Asymmetric Information and Outside Financing
(continued)

THE PECKING ORDER THEORY

Myers and Majluf (1984)

Myers (1984)

See also Tirole, ch. 6.2

Main Ideas:

(1) Good firms prefer to issue securities whose value is least information sensitive because they are least underpriced

(2) Securities may be ranked in terms of their information sensitivity.

(3) Under certain conditions, the ranking is:

- **Internal funds**
- **Risk-free debt**
- **Risky debt**
- **Hybrid securities (convertible debt)**
- **Equity**

Model

Same as before except for

- $A = 0$ (for now)
- $X^F > 0$ so that we can examine different securities
- The bad type project is valuable (to be relaxed later), i.e., $V(p_B) > 0$
  - We will only get pooling equilibrium with both types investing (If $A > 0$ and $V(p_B) < 0$ there can be a separating equilibrium)

DEBT AS THE LEAST INFORMATION-SENSITIVE CLAIM

Case 1: $X^F > I$

$\Rightarrow$ The entrepreneur can raise I with risk-free debt

$$R^S = R^F = K \text{ with } X^F \geq K \geq I$$

- Risk-free claim (debt) sells at fair price.
- Since $X^F > I$, bad types can also issue risk-free debt.
- Thus, there may be pooling, but it is irrelevant.
  - investors are not fooled,
  - there is no subsidizing across types.
- In contrast, if good types issue risky claims (equity), bad types mimic them. Hence, good types' claims would be sold at discount, subsidizing bad types.
  - Good types issue risk-free debt
  - Bad types are indifferent between issuing risk-free debt and issuing risky claim (e.g. equity).
  - Both types sell fairly priced claims

Intuition:

The value of risk-free debt is insensitive to hidden info. Hence, there are no costs associated with asymmetric info.

Case 2: $X^F < I$

The project cannot be financed with risk-free debt

Equilibrium?

The entrepreneur's payoff:

$$\underbrace{V(p)}_{\text{firm's actual value}} + \underbrace{\big(R^F + \widehat{p}(R^S, R^F)\Delta R\big)}_{\text{raised from investors}} - \underbrace{\big(R^F + p\Delta R\big)}_{\text{claim's actual value}}$$

which can be rewritten as

$$\underbrace{V(p)}_{\text{firm's actual value}} - \underbrace{\big(p - \widehat{p}(R^S, R^F)\big)\,\Delta R}_{\text{discount due to info. asymmetry}}$$

No Separating Equilibrium:

Imagine only good type invests

- It implies that bad type does not want to mimic:

$$V(p_B) + \Delta p \Delta R \leq 0$$

Since $V(p_B) > 0$ by assumption, this implies

$$\Delta R \leq 0$$

- However, this would violate the investors' participation constraint. Indeed, they would receive:

$$R^F + p_G \Delta R \leq R^F < I$$

Hence, **no** such equilibrium exists.

Imagine only bad type invests

- Investors' participation constraint must be satisfied $R^F + p_B \Delta R \geq I$
- Even when being mistaken for a bad type, good type makes positive expected return, as he gets

$$
\begin{aligned}
& X^F + p_G \Delta X - I + R^F + p_B \Delta R - (R^F + p_G \Delta R) = \\
= & R^F + p_B \Delta R - I + p_G (X^S - R^S) + (1 - p_G)(X^F - R^F) > 0
\end{aligned}
$$

Hence, **no** such equilibrium exists

Separating equilibrium in which both invest, but offer different terms does not exist either (bad type would always want to mimic good type)

Pooling Equilibrium

First, there can be no pooling equilibrium in which nobody invests, as even $V(p_B) > 0$ by assumption.

In a pooling equilibrium, the good types' expected payoff is

$$\underbrace{V(p_G)}_{\substack{\text{firm's actual}\\\text{value}}} + \underbrace{\left(R^F + \widehat{p}\Delta R\right)}_{\substack{\text{raised from}\\\text{investors}}} - \underbrace{\left(R^F + p_G\Delta R\right)}_{\substack{\text{claim's actual}\\\text{value}}}$$

which can be rewritten as

$$\underbrace{V(p_G)}_{\substack{\text{firm's actual}\\\text{value}}} \quad - \quad \underbrace{(p_G - \widehat{p})\,\Delta R}_{\substack{\text{discount due to}\\\text{info. asymmetry}}}$$

