Lecture 1: Heterogeneity, the Net Worth Channel, and the Financial Accelerator

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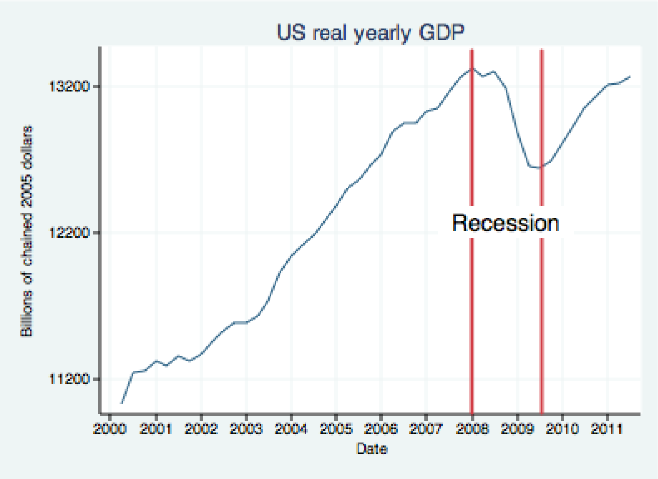
Roadmap

Mini-course logistics

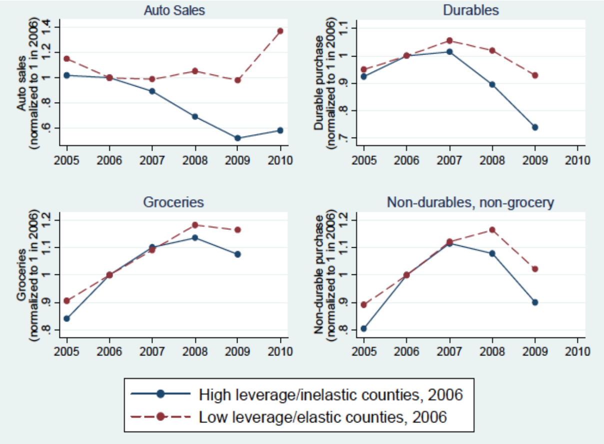
- **Instructor:** Alp Simsek.
- **Readings:** In the syllabus.
- **Textbooks:** None required but Tirole's "The Theory of Corporate Finance" is a useful reference.
- Course is accelerated: 9 lectures in 3 days!

Motivation for the course: The recent recession



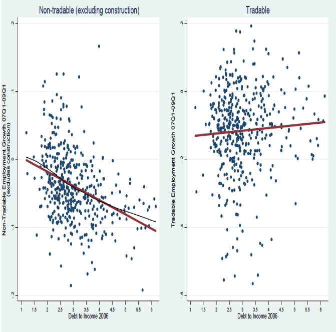
Evidence suggests financial frictions

- Mian, A., K. Rao, and A. Sufi (2011), "Household balance sheets, consumption, and the economic slump."



Evidence suggests demand-side effects

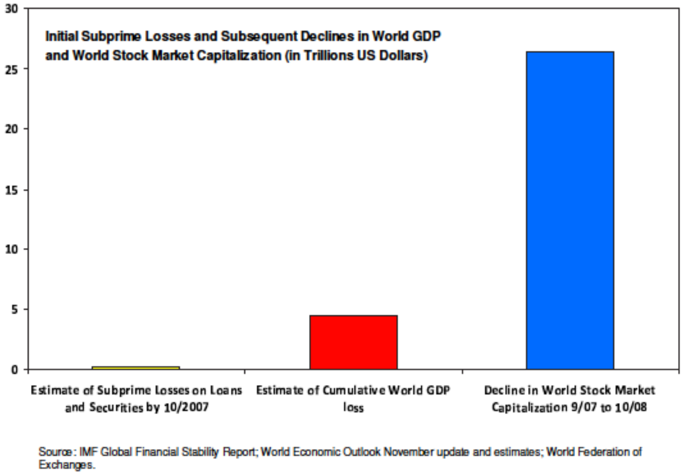
- Mian A. and A. Sufi (2011), "What explains high unemployment? The aggregate demand channel."



