31E12100 Microeconomics policy

Lecture 12: Investments

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Plan for the lecture

Two topics related to investments

They are both closely connected to the main themes covered during the course

1. Investment decisions and the value of information
    - Option values
    - Explains why and when optimal investments decisions cannot be based on NVP calculations only
    - Applies to irreversible decisions: nuclear power investments, development of wilderness areas, etc.
2. Regulation of natural monopolies and investments
    - Yardstick competition
    - Applies to local monopolies: electricity distribution companies, hospitals, water utilities, etc.

Investments and the option value

Investments and the option value of waiting

The following example illustrates a general principle:

- $t \in \{0, 1, 2, 3, ...\}$, periods
- I, investment cost, paid before production
- no other costs, the plant lives forever, once the investment cost is paid.
- output price in any future period is uncertain: can be either high $P = 10$ or low $P = 5$, with 50% probability. Price today is P_0
- $\delta = \frac{1}{1+r}$, discount factor for future revenues. Assume further:

$$P_0 + \frac{\delta}{1-\delta}5 < I < P_0 + \frac{\delta}{1-\delta}10 \qquad (1)$$

Question: Should we invest at time $t = 0$, that is, immediately, or is there something to be gained by postponing the investment?

First case: no value of waiting

- If the price is high $P = 10$ or low $P = 5$, with 50% probability, each future period, then each period expected price is 7.5
- The expected present-value revenue from investing immediately

$$NPV = -I + P_0 + \sum_{t=1}^{\infty} \delta^t 7.5 = -I + P_0 + \frac{\delta}{1-\delta} 7.5$$

- $NPV > 0$, no reason to wait; otherwise, don't invest at all.

Second case: the option value of waiting

- The expected price is still 7.5 but, instead of taking values 5 or 10 in each period, the price will be either 5 or 10 in all future periods
- The expected present-value revenue from investing immediately

$$-I + P_0 + \frac{\delta}{1-\delta}7.5 > 0 \tag{2}$$

- Wait and see:

$$NPV^{wait} = .5 \cdot [-\delta I + \frac{\delta}{1-\delta}10] + .5 \cdot 0 \tag{3}$$

- The value of information, $VI = NPV^{wait} - NPV$

$$VI = .5[-\delta I + \frac{\delta}{1-\delta}10] - [-I + P_0 + \delta \frac{\delta}{1-\delta}7.5] \tag{4}$$

- $VI > 0$, then it is optimal to wait and see. Consider

$$NPV \approx 0 \Rightarrow VI = .5[\frac{\delta}{1-\delta}10 - \delta I] > 0 \tag{5}$$

- It is always optimal to wait for more information if the immediate action is marginally profitable: the downside can be eliminated by waiting.
- Let us look at more closely what determines the option value of waiting

Bad news principle

If the investor is just indifferent between investment and the wait-and-see option:

$$-I + P_0 + \frac{\delta}{1-\delta}(.5 \cdot 5 + .5 \cdot 10) = .5[-\delta I + \frac{\delta}{1-\delta}10]$$

$$\Rightarrow$$

$$P_0 + .5\frac{\delta}{1-\delta}5 = I(1 - .5\delta)$$

This indifference is independent of $P = 10$! If the low price $P = 5$ is reduced, then it is better to wait-and-see; if higher, then immediate investment is strictly preferred. Thus the decision here depends only on how bad too early investment may turn out to be — the bad news principle.

Lessons

Information obtained by waiting can be valuable if (i) uncertain prices have persistence and (ii) investments are irreversible. Persistence means that one learns about future prices through current observations. If prices are independent in each period, then one does not learn by waiting. What creates such dependencies between periods?

- examples of persistent uncertainty: firms experiment with new products or technologies
- examples of idiosyncratic uncertainty: temperatures, rainfall, sunshine

The notion of irreversibility: investment cost is sunk and thus cannot be recovered.

- nuclear power plant: industry-specific investment. If turns out to be not valuable, likely to be so also in the eyes of potential buyers
- development of a wilderness area: preservation value lost for good.