That is, the good type's objective function is equivalent to minimizing underpricing. Hence, the good type's "best" pooling PBE is given by:

$$\begin{cases} \min \ \Delta_R & \\ \text{s.t.} & \\ \quad R^F + \widehat{p}\Delta R \geq I & \text{(IR)} \\ \quad R^F \leq X^F & \text{(LL1)} \\ \quad R^F + \Delta R \leq X^F + \Delta X & \text{(LL2)} \end{cases}$$

Clearly, LL1 and IR are binding

Hence,

$$R^F = X^F \quad \text{and} \quad R^S = R^F + \Delta R = X^F + \frac{I - X^F}{\widehat{p}}$$

which is a debt contract with face value $K = R^S$:

$$R^F = \min\left\{X^F; K\right\} = X^F \quad \text{and} \quad R^S = \min\{X^S; K\} = K$$

Intuition: A debt contract minimizes the discount incurred by the good type.

Remark:

To derive debt as the optimal contract, i.e., least information sensitive claim, in a setting with a continuum of X additional assumptions required (see Tirole, ch. 6.6).

- Monotone Likelihood Ratio Property (**MLRP**): $f_G(X)/f_B(X)$ is increasing (high realisations of X is more likely to be generated by a good type)
- **Monotonic reimbursement**: $R(X)$ is non-decreasing

Extension. Separating equilibrium with good type issuing debt

If $V(p_B) < 0$, there may appear a pooling equilibrium in which nobody invests, and pooling equilibria in which both types invest may disappear. No separating equilibria will appear if we keep $A = 0$.

If, additionally to $V(p_B) < 0$, we assume that $A > 0$, than there will appear a separating equilibrium in which the good type invest and the bad type does not invest (other types of separating eq. will not appear). The most robust (with respect to the parameters) separating equilibrium will be the one in which he issues debt.

- The condition for the investors to provide funds:
$$R^F + p_G \Delta R \geq I - A$$
- The bad type does not mimic the good type iff
$$V(p_B) + \Delta p \Delta R \leq 0$$

(Note: for these two conditions to hold jointly it is necessary that $A \geq X^F + p_B \Delta X - (R^F + p_B \Delta R)$, hence $A > 0$ is needed)

- For given ΔR, these conditions are more likely to hold when $R^F = X^F$, i.e. under a debt contract. Or, to put it another way, given $R^F + p_G \Delta R = I - A$, the second contition is more likely to hold when ΔR is minimized.

Intuition: debt, as the least information sensitive claim, reduces the benefits for the bad type from mimicking the good type.

Comments:

Thus, debt is the best contract for the good enrepreneur regardless the equilibrium:

- if financing can be done via risk-free debt (Case 1), it is the best way to do for good type as it involves no discount
- if financing cannot be done via risk-free debt (Case 2):
  - in a separating equilibrium debt is the best way to discourage the bad type from mimicking
  - debt is issued in the "best" for the good type pooling equilibrium

INFO ASYMMETRY ABOUT ASSETS IN PLACE AND PROJECT FUNDING

Consider a firm with:

- Financial slack $A > 0$
- Assets in place generate $X \in \{X^F, X^S\}$ with $p \in \{p_B, p_G\}$
- New investment opportunity:
  - Invest I to increase p to $p + \tau$
  - Positive NPV: $\tau \Delta X - I > 0$

Note: As in Myers (1977), the new project's income cannot be contracted upon separately from that of the assets in place.

Case 1: $X^F > I - A$

We have already analyzed this case.

- Good firm can finance new project with internal funds and risk-free claim $I - A < X^F$.
  - Risk-free claim sells at fair price.
  - If good types issued risky claims (equity), bad types would mimic and hence good types' risky claims would be sold at discount.
- Bad type may issue either risk-free claim or risky claim. Indifferent because claims are fairly priced.

Hence, **no** cost of information asymmetry.

Case 2: $X^F < I - A$

The project cannot be financed with risk-free claims

In equilibrium:

- Bad firms necessarily invest (positive NPV)
- If good firms invest, bad ones mimic them (issue same security)
- Depending on whether good firms invest or not equilibrium is either pooling or separating (with only bad firms investing)

Analysis is as before. Assume for now that the good type invests.