- Cross-county effects show up in non-tradable industries (restaurants, department stores etc.) but not in tradable industries (manufacturing, software etc.).

Evidence suggests amplification

- Blanchard, O. (2009), "The crisis: Basic mechanisms and appropriate policies."



The roadmap

1. Borrowing constraints and investment (3 lectures)
   - Limited pledgeability, dynamics, financial accelerator, precautionary savings, underinsurance, crises.
2. Financial crises and amplification mechanisms (3 lectures)
   - Leverage, fire sales, bank runs.
3. Borrowing constraints and recessions (3 lectures)
   - Consumption, demand channel, nominal rigidities, liquidity trap.

Roadmap

Consider the neoclassical investment theory (q theory)

- Economy with periods, $t \in \{0, .., \infty\}$, single consumption good, and one factor of production (capital).
- State $s_t \in S = \{s^1, .., s^n\}$ follows a Markov chain.
- Consider a firm with technology $y_t = s_t f(k_t)$.
  - k_t is installed capital and s_t captures productivity.
  - $f(\cdot)$ is a neoclassical function with standard properties.
- **Adjustment costs:** Investing $i_t = \iota_t k_t$ costs the firm $i_t \left(1 + \frac{1}{2}\phi \iota_t\right)$. (CRS)
- **Asset pricing:** Stochastic discount factor $m_{t,t+1} = m(s_t, s_{t+1})$.
  - For simplicity assume $m(s_t, s_{t+1}) = \beta$.
  - Everything generalizes as long as firm takes $m(\cdot)$ as given.

Firm's net profits in a period might be negative

- The firm's net profit in a period is given by:

$$\pi_t = \underbrace{R_t k_t}_{\text{revenues}} - \underbrace{\iota_t k_t \left(1 + \frac{1}{2}\phi \iota_t\right)}_{\text{investment costs}}$$

- Firm chooses investment policy to maximize:

$$\begin{aligned} V(k_0, s_0) &= \max_{\{\iota_t, k_{t+1}\}_{t=0}^{\infty}} E\left[\sum_{t=0}^{\infty} \beta^t \pi_t \mid s_0\right], \qquad (1) \\ \text{s.t. } k_{t+1} &= (1-\delta) k_t + \iota_t k_t \text{ for each } t, s_t. \end{aligned}$$

- **Any positive NPV investment is undertaken (by definition).**

Firm's problem in recursive form

Firm's problem is recursive. Bellman:

$$V(k,s) = \max_{\iota,k'} Rk - \iota k\left(1+\frac{1}{2}\phi\iota\right) + E\left[\beta V\left(k',s'\right) \mid s\right]$$
$$\text{s.t. } k' = (1-\delta)k + \iota k.$$

- Define $q^m(k,s)$ as the marginal value of new capital (the Lagrange multiplier on the constraint).
- This is known as **Tobin's (marginal) q**.
- What is the economic interpretation of q^m?

Investment is increasing in marginal q

- FOC for ι gives:

$$1 + \phi\iota = q^m (k, s) .$$

- After rewriting, we have:

$$\iota (k, s) = \frac{i (k, s)}{k} = \frac{q^m (k, s) - 1}{\phi} . \tag{2}$$

Marginal q is a sufficient statistic for investment (controlling for k and adjustment costs).

- Future profits, discount rates etc are all summarized in marginal q.
- Problem: Marginal q is not observable....

Under some conditions, marginal q equals average q

- Define the average q as the ex-dividend value of installed capital:

$$q(k,s) = \frac{E\left[\beta V(k',s') \mid s\right]}{k'}. \quad (3)$$

- Note problem (1) is linear, i.e., $v(k,s) = v(s)\,k$ for some $v(\cdot)$.
- Using this observation and taking the FOC for k', we then obtain:

$$q^m(k,s) = E\left[\beta v(s') \mid s\right] = q(k,s).$$

Intuition: CRS implies new capital is equally valuable as installed capital (See Hayashi, 1982). Useful starting point.

