Lecture 12 – Economics of Information

1. Introduction

1) Problem of agency, also called *principal-agent problem*. The *principal* should motivate her *agent* to act in her interests. With *common* or *public information*, the problem is trivial. Exchange or compensation is contingent on performance: if you don't deliver the goods, a court enforces the severe penalties enumerated in our contract (*Forcing Contract*).

2) In *private* or *asymmetric information*, the agency problems are more interesting. Something is hidden to at least one side.
Hidden Actions: I don't know whether my employees are working hard or shirking.
(*imperfect information* → *Moral Hazard*)
Hidden Information (or types): I don't know whether your car is a lemon or you are high or low productive workers (*incomplete information* → *Adverse Selection*)

3) Theory of a Firm
A set of cost curves? A production technology? Entrepreneur or plant and equipment? Or Stockholders or top-management?
Now, who owns the firm? Stockholders? Why not bondholders? And what determines what activities are undertaken within the firm and what are purchased as products or services from outside suppliers?

The modern theory of the firm is that the firm is *a collection of contracts*. The firm is a legal fiction concocted to minimize the cost of transacting. We each write a contract with the firm, rather than each of us with each other.

A stylized firm: raw materials + equipments + labor = usable products (with value).
distribution to consumers.
management and finance.

In the absence of agency problems, it would make no difference whether all these activities were centralized within one firm (which would make its own raw materials, and distribute the final products to consumers) or decentralized into many firms (even into individual workers). No market transactions, or all market transactions? Or something in between?

The classical firm buys its raw materials from suppliers; owns much of its equipment; hires its workers; sells its product to another firm for distribution to consumers; and the process is funded by both debt and equity? Why? In particular, why link ownership (i.e. residual authority) with equity holding (i.e. residual income)? The residual authority must have something at stake to float debt. Otherwise, walk away with the proceeds. So decision makers are agents; here the entrepreneur is the agent of the debt holders. Similarly, management is the agent of the stockholders, and workers are agents of management.

2. Structure of Principal-Agent Models

1) Environment, Constraints, and Equilibrium
As with all economic models, we must specify preferences and opportunities, including the production environment. Given these, we can specify the efficient allocation of resources, based on Pareto optimality. This is typically referred to as *the first-best solution.*

The Elements of the Agency Problem

(a) We have the preferences of both the principal and the agent.

(b) Typically we have a production function, which relates the actions of the agent to something valued by the principal.

(c) There's also a participation or reservation utility constraint. Transactions must be voluntary, so here the principal must attract the agent. In standard models, this might take the form of paying the competitive price.

(d) There's also a contract linking the principal to his agent, which enumerates payments from the principal to the agent in various states.

(e) There is an *incentive compatibility constraint*. The agent doesn't do what he's told or even what he says he'll do. He does what is in his interest to do, given the incentives the principal gives him.

(f) The principal chooses a compensation contract, which specifies what the agent is to do and what he will be compensated based on each observable outcome, to maximize his own objective subject to the constraints that the agent accepts the contract and the specified actions be incentive compatible.

2) The Efficiency Wage Theory

A theory that firms pay wages above the equilibrium level in order to prevent workers from shirking. Of course, it is irrational for other companies to pay fixed wage lower than their competitor's level, so we would expect that all other companies would also offer a wage similar (or same) to their competitor's level.

3) Franchising

An alternative ownership is franchising, in which a franchisor, such as McDonald's Corporation , sells the right to open outlets under its trademark to independent entrepreneurs called franchisees. Typically, the franchisee pays the franchisor a fixed franchise fee plus a royalty based on sales. One of the advantages of franchising over company ownership is that franchisees have a strong incentive to run their outlets as active owner-managers who attempt to prevent workers from shirking. Franchise chains typically begin with one or a few company-owned outlets in one geographic area, so initially the owners are able to effectively monitor workers and deter shirking. As a chain expands beyond a few outlets in one region, however, it becomes increasingly difficult for the owners to monitor each outlet. One possible solution is to hire high-quality managers to prevent shirking, but rapid expansion makes it difficult to find high-quality managers. Furthermore, managers have an incentive to shirk themselves, so managerial oversight is likely to be moderately successful at best. Franchising has become a common method of trying to reduce the principal-agent problem associated with rapid chain expansion.

3. Mathematical Model: Risk Sharing Without Moral Hazard[*]

The existence of moral hazard means that the Pareto optimal sharing of risk cannot be achieved.