The good type's objective function is equivalent to minimizing underpricing.

$$\underbrace{(V(p_G) + \tau \Delta X)}_{\text{firm's actual value}} \quad - \quad \underbrace{(p_G - \widehat{p})\, \Delta R}_{\text{discount due to info. asymmetry}}$$

Hence, the "best" pooling eq. is given by,

$$\begin{cases} \min \ \Delta R \\ \text{s.t.} \\ \qquad R^F + (\widehat{p} + \tau)\Delta R \geq I - A & \text{(IR)} \\ \qquad R^F \leq X^F & \text{(LL1)} \\ \qquad R^F + \Delta R \leq X^F + \Delta X & \text{(LL2)} \end{cases}$$

(IR) and (LL1) are binding. Thus $R^{F^*} = X^L$ and the good type raises as little as needed, $I - A$, in debt with face value:

$$R^{S^*} = X^F + \frac{I - A - X^F}{\widehat{p} + \tau}$$

Hence, again the best contract for the good type is the debt contract!

Note: Assets in place of the good type are underpriced.

For the new project to be worthwhile for the good type under pooling, its NPV has to exceed the discount.

$$NPV \geq (p_G - \widehat{p})\,(R^{S^*} - R^{F^*})$$

which can be rewritten as

$$\tau \Delta X - I \geq (p_G - \widehat{p})\,\frac{I - A - X^F}{\widehat{p} + \tau}$$

The equilibrium is:

- Pooling (both types invest) if the inequality is satisfied
- Separating (only bad firms invest) if it is not satisfied

Comments

Good firms are "less likely" to invest, i.e.,

$$\tau \Delta X - I \geq (p_G - \widehat{p}) \frac{I - A - X^F}{\widehat{p} + \tau}$$

is "less likely to be satisfied" **when**:

- **More funds need to be raised (using risky securities)**, i.e., when $I \nearrow$, $A \searrow$ or $X^F \searrow$
- **Good firms suffer from a greater information asymmetry**, i.e., when $\nu \searrow$, $p_G \nearrow$ or $p_B \searrow$
- **The new opportunity is less valuable**, i.e. $\tau \searrow$
- **The firm cannot issue debt (for exogenous reasons)**
- **Negative stock price reaction to equity offerings**

IMPLICATION OF THE LAST TWO MODELS: PECKING ORDER THEORY

Firms prefer retained earnings to outside financing

Given they need outside financing, they prefer debt to equity.

- Robustness of the Proposed Order?
  - Risk-free debt is without problem
  - The rest depends on the type of information asymmetry
  - For instance, if information is about risk, equity may be less information sensitive than debt

- Implications for capital structure
  - Changes in debt ratios are driven by the need for external finance. (Debt ratio increases in "deficit" years and decrease in "surplus" years.)
  - Factors affecting capital structure:
    * Investment opportunities (need for funds)
    * Past profitability (availability of internal funds)
    * Degree of information asymmetry
  - There may be better and worse times to issue equity (issue equity in booms, when asymmetry of information becomes a smaller problem)

Evidence

Much (but not all) empirical evidence is roughly consistent with Myers and Maljuf's theory:

- Equity issues are infrequent:
- Non-positive stock price reaction to the announcement of a Seasoned Equity Offering
- Firms issuing stock (IPO or SEO) underperform relative to similar non-issuing firms during the five years following the issue.

SIGNALING

- Given that asymmetric information is costly for good types, they have incentive to reduce informational gap

- Above, i.e., in Pecking Order Theory, this is (partially) achieved by issuing claims with low information sensitivity.

- An alternative for the good types to overcome information asymmetry is to engage in **costly signaling**.

- **General Idea:** Good type proves himself by undertaking an action costly enough to deter mimicking by bad types

Many signaling models in corporate finance (see Tirole, ch. 6.3). Signalling by:

- collateral pledging (readiness to pledge collateral in case of failure)

- debt (readiness to bear bankruptcy risk)

- certification

- dividends

- IPO underpricing

We will look at signalling by retaining a large equity stake (risk-bearing).

RISK-BEARING AS A SIGNAL

Leland and Pyle (1977)

Main Idea:

By retaining a large equity stake in their firms, good entrepreneurs can signal their type to investors because:

- **A large stake is costly (under-diversification)**
- **It is more costly for bad entrepreneurs.**

Model

A risk-averse entrepreneur considers selling part of his firm's cash flow claims to risk-neutral investors so as to reduce his risk exposure.