Summary: q is a sufficient statistic for investment

- Bringing back Eq. (2), we have:

$$\frac{i(k,s)}{k} = \frac{q(k,s)-1}{\phi}.$$

Average q is a sufficient statistic for investment.

- **Implication:** Eq. (2) now becomes **testable.** How?

Alternative to q theory: Cash flows might matter

Towards developing an alternative against which to test q theory, suppose the firm chooses to finance-as-you-go (no asset accumulation).

- If $\pi_t > 0$, firm pumps out cash in period t (dividends etc.).
- If $\pi_t < 0$, firm borrows in period t (issues claims, takes loan etc.).

Alternative to q theory: Cash flows might matter

- Now suppose the firm faces an additional **borrowing constraint**:

$$\pi_t \geq 0 \text{ for each } t \text{ and } s_t.$$

To highlight the differences with q theory:

- Suppose shocks are iid so that $q^m = \beta E[v(s') \mid s]$ independent of s.
- Consider a state with low current cash flows, $s \simeq 0$.
- What happens to investment in the frictionless benchmark?
- What happens in the alternative with borrowing constraints?

First pass: horse race between q and cash flows

Collecting the observations, we have:

- **Frictionless: Average q is a sufficient statistic for investment.**
- **Alternative: Current cash flows also matter for investment.**

Fazzari, Hubbard, Petersen (1988) run the panel regression:

$$\left(\frac{i}{k}\right)_{j,t} = q_{j,t}\beta_1 + \left(\frac{cash\ flow}{k}\right)_{j,t}\beta_2 + \varepsilon_{j,t},$$

for the US manufacturing firms.

- q theory suggests $\beta_1 > 0$ and $\beta_2 \simeq 0$.
- In the data: $\beta_2 > 0$ and $\beta_1 \simeq 0$.

FHP: q is generally insignificant, cash flows are significant

Table 4. Effects of Q and Cash Flow on Investment, Various Periods, 1970–84[a]

Independent variable and summary statistic	*Class 1*	*Class 2*	*Class 3*
		1970–75	
Q_{it}	−0.0010	0.0072	0.0014
	(0.0004)	(0.0017)	(0.0004)
$(CF/K)_{it}$	0.670	0.349	0.254
	(0.044)	(0.075)	(0.022)
$\overline{R}^2$	0.55	0.19	0.13

Class 3 retain less earnings (pay more dividends) than class 1 firms.

Second pass: exogenous shocks to cash flows

- FHP calculate q using the firm's market value.
- Perhaps q is mismeasured (e.g., market sentiment) and CF is a better predictor of future profits.
- Another alternative is to try to find an exogenous variation in CF.
- Blanchard, Lopez-de-Silanes, and Shleifer (1994), Lamont (1997), Rauh (2006)...

Results generally suggest cash flows/internal funds also matter.

Roadmap

Theories of investment with financial frictions

Alternative: Investment with financial frictions:

- Asymmetric information (see Stein, 2003):
  - Moral hazard: Borrowers'/managers' unobserved effort/project choice.
  - Adverse selection: Borrowers' private information.
- Incomplete contracts and control (see Hart, 2001):
  Not all contingencies can be foreseen.
- Commitment and collateral:
  Borrowers might default. How to enforce payment.

We start with asymmetric information but emphasize mechanisms that are general across frictions.

- Normative analysis usually depends on nature of frictions.

Investment with moral hazard: Preview of results

Key implication: **Limited pledgeability** and **borrowing constraints**:

1. **Net worth channel** in investment.
2. **Financial shocks** matter for macro outcomes.
3. Financial shocks exacerbate and propagate other shocks (**financial accelerator**).
   Next:

- Holmstrom and Tirole's moral hazard model to illustrate 1 and 2.
- A variant of Bernanke and Gertler (1989) to illustrate 3.