1) Assumptions

- Two states of the world: State 1 (bad) and State 2 (good)
- Agent produces output (x_1 or x_2) and then shares the output with the principal.
- In state 1, principal will get ($x_1 - w_1$) and agent will get w_1.
- In state 2, principal will get ($x_2 - w_2$) and agent will get w_2.
- If no moral hazard, we could determine the optimal sharing rule (from the principal's view

[*] This model is adapted from Bengt Holmstrom, "Moral Hazard and Observability." *The Bell Journal of Economics* 10 (1979): 74-91.

point) by maximizing the principal's utility.
- We have to guarantee the minimum utility, or the agent would never enter into the contract.
- The agent's expected utility from the contract with the principal has to be at least as high as his opportunity cost associated with working in the next best alternative employment.

2) Analysis

$$\max E\{U_p\} = \rho U_p(x_1 - w_1) + (1-\rho)U_p(x_2 - w_2) \qquad (i)$$

$$s.t.\ E\{U_A\} = \rho U_A(w_1) + (1-\rho)U_A(w_2) \geq \overline{U}_A$$

The Lagrangean is

$$L = \rho U_P(x_1 - w_1) + (1-\rho)U_P(x_2 - w_2) + \lambda[\rho U_A(w_1) + (1-\rho)U_A(w_2) - \overline{U}_A] \qquad (ii)$$

The first-order conditions are

$$\begin{cases} \dfrac{\partial L}{\partial w_1} = -\rho MU_P(1) + \lambda\rho MU_A(1) = 0 \Rightarrow \lambda = \dfrac{MU_P(1)}{MU_A(1)} & (iii) \\ \dfrac{\partial L}{\partial w_2} = -(1-\rho)MU_P(2) + \lambda(1-\rho)MU_A(2) = 0 \Rightarrow \lambda = \dfrac{MU_P(2)}{MU_A(1)} & (iv) \end{cases}$$

Solving for λ from (*iii*) and (*iv*),

$$\lambda = \frac{MU_P(1)}{MU_A(1)} = \frac{MU_P(2)}{MU_A(2)} \qquad (v)$$

The last expression shows that the optimal sharing rule equates the marginal rates of substitution (MRS) between states of the world of the principal and the agent.

If the principal is risk neutral and the agent is risk averse, the optimal sharing rule has the principal guarantee the agent a fixed income, regardless of the state of the world. This is equivalent to having the principal pay the agent a fixed wage.

If the agent is risk neutral and the principal is risk averse, the optimal sharing rule has the agent guarantee the principal a fixed income, regardless of the state of the world. This is equivalent to having the agent pay a fixed rent to the principal.

Finally, if both parties are risk averse, the optimal sharing rule pays some share to each party in each state of the world, where the actual shares depend on the parties' relative attitudes toward risk.

4. Second-best Risk Sharing with Moral Hazard

If there is moral hazard, the agent will choose an unobservable action, which affects either the probability of a particular state of the world occurring or the level of output obtainable in each state of the world. Moral hazard exists when taking action to raise expected output involves some cost to the agent. This gives the agent an incentive to shirk.

Let's assume that the probability is a function of the action (*a*) and that there is some cost (*ca*), in utility terms, that is subtracted from the agent's expected utility or income.

The probability function is such that taking more action (working harder) lowers the

probability of observing the "bad" state,

$$\frac{\partial \rho}{\partial a} < 0 \qquad (vi)$$

This makes the agent's expected utility function with moral hazard

$$E\{U_A\} = \rho(a)U_A(w_1) + [1-\rho(a)]U_A(w_2) - ca \qquad (vii)$$

The agent chooses *a* to maximize his expected utility:

$$\frac{\partial}{\partial a}E\{U_A\} = \frac{\partial \rho}{\partial a}U_A(w_1) - \frac{\partial \rho}{\partial a}U_A(w_2) - c = 0 \qquad (viii)$$

The equation (*viii*) adds a further constraint to the principal's maximization problem. This is referred to as the incentive-compatibility constraint, meaning any sharing rule has to be compatible with the agent's incentive to shirk.

The new Lagrangean function (with moral hazard) will be

$$L = \rho(a)U_P(x_1 - w_1) + [1-\rho(a)]U_P(x_2 - w_2) + \lambda\left\{\rho(a)U_A(w_1) + [1-\rho(a)]U_A(w_2) - ca - \overline{U}_A\right\}$$
$$+ \mu\left[\frac{\partial \rho}{\partial a}U_A(w_1) - \frac{\partial \rho}{\partial a}U_A(w_2) - c\right] \qquad (ix)$$

The FOCs are

$$\begin{cases} \dfrac{\partial L}{\partial w_1} = -\rho MU_P(1) + \rho\lambda MU_A(1) + \mu MU_A(1)\dfrac{\partial \rho}{\partial a} = 0 & (x) \\ \dfrac{\partial L}{\partial w_2} = -(1-\rho)\,MU_P(2) + \lambda(1-\rho)\,MU_A(2) - \mu MU_A(2)\dfrac{\partial \rho}{\partial a} = 0 & (xi) \end{cases}$$

