrawing may introduce bankers’ discipline. (Diamond and Rajan).
- Banks whole point is to hide information, exactly to prevent ex-post trading (Dang, Gorton, Holmstrom and Ordonez).
- Bank runs are coordinated by movements in fundamentals, possible explaining why they hit many banks. (Morris and Shin).

- But first...what if firms suffer liquidity shocks?
Preview

- Here firms demand liquidity (advance financing), not consumers.
- Moral hazard: firms should induce managers to work by paying them a share. Since lenders cannot claim the total value of the firm, there are problems of liquidity demand.
- Since firms can sell to outsiders only a fraction of their expected returns, there are problems of liquidity supply.
- Four ways a firm can satisfy its liquidity needs.
  - Issuing claims on its own productive assets.
  - Holding claims on other firms.
  - Holding government-issued claims.
  - Using a credit line.
Preview

- **NO aggregate uncertainty**: Financial intermediaries achieve efficiency and the private sector is self-sufficient to finance its needs.

- **Aggregate uncertainty**: The government should issue securities to achieve efficiency since the private sector is not self-sufficient to finance its needs. Inter-temporal insurance by state contingent bonds.
Moral hazard leads to underinvestment

- Before going to H&T, let me show the effects of Moral Hazard.
  - Entrepreneur (E) and lender (L) are risk neutral.
  - E has no wealth, L is deep pocket.
  - E are scarce (they have all the bargaining power).
  - E has a project that costs \( I \) and pays \( RI \) with probability \( p \) and 0 otherwise.
  - \( p \in \{p_L, p_H\} \) depending on E’s unobservable efforts.
  - Assume \( p_H RI \geq I \geq (p_L R + B)I \). E should work!!!
  - Contract specifies: Loan and Investment (\( I \)) and repayment (\( P \)).
Moral hazard leads to underinvestment

- $E$ maximizes $E(\pi) = p_H(RI - P)$ subject to,
  
  IC: $p_H(RI - P) \geq p_L(RI - P) + BI$
  
  PC: $p_H P \geq I$

- IC binds: Given $I$, for the manager to work, the payment to $L$ cannot be higher than
  
  $$P \leq \left[ R - \frac{B}{p_H - p_L} \right] I$$
Moral hazard leads to underinvestment

- Since the maximum pledgable return that guarantees no cheating is
\[
p_H \left[ R - \frac{B}{p_H - p_L} \right] I,\]
lenders lend only if the following condition is fulfilled
\[
p_H \left[ R - \frac{B}{p_H - p_L} \right] \geq 1
\]

- A project can be financed if
\[
R > \hat{R} = \frac{1}{p_H} + \frac{p_H}{p_H - p_L} B
\]

- A project should be financed (positive NPV) if
\[
R > R^* = \frac{1}{p_H}
\]
Moral hazard leads to underinvestment

- There is a range of projects with returns $R \in [R^*, \hat{R})$ that would be optimal to finance, but are not. This is because moral hazard creates a wedge that translates into underinvestment.

- What creates firms’ demand for liquidity is the combination between the uncertainty about future cash needs and moral hazard.
Question

- To what extent do financial contracts and intermediaries provide adequate amount of cash?
Model

- **Date 0**: E has endowment $A > 0$ and all the bargaining power. E needs funds to invest $I$ in the project. L has deep pockets.

- **Date 1**: $E$ needs to reinvest $\rho I$ to continue. $\rho$ is uncertain at $T = 0$ and known at $T = 1$ by everyone.

- **Date 2**: Moral hazard and outcome.
Model

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- **Date 2**: Moral hazard and outcome.

Difference with DD(83): No private information, but private actions.
First Best

- Reinvest only if $\rho < \rho_1 \equiv p_H R$

- Assumption

$$\int \max [p_H R - \rho, 0] f(\rho) d\rho - 1 > 0 > \int \max [p_L R + B - \rho, 0] f(\rho) d\rho - 1$$

- The contract needs to implement high efforts. E should work!!!
Contract

- **Contract** = \( \{ I, \lambda(\rho), R_E(\rho) \} \), where
  - \( I \) is the initial investment (sunk cost at \( T = 1 \)).
  - \( \lambda(\rho) \) is the prob. of continuation contingent on \( \rho \).
  - \( R_E(\rho) \) is what \( E \) keeps in case of success. (\( R - R_E(\rho) \) goes to \( L \))
Optimal Contract

- E solves
  \[ \max U_E = l \int p_H R_E(\rho) \lambda(\rho) f(\rho) d\rho - A \]
  subject to
  IC: \( p_H R_E(\rho) \geq p_L R_E(\rho) + B, \) for all \( \rho \)
  PC: \( l \int \{ p_H [R - R_E(\rho)] - \rho \} \lambda(\rho) f(\rho) d\rho \geq l - A \)

- This problem is linear in \( l \). E wants to have the highest possible \( l \)
Solution

- IC is binding, $\Rightarrow R_E(\rho) = \frac{B}{p_H - p_L}$

- This gives us the date 1 pledgeable unit return from investment,

$$\rho_0 \equiv p_H \left( R - \frac{B}{p_H - p_L} \right) < \rho_1$$
Solution

- Minimize the money investors have to contribute to continue. This is a cutoff rule.

\[
\lambda(\rho) = \begin{cases} 
1 & \text{if } \rho \leq \hat{\rho} \\
0 & \text{if } \rho > \hat{\rho}
\end{cases}
\]