Roadmap

Financial frictions: Key feature is heterogeneity

- Two dates $t \in \{0, 1\}$, and a single consumption good (dollar).
- Two types of agents: financiers (F) and potential investors. We refer to the latter as an entrepreneur (E), but think more broadly.
- Both types with linear preferences $U = C_1 + \beta C_2$.
- F's have large endowment of dollars. Competitive loan market. Ensures the interest rate is $1 + r \equiv 1/\beta$. Will endogenize this later.

Key modeling feature is heterogeneity. Focus is on Es.

Financial frictions: Key feature is heterogeneity

- One E with access to a fixed scale project:
  Investing 1 dollar (normalized) at date 0 yields output at date 1.
- E has endowment (net worth) N dollars at date 0.
  Assume $1 > N$ so that project needs financing.
- E has no endowment at date 1.
- E has **limited liability** at both dates: $C_1 \geq 0$ and $C_2 \geq 0$.

Fundamental problem is a mismatch of ideas and resources.

Moral hazard: E can misbehave

- Two states at date 1: Project either succeeds and yields $\frac{R}{p_H}$, or fails and yields 0. (We normalize R to be the average return).
- **Moral hazard:** E may shirk and choose a different project.
- Two versions of the project:

Project	Good	Bad
Private benefit	0	$B > 0$
Prob. of success	p_H	$p_L < p_H$

.

- Project is positive NPV iff E behaves, that is:

$$\beta \left(p_L \frac{R}{p_H} + B \right) < 1 < \beta R.$$

Information friction: E's project choice is not observable to Fs.

A contract specifies the division of output

A contract transfers $1 - N$ to E and specifies the division of output in case of success subject to:

- **Resource constraints (RC)**:

$$\frac{R^F}{p_H} \text{ and } \frac{R^E}{p_H} \geq 0, \text{with } R^F + R^E \leq R.$$

- **F's participation constraint (PC):**

$$1 - N = \beta \left(p_H \frac{R^F}{p_H} \right).$$

- **E's incentive constraint (IC):**

$$p_H \frac{R^E}{p_H} \geq p_L \frac{R^E}{p_H} + B \text{ which implies } R^E \geq \frac{p_H}{\Delta p} B.$$

For good management, E must have "skin in the game."

Key implication: Limited pledgeability (LP)

- Combining (RC) with (IC), we obtain a **limited pledgeability (LP)** constraint**:**

$$R^F \leq \rho \equiv R - \frac{p_H}{\Delta p} B.$$

Here, $\rho < R$ is the (expected) **pledgeable output.**

- LP is the main difference from the frictionless benchmark.
- It is also the **common denominator of various frictions**:
  - Adverse selection generates a similar effect. Why?
  - Incomplete contracts generate a similar effect. Why?
  - Commitment/collateral generates a similar effect. Why?

LP generates a borrowing constraint...

Combining (LP) with (PC), we obtain a **borrowing constraint (BC)**:

$$1 - N \leq \beta \rho.$$

E can only borrow up to the pdv of the **pledgeable output.**

- Some positive NPV projects may not be undertaken.
- Whether or not this happens depends on E's net worth.

...and a net worth channel in investment

Net worth channel: Rewtire the inequality as:

$$N \geq \overline{N} = 1 - \beta\rho.$$

- E's with sufficient (liquid) net worth receive financing and invests.
- E's with insufficient net worth ($N < \overline{N}$) are denied credit.

Credit rationing: When prices have incentive (or information) effects, credit markets may clear with quantities rather than prices.

- E's with $N < \overline{N}$ are willing to promise a higher rate, R^F. But F's don't accept this because of adverse incentives.

Holmstrom-Tirole model: Flexible scale version

- It is also useful to consider another variant of the model. (Building block for many other models. See Tirole's book).
- Slight difference for investment technology: **Scale is flexible.**
- Investing I units in the project yields $\frac{R}{p_H} I$ units in case of success and 0 units in case of failure.
- Two versions of the project:

Project	Good	Bad
Private benefit	0	$BI > 0$
Prob. of success	p_H	$p_L < p_H$

.

Private benefit also scales up with investment (for simplicity).

