Lecture: Information Frictions and Investment

Advanced Macroeconomics

22/10/2019

Theories of investment with financial frictions:

- An important friction is asymmetric information between borrowers and lenders
  - Hidden effort (**moral hazard**): Potential investors (managers) must have the right incentives
  - Private information (**adverse selection**): Potential investors know more about the project or the firm than financiers
- This asymmetric information has implications for investment

Preview of the results:

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

1. **Net worth channel** in investment

2. **Financial (balance sheet) shocks** matter for macro outcomes

3. **General equilibrium effects** (on the interest rate)

4. **Financial accelerator**

The plan is to:

- Use Holmstrom and Tirole (1998) “Private and public supply of liquidity”, JPE, a moral hazard model to illustrate 1,2
- A variant of Bernanke and Gertler (1989) “Agency costs, net worth and business fluctuations” AER, to illustrate 4

Holmstrom and Tirole's moral hazard model

- Two dates: $t \in \{0,1\}$, and a single consumption good (dollar)
- Two types of agents: financiers (F) and potential investors or entrepreneurs (E).
- Both types have linear preferences: $U = C_1 + \beta C_2$
- F's have a large endowment. Competitive loan market ensures the interest rate is $1/\beta$. Later we endogenize this.
- Each E has endowment (net worth) *N* at date 0. Has access to a **fixed** scale project:
  - Investing 1 at date 0 yields output at date 1.
  - Assume 1>N so that the project needs financing

Fundamental problem: **mismatch of ideas and resources**

Moral hazard: E can misbehave

- Suppose project either succeeds: yielding $\frac{R}{p_H}$, or fails: yielding 0.
- E may shirk and choose a different project (don't exert effort, another project, private benefits)
- Two versions of the project:

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

- Information friction: **E's project choice is not observable to F's**

A contract specifies the division of the output

- A contract specifies the partition of the output (in case of success) between F and E:

$$\frac{R^F}{p_H} \text{ and } \frac{R^E}{p_H}, \text{ with } R^F + R^E = R$$

- Assume

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

- so the project is positive NPV if E behaves, but negative NPV otherwise

Constraints

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

$$\beta \; p_H \frac{R^F}{p_H} = 1\text{-}N$$

F's receives the market return on her lending

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

$$p_H \frac{R^E}{p_H} \geq p_L \frac{R^E}{p_H} + B$$

- Which can be written as

$$R^E \geq \frac{p_H}{\Delta p} B$$

Next: For good management, E must have **"skin in the game"**

Limited pledgeability

- Combining the last inequality with $R^F + R^E = R$, we obtain the **limited pledgeability (LP) constraint:**

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

where ρ is the (expected) **pledgeable output**

Limited pledgeability says that do to frictions not all returns can be promised to F

Limited pledgeability is the key difference from the frictionless benchmark

Limited pledegeability generates a borrowing constraint

- Combining LP with PC, we obtain:

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

Borrowing constraint: 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 generates a "net worth channel in investment"

- Rewrite the last inequality as:

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

Net worth channel:

- E's with sufficient net worth receive financing and invest
- E's with insufficient net worth, $N < \overline{N}$, are denied credit

Credit rationing: markets clear with quantities

- E's with $N < \overline{N}$ are willing to pay a higher interest rate (i.e. to promise a higher R^F)

- But F's do not accept this because of adverse incentives

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

Holmstrom and Tirole's model: flexible scale version

- 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 leads to **limited pledegeability:**

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

- Combined with PC generates a **borrowing constraint (BC)**

$$I - N \leq \frac{\rho I}{1+r}$$

- **E's problem:** Choose $I \geq N$ that maximizes her payoff, $RI - (1+r)(I-N)$ subject to BC

Investment depends on E's net worth

- Assume: $\rho < 1 + r < R$
- RHS ensures that project is worth undertaking. LHS ensures the project is not self financing
- This implies E invests up to the maximum possible scale

$$I = \frac{N}{1 - \rho/(1+r)}$$

This is just a restatement of the net worth channel with flexible scale

- This aggregates over all E's: $I^{agg} = \dfrac{N^{agg}}{1 - \rho/(1+r)}$

Aggregate investment depends on the net worth of E's in the economy

Implications of the net worth channel

- **Financial (balance sheet) shocks** that lower E's net worth will lower investment:
  - A transfer of net worth from E's to F's (e.g. nominal contracts and Fisher's debt deflation)
  - Shocks to E's assets (e.g. subprime shock). Amplified by leverage
- Balance sheet effects will also amplify other shocks
  - Deterioration of E's net worth because of low profits in a recession
  - These 2 effects would not be present in a representative agent framework
- Next: General equilibrium implications (endogeneize the interest rate)