- Same model as before except that the entrepreneur:
  - already undertook the project at $t = 0$
  - considers selling some shares at $t = 1$
  - is risk-averse with respect to wealth at $t = 2$:
    - VNM utility function $u(X)$, with $u' > 0$ and $u'' < 0$
    - $u(0) = 0$.
  - $X^F = 0$

First Best

By selling a fraction $(1-\alpha)$ at price S, type i gets

$$U_i(\alpha, S) = p_i u\left(\alpha X^S + (1-\alpha)S\right) + (1-p_i)u\left((1-\alpha)S\right)$$

Absent information asymmetry, the price is $S = p_i X^S$, and

$$\begin{aligned} U_i(\alpha, p_i X^S) &= p_i u\left(\alpha X^S + (1-\alpha)p_i X^S\right) \\ &\quad +(1-p_i)u\left((1-\alpha)p_i X^S\right) \end{aligned}$$

The entrepreneur's expected utility is maximized for $\alpha = 0$ since

$$\begin{aligned} \frac{\partial U_i(\alpha, p_i X^S)}{\partial \alpha} &= p_i(1-p_i)X^S \left[\begin{array}{c} u'\left(\alpha X^S + (1-\alpha)p_i X^S\right) \\ -u'\left((1-\alpha)p_i X^S\right) \end{array} \right] \\ &< 0 \text{ because it is } < 0 \text{ at } \alpha = 0 \text{ and } u'' < 0 \end{aligned}$$

- In the First Best:
  - The entrepreneur sells his entire stake
  - The investors bear all the risk (but they are risk averse, so they don't care)
  - The entrepreneur is fully insured

Asymmetric Information

Absent further information, investors are willing to pay

$$\widehat{p}X^S$$

Given these expectations, an entrepreneur's utility for selling claims on all cash flows (i.e. $\alpha = 0$) is

$$u\left(\widehat{p}X^S\right) \quad \text{rather than} \quad u\left(pX^S\right)$$

$\Longrightarrow$ "Bad" entrepreneurs are even more eager to sell

Assumption (*):

$$\frac{\partial U_G(\alpha, \widehat{p}X^S)}{\partial \alpha} > 0 \text{ at } \alpha = 1$$

That is,

$$\frac{p_G\left(1-\widehat{p}\right)}{\widehat{p}\left(1-p_G\right)} > \frac{u'\left(0\right)}{u'\left(X^S\right)}$$

This implies (you can check!)

$$\frac{\partial U_G(\alpha, \widehat{p}X^S)}{\partial \alpha} > 0 \text{ for all } \alpha$$

and

$$\frac{\partial U_G\left(\alpha, p_B X^S\right)}{\partial \alpha} > 0 \quad \forall \alpha$$

A Perfect Bayesian Equilibrium (PBE) of this game is defined as:

- - Strategies α_G and α_B are optimal given the investors' beliefs.
  - Investors' beliefs ν that the type is good obtained from a priori distributions and observed actions using Bayes' Rule

$$\nu(\alpha_0) = \Pr\left[p = p_G \mid \alpha = \alpha_0\right] = \frac{\Pr\left[(p = p_G) \cap (\alpha = \alpha_0)\right]}{\Pr\left[\alpha = \alpha_0\right]}$$

- If $\alpha_G \neq \alpha_B$, investors' beliefs are $\nu(\alpha_G) = 1$ and $\nu(\alpha_B) = 0$
- If $\alpha_G = \alpha_B$, investors' beliefs are $\nu(\alpha_G) = \nu$
- Beliefs for out-of-equilibrium moves (more on this later).

Quick implication:

No Perfect Bayesian Equilibrium with $\boldsymbol{\alpha_G} = \mathbf{0}$ (Good type can't be fully insured anymore!)

Proof by contradiction. Suppose that $\alpha_G = 0$.

Given the investors' beliefs $\nu(\alpha)$, they will pay $S(\alpha)$ for claims on a fraction $(1-\alpha)$ of the cash flows with

$$S(\alpha) = (p_B + \nu(\alpha)\,\Delta p) \cdot X^S$$

Good entrepreneurs prefer $\alpha_G = 0$ to α if

$$U_G(0, S(0)) \equiv u(S(0)) \geq U_G(\alpha, S(\alpha)) \qquad (IC_G)$$

Bad entrepreneurs prefer α_B to α if

$$U_B(\alpha_B, S(\alpha_B)) \geq U_B(\alpha, S(\alpha)) \qquad (IC_B)$$

- It cannot be that $\alpha_B = 0$. Then we are in pooling, $\nu(0) = \nu$, but due to assumption (*) then good type prefers $\alpha_G = 1$.
- Suppose that $\alpha_B \neq 0$. Then $\nu(0) = 1$ and $\nu(\alpha_B) = 0$, but then bad type would prefer to sell more to reduce his risk exposure.