- Hence, the binding PC can be rewritten as (recall \( \rho_1 = p_H R \))

\[
l \int_0^{\hat{\rho}} p_H R_E(\rho)f(\rho)d\rho - A = \left[ \int_0^{\hat{\rho}} [\rho_1 - \rho]f(\rho)d\rho - 1 \right] l
\]
Solution

- Replacing the IC in the maximization problem

\[
\max U_E(\hat{\rho}) = m(\hat{\rho})I
\]

where

\[
m(\hat{\rho}) = \int_{0}^{\hat{\rho}} [\rho_1 - \rho] f(\rho) d\rho - 1
\]

- \(m(\hat{\rho})\) is the marginal net social return on investment.
Solution

- From the PC (recall $\rho_0 = p_H[R - R_E(\rho)]$)

$$I \left[ \int_0^{\hat{\rho}} (\rho_0 - \rho)f(\rho)d\rho \right] = I - A \Rightarrow I = k(\hat{\rho})A$$

where

$$k(\hat{\rho}) = \frac{1}{1 - F(\hat{\rho})\rho_0 + \int_0^{\hat{\rho}} \rho f(\rho)d\rho}$$

- $k(\hat{\rho})$ is the equity multiplier.

- Hence, the firm maximizes $U_E(\hat{\rho}) = k(\hat{\rho})m(\hat{\rho})A$
Solution

- We assumed
  \[\int_0^{\rho_1} (\rho_1 - \rho) f(\rho) d\rho > 1\]

- Now assume self finance is ruled out,
  \[\int_0^{\rho_0} (\rho_0 - \rho) f(\rho) d\rho < 1\]

which is consistent with a positive wedge \((\rho_1 - \rho_0) > 0\).
Solution

- The firm maximizes $U_E(\hat{\rho}) = k(\hat{\rho})m(\hat{\rho})A$

- Which is the same, the firm chooses $\rho^*$ to minimize

$$1 + \int_0^{\hat{\rho}} \frac{\rho f(\rho) d\rho}{F(\hat{\rho})}$$

the expected unit cost of total expected investment.

- Hence $\rho^*$ satisfies

$$\int_0^{\rho^*} F(\rho) d\rho = 1$$

and

$$U_E(\rho^*) = \frac{\rho_1 - \rho^*}{\rho^* - \rho_0} A$$
Solution

Refinance  \( \rho_0 \)  Moral Hazard severe enough. Refinancing NOT feasible  \( \rho^* \)  NOT optimal to continue  \( \rho_1 \)
Implementation of second best

- Investors do not want to inject more cash into the project if $\rho > \rho_0$.
- Possible solutions to implement $\rho^*$
  - **Irrevocable line of credit.** Give $I - A$ at $T = 0$ and a line of credit up to $\rho^* I$.
  - **Cash account.** Give $(1 + \rho^*) I$ at $T = 0$ with the covenant of keeping $\rho^* I$ in reserve for reinvestment. (equivalent to a liquidity ratio $\frac{\rho^*}{1 + \rho^*}$).
- What if storage is not feasible? We need to replicate cash by financial contracts. This is, entrepreneurs hold financial claims against each other.
A Financial Market for Individual Claims

- Continuum of ex-ante identical E.
- $\rho_i$ are i.i.d. across $i$. NO aggregate uncertainty.
- L are deep pockets. They cannot sell claims on future endowments. Only claims on firms can be made (backed up by marketable assets).
- Claim: $P$ at $T = 0 \Rightarrow (R - R_E)$ at $T = 2$ if success (share in the firm).
- Can the firm cover a potential shortfall by buying, at date 0, claims issued by other firms and selling these claims at date 1, when liquidity is needed?
A Financial Market for Individual Claims

- Not in general.
  - Lucky firms hold shares they do not need.
  - Unlucky firms cannot continue because the average share of the market portfolio offers insufficient liquidity.
- When the market fails, the second best can be implemented by an intermediary that pool liquidity needs (a mutual fund, for example)
Intermediation

- A conglomerate of firms (mutual fund) generate enough liquidity to implement the second best. Recall, from investors PC

\[
I \left[ F(\rho^*)\rho_0 - \int_0^{\rho^*} \rho f(\rho) d\rho \right] = I - A > 0
\]
Intermediation

- At $T = 0$ the intermediary signs a contract with investors on scale:
  - Overall operation $I^*$ at $T = 0$
  - Total transfer at $T = 1$, $I^* \int_0^{\rho^*} \rho f(\rho) d\rho$
  - Total repayment at $T = 2$ to make outsiders break even

- At $T = 0$ the intermediary signs a contract with each entrepreneur, that specifies:
  - Investment $I$.
  - Continuation policy $\lambda(\rho)$
  - Payoff policy $R_E(\rho)$

  and guarantees a credit line for $T = 1$ up to $\rho^*$
Aggregate Uncertainty

- Assume shocks are not iid, but perfectly correlated (all firms have the same $\rho$).
- No role for pooling.
- We go back to the original situation.
Role for the government?

- Governments should issue bonds at $T = 0$ and force $E$ to hold them.
- Bonds proceeds to investments.
- $E$ sell and/or redeem bonds.
- Government taxes $L$’s to finance repayment.
- **Government uses its taxation power to create storage opportunities**
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- **CHICKEN MODEL!!!**