Equilibrium in the asset market: Supply side

- To endogeneize *r*, think of the equilibrium in the asset market
- Recall that the interest rate is the inverse of the asset prices
- We have the **supply of assets** in terms of pledgeable output)

$$S^{asset}(r) = \rho I^{agg} = \frac{\rho N^{agg}}{1 - \rho/(1+r)}$$

The E's offer more assets the lower is r

Equilibrium in the asset market: Demand side

- For the demand side suppose F's preferences are: $u(C_0^F) + \beta u(C_1^F)$
- Consider the optimal savings decision:

$$\max_{C_0^F, C_1^F} \; u(C_0^F) + \beta u(C_1^F)$$

$$\text{s.t.} \quad C_0^F + \frac{C_1^F}{1+r} \leq N^F$$

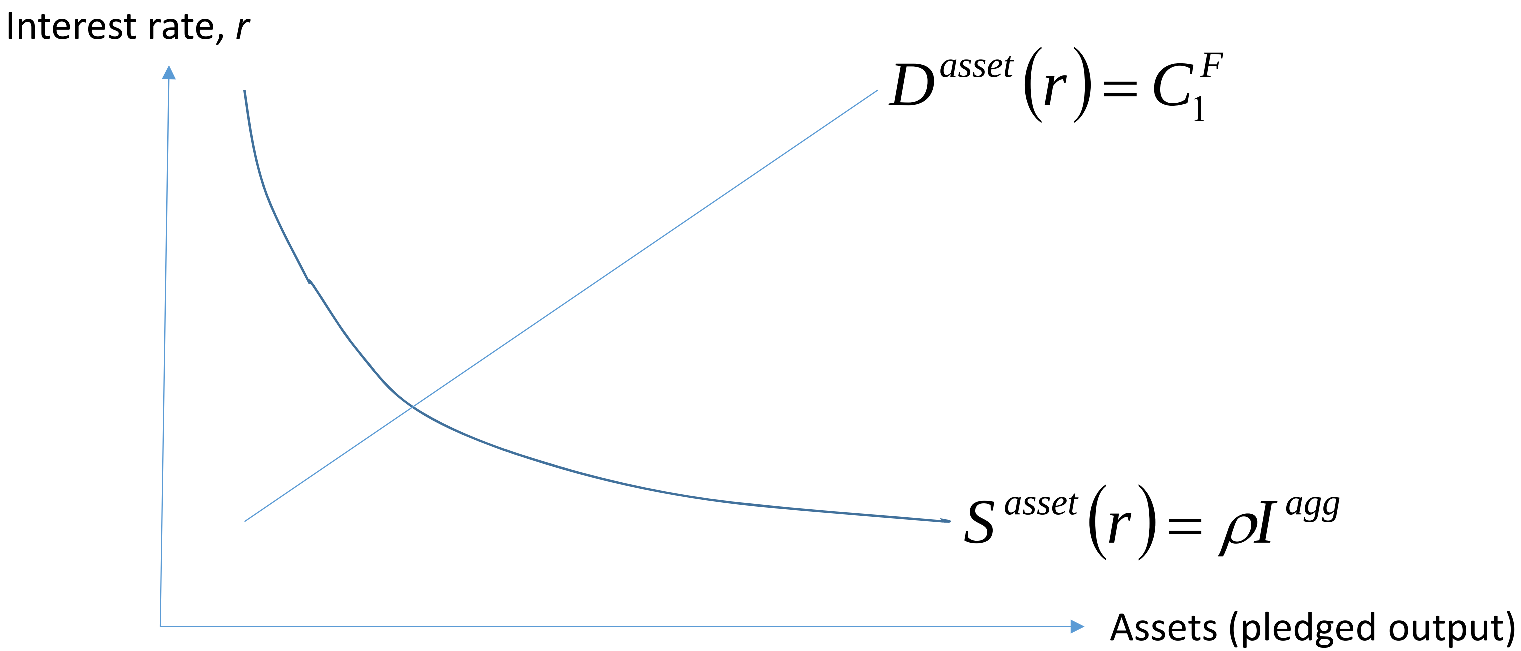
The solution is characterized by the Euler equation:

$$u'(C_0^F) = (1+r)\beta u'(C_1^F)$$

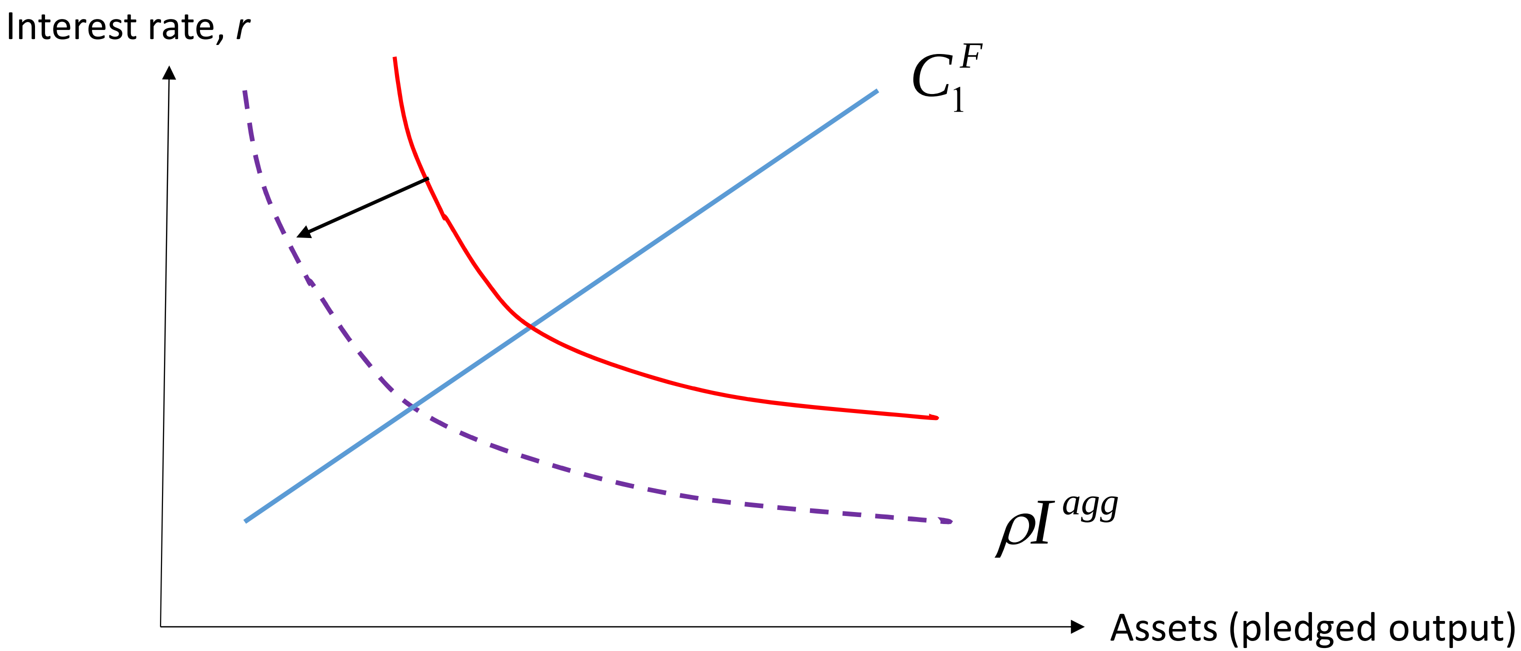
The demand for assets is given by: $D^{asset}(r) = C_1^F$