Investments and regulation

Investments and regulation: yardstick competition

- Schleifer: A theory of yardstick competition, Rand Journal of Economics Vol. 16, No. 3, Autumn 1985
- N local monopolies: hospitals, electricity distribution operators, water utilities,..
- Cost-of-service pricing is typical. But this gives no incentives to take actions that lead to lower costs
- Yardstick competition: regulator sets the price of service (p_i) of firm i equal to the average marginal cost of all other firms j ($j \neq i$)
- $p_i = \frac{1}{N-1} \sum_{j \neq i} c_j$

First-best solution

For given choice of marginal cost c, firm's profits are

$$(p - c)q(p) - R(c)$$

where p is the price set by the regulator, $q(p)$ is the demand with that price, and $R(c)$ is the cost from choosing marginal cost c. Note that at production stage, we can take $R(c)$ as given, just like fixed cost:

$$TC = cq + R(c)$$
$$AC = c + \frac{R(c)}{q}$$

We have seen the solution to this problem: set $p = c$ and cover the losses with transfers $T = R(c)$

First-best solution: formally

We should choose (c, p, T) to maximize

$$\underbrace{[U(q) - pq)]}_{\textit{consumer}} + \underbrace{[(p - c)q - R(c)]}_{\textit{firm}}$$

where $q = q(p)$.

Optimal p:

$$\underbrace{[U'(q) - p]}_{=0} q'(p) \underbrace{-q + q}_{=0} + (p - c)q'(p) = 0$$

$$\Rightarrow p = c.$$

Optimal c:

$$-q - R'(c) = 0$$

Optimal T is then just T=R(c) (or anything larger than this, if transfers to the firm are not costly).

Costly transfers and Yardstick competition

The previous outcome can be modified to include transfers i.e., there could be a shadow cost of public funds, $\lambda > 0$. Then, the optimal (c, p, T) is found by maximizing

$$[U(q) - pq)] - (1 + \lambda)[R(c) + cq - pq]$$

Yardstick competition

In reality, the choice of c is made by the firm and $R(c)$ not observed. How to provide incentives for efficient choices?

$$p_i = \bar{c}_i = \frac{1}{N-1}\sum_{j\neq i} c_j$$
$$T_i = \bar{R}_i = \frac{1}{N-1}\sum_{j\neq i} R(c_j)$$

$$\max_{c_i}[q(\bar{c}_i)(\bar{c}_i - c_i) - R(c_i) + \bar{R}_i]$$
$$\Rightarrow -q(\bar{c}_i) - R'(c_i) = 0$$

That is, best response to $c_{j\neq i} = c^*$ is $c_i = c^*$. If all others choose efficient cost level, firm i will follow suit.

Yardstick competition: illustration from electricity distribution

- How to incentivize the companies to operate efficiently, taking into account information asymmetries etc.
- Finnish solution is a yardstick competition model on the efficiency of operations (CAPEX).
- Characteristics of the companies taken into account with an efficient frontier model
- Efficiency determined against an efficient frontier that is calculated with data from all companies.

Efficiency of operations

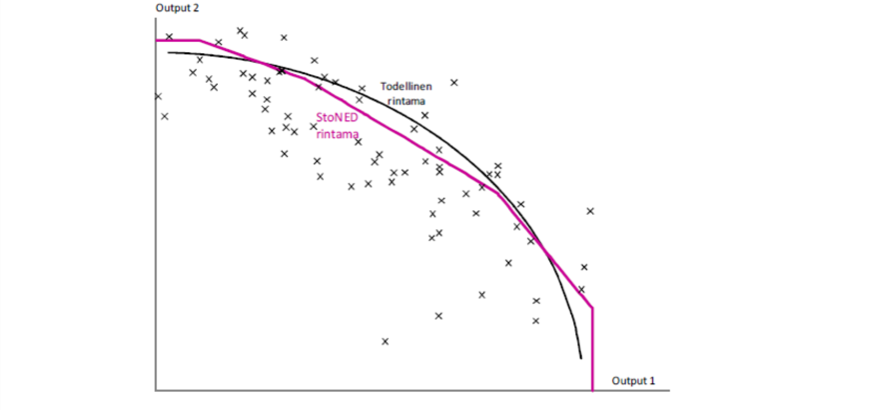

Figure 1: Efficient frontier gives the reference efficiency level for each company. An efficiency incentive rewards companies if they exceed their benchmark efficiency and penalizes them if not. Source: Energy Authority.