From (*x*),

$$\frac{MU_P(1)}{MU_A(1)} = \lambda + \frac{\mu}{\rho}\frac{\partial \rho}{\partial a} \qquad (xii)$$

From (*xi*)

$$\frac{MU_P(2)}{MU_A(2)} = \lambda - \frac{\mu}{1-\rho}\frac{\partial \rho}{\partial a} \qquad (xiii)$$

1) Sharing Rules

If the principal is risk neutral and the agent is risk averse, the last two expressions imply that the optimal sharing rule guarantees the agent a fixed payment, plus a variable payment which is a function of the amount of the observed output. The fixed payment represents less than full insurance provided by the principal. (If the agent were not risk averse, s/he would be willing to pay a fixed amount and absorb all the risk. That would solve the moral hazard problem and generate a Pareto optimal outcome.)

With a risk-averse agent, some insurance may be Pareto superior to none, but moral hazard means that Pareto optimality cannot be achieved with full insurance, even if the principal is risk neutral. A sharing rule that gives the agent more if x_2 is observed than if x_1 is observed [$(\partial\rho/\partial a) < 0$] reduces that moral hazard. Such a sharing rule is referred to as being **second best**. It is not Pareto optimal because both parties could be made better off if the agent's effort could be specified and enforced at no cost. But it does maximize the principal's utility, subject to the incentive-compatibility constraint and a minimum utility constraint for the agent.

5. Market signaling[†]

1) Education as a signal

Market signaling is a way for sellers of a good or service to convey hidden information about quality to buyers. Let's think about the model, where a worker's college educational background serves as a signal of the potential quality of his work. In this model, college education has no direct impact on the worker's productivity. High-quality workers are more productive because they are more efficient, not because they are well educated.

2) Educational Signaling Game (model)

- 1 worker and 2 prospective employers
- Nature specifies a worker as either high-quality or low-quality with probability 0.5. The worker knows her quality, but employers do not. Low-quality workers produce output $q = 6.00$ and high-quality workers produce output $q = 16.50$.
- Workers select a level of college education. $s_i = 1$ (college) and $s_i = 0$ (no college).
- The two employers each offer the worker a wage $w = w(s_i)$
- The worker accepts one of the two contracts or rejects both.
- $w(1) = 16.50$ and $w(0) = 6.00$
- $\pi_W = w - 72(s/q)$ (worker's payoff if s/he accepts one $w(s_i)$)
- $\pi_W = 0$ (if worker rejects both)
- $\pi_E = q - w$ (employer's payoff whose contract is accepted. Zero-profit line)
- $\pi_E = 0$ (for employer whose contract is rejected)

A crucial assumption of the Spence model is that the cost of education, $72(s/q)$, is greater for low-quality workers ($72/6 = 12$) than high-quality workers ($72/16.50 = 4.36$). This means that high-quality workers complete school in less time than low-quality workers, and there have lower opportunity costs of education (**single crossing condition** or **Spence-Mirrless condition**).

Competition between employers ensures that firms hire workers as long as the wage equals the value of the worker's output ($wage = VMP_L = p \cdot MP_L$).

- Hire low-quality worker if $w(s_i) = w(0) = q_L = 6.00$
- Hire high-quality worker if $w(s_i) = w(1) = q_H = 16.50$

- $\pi_W{}^L = w(0) - 0 = 6.00 - 0 = 6.00 > w(1) - \frac{72}{6.00} = 16.50 - 12 = 4.50$

  (The low-quality worker is better off not going to college)
- $\pi_W{}^H = w(0) - 0 = 6.00 - 0 = 6.00 < w(1) - \frac{72}{16.50} = 16.50 - 4.36 = 12.14$

  (The high-quality worker is better off going to college)

- The equilibrium for the education game is:

  s(*low-quality* worker) = 0; s(*high-quality* worker) = 1

  and

[†] A. Michael Spence, "Job Market Signaling," *Quarterly Journal of Economics*, vol. 87. pp. 355-374 (August 1973).

$$w(0) = 6.00 \; ; \; w(1) = 16.50$$

- Only high-quality workers get an education, so employers identify the high-quality workers and pay them a wage equal to 16.50. Low-quality workers elect not to get an education, so employers identify the low-quality workers and pay them a wage equal to 6.00.

- In this game, college education seems to be wasteful, because it imposes costs on society but does nothing to increase workers' productivity. Although this may be a disturbing conclusion, there are reasons to believe that even if a college education is only a signaling device, we are better off with a college education system.

- College enables us to match workers with jobs more efficiently. In the absence of college, employers would be unable to differentiate between high-quality and low-quality workers. Without college education signal, low-level position may be filled with high-quality workers and they are underutilized and many of the high-level positions will be under-productive.