It is increasing in r

Equilibrium in the asset market

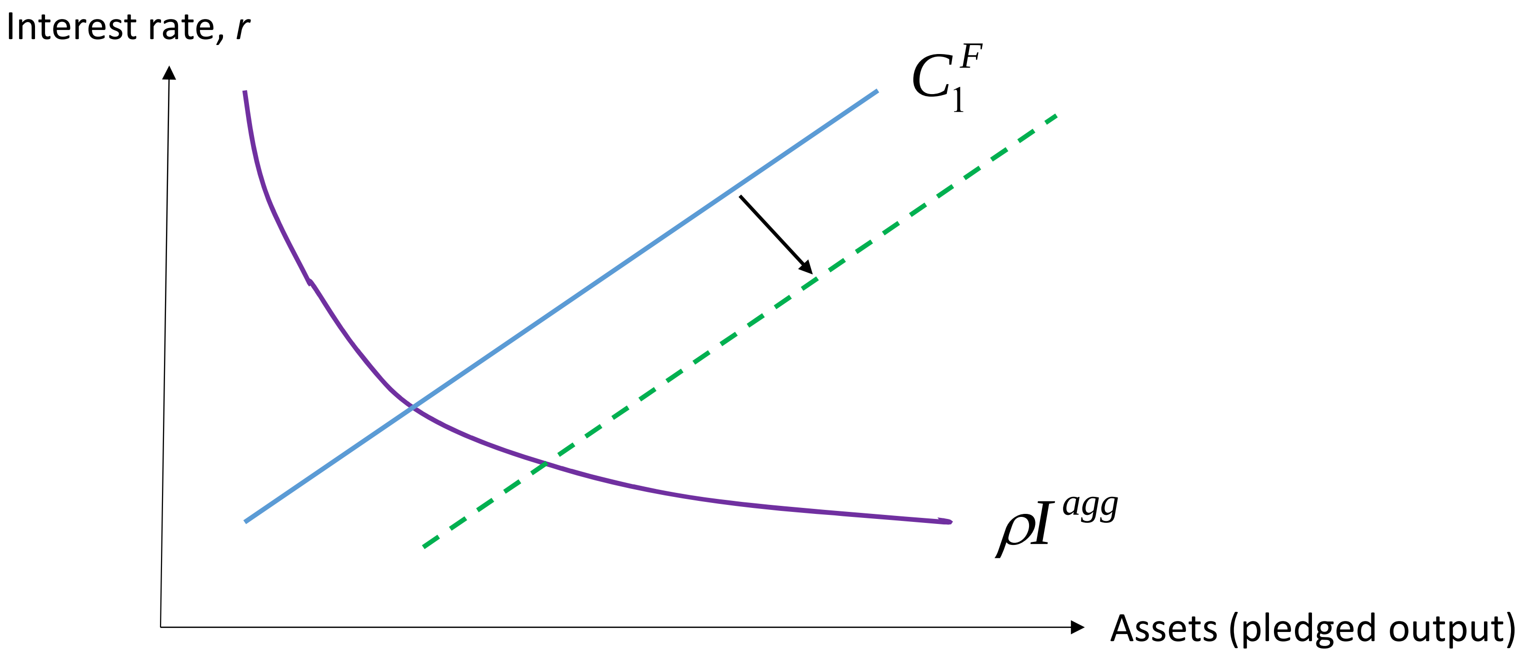


Reduction in E's net worth lowers investment, assets supply, and interest rate



A reduction in ρ has the same effect

Reduction in savings demand (i.e. precautionary motive) increases credit and lowers interest rate



Balance sheet channel has dynamic implications

- Bernanke and Gertler (1989) put financial frictions into a dynamic equilibrium macro model and emphasize the role of the balance sheet channel in the origination and the **propagation** of shocks

- **Persistence and propagation of 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 propagate the recession (and vice versa for boom)

- Next: Holmstrom and Tirole model in a dynamic macro environment to illustrate the propagation mechanism

Consider a standard OLG model

- Consider an OLG economy with a single consumption good (euros) and two factors: capital and labor
- Generation *t* agents live 2 periods: Continuum of 1 (total)
- E's and F's with preferences: $C_{t,1} + \frac{1}{1+r} C_{t,2}$, (back to exogenous *r*)
- Production technology (consumption): $A_t F(K_t, L_t)$
  - Suppose (for simplicity) that A_t is i.i.d. with mean $\overline{A}$
  - Suppose (for simplicity) that capital depreciates completely after 1 period
- Labor is supplied inelastic by the young, $L_t = 1$
- Factor markets are competitive:

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

Benchmark: equilibrium without frictions

- Start with a benchmark with no frictions
- Young E's have access to an investment technology: I_t (consumption good) invested at date *t* generate I_t / p_H units of capital date *t*+1 with probability p_H (0 otherwise)
- Continuum with no aggregate uncertainty implies:

$$K_{t+1} = I_t (\#\text{Entrepreneurs})$$

- Equilibrium capital found from:

$$1 + r = E\left[R_{t+1}\right] = \overline{A} F_K\left(K^*, 1\right)$$

- Note that $K_{t+1} = K^*$ is independent of A_t
- **Without frictions, temporary productivity shocks have no effect on investment**

Introduce asymmetric information

- Assume E's have mass η, and F's have mass 1- η
- E's and F's net worth is their labor income

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

E's net worth is endogenous

E's investment is subject to moral hazard

- Next suppose E's are subject to moral hazard as in Holmstrom and Tirole:

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

- Still no aggregate uncertainty (in a symmetric equilibrium)

$$K_{t+1} = I_t(1-\eta)$$

E's contract is isomorphic to previous model

- Expected return from success:

$$E_t(R_{t+1})\frac{I_t}{p_H} = \overline{A}F_K(K_{t+1},1)\frac{I_t}{p_H}$$

which is deterministic

- E's private benefit: BI_t
- Given N_t , E chooses the contract: $(I_t \geq N_t, R_{t+1}^{E,\text{expected}}, R_{t+1}^{F,\text{expected}})$
- To maximize her payoff subject to:
    - Resource constraint $R_{t+1}^{E,\text{expected}} + R_{t+1}^{F,\text{expected}} = E[R_{t+1}]$ (with linear prefs, exact distribution of returns not important)
    - E's (IC): $R_{t+1}^{E,\text{expected}} \geq p_H B / \Delta p$
    - F's (PC): $R_{t+1}^{F,\text{expected}} I_t = (I_t - N_t)(1+r)$

- **E's problem is the same as in the two period version (with ER_{t+1} replacing *R*)**

Definition of equilibrium

- Given the initial stock of capital K_0 an equlibrium is a vector of factor allocations $\{K_t, L_t = 1\}_{t=0}^{\infty}$, prices $\{R_t, w_t\}_{t=0}^{\infty}$ and contracts $(I_t, R_{t+1}^{E,\text{expected}}, R_{t+1}^{F,\text{expected}})_{t=0}^{\infty}$ such that:

1. Factor markets clear
2. E's in each period make their investment and contract decisions optimally
3. Capital evolves as $K_{t+1} = I_t(1-\eta)$

Make parametric assumption such that

$$\rho_t \equiv E_t(R_{t+1}) - \frac{p_H B}{\Delta p} < 1 + \mathrm{r} < E_t(R_{t+1})$$

Investment is the solution to a fixed point theorem

- From the earlier analysis, we have

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

Plugging in the definition of ρ_t and using $E_t\left[R_{t+1}\right] = \overline{A}F_K\left(K_{t+1},1\right)$

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

Under regularity conditions, there is a unique $K^{next}\left(.\right)$ s.t. $K_{t+1} = K^{next}\left(N_t\right)$

The function $K^{next}\left(N_t\right)$ is increasing in N_t

Check these claims for the Cobb Douglas case: $F\left(K_t,1\right) = K^{\alpha}$

Financial accelerator and the propagation of shocks

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

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

- **Persistency and propagation of shocks:** next period capital stock (and investment) is increasing in A_t and K_t . Temporary shocks have long lasting effects, in contrast with the frictionless benchmark:

$$A_t \downarrow \;\Rightarrow\; K_{t+1} \downarrow \;\Rightarrow\; K_{t+2} \downarrow \ldots$$

  - **Intuition (balance sheet channel):** shocks propagate through E's net worth:

$$A_t \downarrow \;\Rightarrow\; N_t \downarrow \;\Rightarrow\; K_{t+1} \downarrow \;\Rightarrow\; N_{t+1} \downarrow \;\Rightarrow\; K_{t+2} \downarrow \ldots$$

This is known as the **financial accelerator.** The particular propagation illustration in B-G (through wages) is not convincing. But the mechanism is more general.

Taking stock: Net worth channel and investment

- Asymmetric information between financiers and potential investors.

- Key implication is borrowing constraints and limited pledgeability. Generate:

  - **Net worth channel** in investment
  - **Financial (balance sheet) shocks**
  - **GE effects**: Tightening of constraint reduces supply of assets, increases assets prices, and lowers the interest rate
  - **Financial accelerator** and the propagation of shocks