E chooses the investment level and a feasible contract

- E with net worth N invests $I \geq N$. Now choice variable.
- As before, (IC) and (RC) lead to **(LP)**

$$R^F \leq \rho \equiv R - \frac{p_H B}{\Delta p}.$$

- Combined with (PC), generates a **(BC)**:

$$I - N \leq \beta \rho I.$$

- **E's problem:** Choose $I \geq N$ that maximizes her expected payoff, $\beta R I - (I - N)$, subject to (BC).

Investment depends on E's net worth

- Assume the following (why?):

$$\beta\rho < 1 < \beta R.$$

- Then, E invests up to the maximum possible scale:

$$I = \frac{N}{1 - \beta\rho}.$$

- This aggregates nicely over all E's:

$$I^{agg} = \frac{N^{agg}}{1 - \beta\rho}.$$

Aggregate investment depends on the **net worth of Es** in the economy.

Implications of the net worth channel

1. **Financial shocks** that lower E's net worth lower investment:
   - Shock to Es cash flows. Consistent with earlier evidence.
   - Shocks to Es assets, e.g., subprime shock.
2. **Heterogeneity** and **distribution of wealth** matters.
   - Transfer of wealth from Es to Fs lower investment. E.g., nominal contracts and deflation (Fisher).

None of these effects would be present in a rep. agent framework.

Roadmap

Net worth channel also has dynamic implications

- Bernanke and Gertler (1989): Net worth channel in a dynamic setting.
- **Financial accelerator**: Amplification and propagation of other (business cycle) shocks.
    - E's net worth likely to be procyclical (less solvent during bad times).
    - A recession will erode net worth, which in turn will reduce investment and exacerbate the recession (and vice versa for a boom).
- **Next:** H-T model in a dynamic macro environment to illustrate the mechanism.

Consider a standard OLG model

- Consider an OLG economy with a single consumption good (dollars) and two factors: capital and labor.
- Generation t individuals live for two periods. Continuum of 1 total.
- E's and F's with prefs: $C_{t,1} + \frac{1}{1+r} C_{t,2}$.
- Production technology: $A_t F(K_t, L_t)$.
  - Suppose (for simplicity) A_t is i.i.d. with mean $\overline{A}$.
  - Suppose (for simplicity) capital depreciates fully after use.
- Labor is supplied inelastically by the young, $L_t = 1$.
- Factor markets are competitive:

$$R_t = A_t F_K(K_t, 1) \text{ and } w_t = A_t F_L(K_t, 1). \qquad (4)$$

Benchmark: Equilibrium without frictions

- Start with a benchmark with no frictions.
- Young E's have access to an investment technology: I_t dollars invested generates $\frac{I_t}{p_H}$ units of **capital** date $t+1$ with prob. p_H (0 otherwise).
- Continuum with no aggregate uncertainty implies:

$$K_{t+1} = I_t.$$

- Equilibrium capital found from:

$$\underbrace{1 + r = E\left[R_{t+1}\right]}_{\text{intuition?}} \quad = \quad \overline{A} F_K\left(K^*, 1\right).$$

- Note that $K_{t+1} = K^*$ is independent of A_t.

Without frictions, temporary productivity shocks have no effect on investment.

Introduce heterogeneity and frictions

- Suppose E's have mass η, and F's have mass $1 - \eta$.
- E's and F's net worth is their labor income:

$$N_t = \eta w_t \text{ and } N_t^F = (1 - \eta) w_t. \tag{5}$$

E's net worth is endogenous.