Remark: at $\alpha = 1$ asymmetry of info (i.e. share price) has no effect on entrepreneur's utility since he does not sell anything.

Pooling Equilibria?

Due to implications of Assumption (*), **no** pooling equilibrium is possible:

- Suppose $\alpha_B = \alpha_G < 1$. Then the good type would prefer to deviate to $\alpha_G = 1$ (since $\frac{\partial U_G(\alpha, \widehat{p} X^S)}{\partial \alpha} > 0$ for all α)
- Suppose $\alpha_B = \alpha_G = 1$. Then the bad type would prefer to diversify completely: $\alpha_B = 0$ (since $\frac{\partial U_B\left(\alpha, p_B X^S\right)}{\partial \alpha} < 0$)

Separating Equilibria

In any separating equilibrium it must be that $\alpha_B = 0$. If $\alpha_B > 0$ the bad guy would wants to deviate to $\alpha_B = 0$ (he is anyway believed to be bad, and $\frac{\partial U_B\left(\alpha, p_B X^S\right)}{\partial \alpha} < 0$)

There exists Separating Equilibrium with $\boldsymbol{\alpha}_{\mathbf{G}}= \mathbf{1}$. In this eq-m:

- $\alpha_G = 1$
- $\alpha_B = 0$
- $\forall \alpha \neq 1, \nu(\alpha) = 0$
- $\nu(1) = 1$

Recall that Assumption (*) implies that

$$\frac{\partial U_G\left(\alpha, p_B X^S\right)}{\partial \alpha} > 0 \quad \forall \alpha$$

Hence, the good type prefers $\alpha_G = 1$ to deviating to any α if the market believes he is bad whenever $\alpha < 1$

Intuition: Retaining shares acts as a signal of confidence about the likelihood of success.

Other Separating Equilibria

- Suppose that investors interpret "selling a very small fraction" as a signal of good quality.
- Good type will then obviously sell a very small fraction.
- Bad type would not mimic as his expected utility from mimicking the good type would not change much.

$\Rightarrow$ this is a PBE

Remark: to deter good type from deviation assign bad beliefs following out-of-equilibrium moves

How much can the good type sell in equilibrium, i.e. how large can $(1-\alpha)$ be?

- Given risk-aversion, good types interested in selling as much as possible, while preventing bad types from mimicking.
- Bad types must prefer to sell the entire firm. Hence, α must satisfy
$$U_B(0, p_B X^S) \geq U_B\left(\alpha, p_G X^S\right)$$

- The RHS is strictly decreasing in α (you can check!)

- The inequality is satisfied for $\alpha = 1$ and violated for $\alpha = 0$

$\Rightarrow$ There exists a unique $\alpha^* \in (0,1)$ such that LHS=RHS

- Hence, separation can be sustained for all
$$\alpha_G \geq \alpha^* \text{ and } \alpha_B = 0$$
- There are no separating PBE with $\alpha_G < \alpha^*$
- Any $\alpha_G \geq \alpha^*$ can be supported as separating equilibrium (use bad beliefs following out-of-equilibrium moves)

Multiplicity of equilibria because no constraints on beliefs about out-of-equilibrium behaviour, except they must sustain chosen equilibrium. By constraining out-of-equilibrium beliefs to "reasonable" beliefs, one can reduce number of equilibria. Using Intuitive Criterion (Cho-Kreps) we can eliminate all except the one, in which:

- - $\alpha_G = \alpha^*$ (partial insurance for good type)
  - $\alpha_B = 0$ (full insurance for bad type)

Selection procedure

- Consider a PBE with $\alpha_G = \hat{\alpha} > \alpha^*$
- Suppose the investors observe an out-of-equilibrium move $\alpha = \alpha^*$
- Can they "reasonably" believe that the firm is bad?
- For any ν, the bad type is better-off with $\alpha_B = 0$ than with $\alpha_B = \alpha^*$
- Thus, it cannot be bad type, i.e. $\nu(\alpha^*) = 1$
- With such belief $\alpha_G = \alpha^*$ is optimal for good type, hence all equilibria with $\alpha_G > \alpha^*$ are eliminated.

Bottom line:

We have selected a single equilibrium:

- The entrepreneur of a bad firm sells the entire cash flows and gets full insurance;
- The entrepreneur of a good firm retains α^* and gets partial insurance
- α^* satisfies:

$$U_B(0, p_B X^S) = U_B\left(\alpha^*, p_G X^S\right)$$

Retaining a fraction of shares acts as a **signal** by the entrepreneur that he is confident about the likelihood of a high income.