E's investment technology is subject to moral hazard

- Next suppose E's are subject to moral hazard as in H-T:

Project	Good	Bad
Private benefit	0	BI_t dollars.
Prob. of success	p_H	$p_L < p_H$

- In equilibrium, good project is implemented. Still no uncertainty:

$$K_{t+1} = I_t. \tag{6}$$

E's contract choice is isomorphic to the earlier model

- E's expected return from success: $E\left[R_{t+1}\right]\frac{I_t}{p_H} = \overline{A}F_K\left(K_{t+1},1\right)\frac{I_t}{p_H}$.
- Her private benefit: BI_t.
- Given N_t, E chooses the contract $\left(I_t \geq N_t, R^E_{t+1}, R^F_{t+1}\right)$ to maximize her payoff subject to IC and PC:

$$R^E_{t+1} + R^F_{t+1} = E\left[R_{t+1}\right].$$

  (Distribution of R^E and R^F across A-shocks does not matter since agents are risk-neutral. Will come back to this.)
- E's problem is the same as before with $E\left[R_{t+1}\right]$ replacing R.

Definition of dynamic equilibrium

Definition

Given the initial capital level K_0, a dynamic equilibrium is a collection of factor allocations $\{K_t, L_t = 1\}_{t=0}^{\infty}$, prices $\{R_t, w_t\}_{t=0}^{\infty}$, and contracts $\left\{I_t, R_{t+1}^E, R_{t+1}^F\right\}_{t=0}^{\infty}$ such that:

1. Factor markets clear [cf. Eq. (4)] and the agents' net worths are given by (5).
2. Es in each period t make their investment and contract decisions optimally.
3. Capital evolves according to (6).

Make parametric assumptions such that:

$$\rho_t \equiv E_t\left[R_{t+1}\right] - \frac{p_H B}{\Delta p} < 1 + r < E_t\left[R_{t+1}\right] \text{ for each } t. \tag{7}$$

Investment is the solution to a fixed point problem

- From the earlier analysis, we have:

$$K_{t+1} = \frac{N_t}{1 - \rho_t / (1 + r)}.$$

- Plugging in the definition of ρ_t from (7), and using $E[R_{t+1}] = \overline{A} F_K(K_{t+1}, 1)$, we have:

$$K_{t+1} = \frac{N_t}{1 - \left(\overline{A} F_K(K_{t+1}, 1) - B \frac{p_H}{\Delta p}\right) / (1 + r)}.$$

- Under regularity conditions, there exists a unique $K^{next}(\cdot)$ such that $K_{t+1} = K^{next}(N_t)$. The function $K^{next}(N_t)$ is increasing in N_t.
- Check these for the Cobb-Douglas case, $F(K, 1) = K^{\alpha}$.

Financial accelerator and the propagation of shocks

- Plugging in $N_t = \eta A_t F_L(K_t, 1)$ we obtain:

$$K_{t+1} = K^{next}(\eta A_t F_L(K_t, 1)).$$

- **Amplification:** K^{next} is increasing in A_t.
  Temporary shocks reduce investment and exacerbate the recession.
- **Propagation:** K^{next} is increasing in A_t and K_t.

Temporary shocks have long lasting effects:

$$A_t \downarrow \Longrightarrow K_{t+1} \downarrow \Longrightarrow K_{t+2} \downarrow ...$$

Intuition: Net worth channel:

$$A_t \downarrow \; \Longrightarrow N_t \downarrow \Longrightarrow K_{t+1} \downarrow \Longrightarrow N_{t+1} \downarrow \Longrightarrow K_{t+2} \downarrow ...$$

Issues with Bernanke-Gertler

- Endogenizing E's net worth through wages not very compelling. Most investment done by old firms, not entrants.
- The mechanism is more general and applies for longer-horizon firms: Low $A_t \implies$ Low profits and low net worth $\implies$ Lower investment $\implies$ Low profits and net worth in the future...
- But longer horizons generate a demand for hedging aggregate shocks (A-shocks here). Will come back to this.

Taking stock: Heterogeneity and net worth channel

- Cash flows/internal funds seem to matter for investment.
- Alternative to q theory: Investment with financial frictions:
- Common ingredients:
  - **Heterogeneity** (Es and Fs).
  - **Limited pledgeability**.
- Common implications:
  - **Borrowing constraints** and **net worth channel** in investment.
  - **Financial shocks** affect investment.
  - Financial frictions **accelerate** other shocks.

Next time: Dynamics and the precautionary savings motive.