Contracts and Organizations

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Lecture 1

- Economics began with Xenophon's Oeconomicus (c 360 BCE), in which Socrates interviews a model citizen who has two primary concerns. He goes out to his farm in the country to monitor and motivate his workers there. Then he goes back to the city, where his participation in various political institutions is essential for maintaining his rights to own this farm. Such concerns about agents' incentives and political institutions are also central in economic theory today. But they were not always. (Myerson, AER, 2008)

- In this part of the course we look at incentives, organization design and contracting issues for provision of public goods & services

- Public organizations are wholly or partly involved with the production of public goods/services (e.g., schools, hospitals, environmental protection).

- This is to be distinguished from public sector organizations (i.e., government owned) or publicly traded companies (i.e., corporations).

- Effective provision of public goods
  - key determinant of quality of life
  - markets fail because the price mechanism cannot internalize externalities
  - Example: pollution, social concerns

- Traditional view equated public goods to government provision

- Benevolent government steps in, and uses

  - corrective taxes/subsidies

  - regulation

  - direct provision

- This view ignored

  - government failure

  - role of non-state non-market institutions such as voluntary organizations (non-profits, NGOs)

  - Earlier model assumed there are no agency problems within the public sector

- Does not mean we should mechanically apply the standard organization design of private goods provision (e.g., give high-powered incentives to all government employees)

- What is the key difference between a large corporation like Microsoft and a large government agency, for example, environmental protection

- Both have bureaucracies

- However, in the former case, in the end all the tasks have "money" prices associated with them (needs qualification)

- With public goods and services, there is an inherent element of the outcome that is non-priced ("quality" of health service)

- However, even for private goods quality may be non-contractible (e.g., "quality" of restaurants and plumbers)

- Some of the issues will be common

- After all, even for financial services the need for regulation and to monitor quality is abundantly clear at this very moment!

- However, for health and education, the benefits are realized much later, and may not be fully realized by the "consumers"

- Also, there is a public good element and so this calls for some degree of subsidization

- Optimal organization design depends not on which sector (public/private) happens to provide it but on:

  - distinguishing characteristics of public goods (e.g., benefits/costs not fully internalized in firm's profits)

  - technology of production

  - informational/contracting environment

Benchmark Principal-Agent Model

(based on Schmidt, 1997, Banerjee, Gertler, Ghatak, JPE 2002)

- A firm consists of a risk neutral principal & a risk neutral agent who is needed to carry out a project.

- The project's outcome is high $(Y = 1)$ or low$(Y = 0)$.

- When outcome is high, the principal receives a payoff of $\pi < 1$, otherwise receives 0.

- The agent does not directly care about project outcome.

- The probability of the high outcome is the effort supplied by the agent, e, at a cost $c(e) = e^2/2$.

- Effort $e \in [\underline{e}, \overline{e}]$ where $0 < \underline{e} < \overline{e} < 1$

- Unobservable and hence non-contractible.

- The agent has no wealth which can be used as a performance bond.

- Minimum consumption constraint of $\underline{w} \geq 0$ every period.

- The agent has a reservation payoff $\overline{u} \geq 0$

- The principal must earn a non-negative payoff.

First-best (effort contractible)

- Solve
$$\max_{e} \pi e - \frac{1}{2}e^2.$$
  - effort: $e = \pi$
  - expected joint surplus: $\pi^2 - \frac{1}{2}\pi^2 = \frac{1}{2}\pi^2$.

Second best (effort non-contractible)

- Two outcomes so a contract can be described by two components w (fixed wage) & b (bonus)

- Principal solves:
$$\max_{b,w} u^p = (\pi - b)\, e - w$$
subject to:

- *limited liability constraint* (LLC):

$$b + w \geq \underline{w}, w \geq \underline{w}.$$

- *participation constraint* (PC):

$$u^a = eb + w - \frac{1}{2}e^2 \geq \overline{u}.$$

- *incentive-compatibility constraint* (ICC):

$$e = \arg\max_{e \in [0,1]} \left(eb + w - \frac{1}{2}e^2 \right) = b.$$

- Can achieve first-best by setting $b = \pi$ but that implies non-positive expected profits as $\underline{w} \geq 0$.

- Trade-off between efficiency (setting b high) and rent extraction (setting b low).

- If agent had wealth or limited liability constraint was absent, the principal could have "sold off" the firm to the agent by setting $b = \pi$ & $w = \overline{u} - \frac{1}{2}\pi^2 < 0$.

- So set w as low as possible (no risk-sharing issues), i.e., $w = \underline{w}$ and choose b to balance incentive provision & rent extraction.

- Case 1 (PC does not bind as $\overline{u}$ low)
  - Principal maximizes $(\pi - b)b - \underline{w}$
  - Bonus is $b^* = \frac{\pi}{2}$

- Case 2 (PC binds as $\overline{u}$ high)
  - Agent's binding PC: $\frac{1}{2}b^2 + \underline{w} = \overline{u}$.
  - Yields $b^* = \sqrt{2\left(\overline{u} - \underline{w}\right)}$

- Figure displays b and expected joint surplus (S) against reservation payoff.

- Bonus first flat (reservation payoff low, PC doesn't bind) and then increases with $\overline{u}$.

Advantages of this Model

- Payoffs are linear - gives you closed form solutions for contracts, efforts

- Since two outcomes are possible, the contract is the optimal mechanism - no ad hoc contracting assumption

- Generates the possibility of rents (PC not binding)

- Comparative statics with respect to u, π straightforward: richer agents need more incentive pay

Measurement Problems (Baker, JPE 1992)

- Often output or performance in the context of provision of public goods or services is very hard to measure.

- For private goods, however complex the product, there is always a “bottom line” in the form of sales or profits

- Not true for "experience goods": quality of some consumer goods can only be full realized well after the purchase

- Outcome measure is noisy: signal $\sigma \in \{0, 1\}$

- Let $\gamma(1)$ denote the probability that the signal is $\sigma = 1$ when the project is successful and let $\gamma(0)$ denote the probability that the signal is $\sigma = 1$ when the project is a failure.

- We assume that the signal is (weakly) informative in the sense that $\gamma(1) \geq \gamma(0)$.

- If $\gamma(1) = 1$ and $\gamma(0) = 0$, then output is perfectly observed.

- The first-best effort level is:

$$e^* = \arg\max_e \left\{ e\pi - \frac{c}{2}e^2 \right\} = \frac{\pi}{c}.$$

- We assume $\frac{\pi}{c} < 1$ to focus on interior solutions.

- A contract is a pair $\{b(\sigma)\}_{\sigma\in\{0,1\}}$. It is straightforward to solve for the optimal incentive scheme.

- Let $\Delta = \gamma(1) - \gamma(0)$.

- First, observe that the optimal effort level of the agent is:

$$\begin{aligned}\hat{e} &= \arg\max_{e}\{e\Delta\left[b(1) - b(0)\right] + \\ &\quad \left[\gamma(0)\left[b(1) - b(0)\right] + b(0) - \frac{c}{2}e^2\right]\} \\ &= \frac{\Delta\left[b(1) - b(0)\right]}{c}.\end{aligned}$$

- Plugging this into the principal's payoff function, she chooses the contract to maximize:

$$\frac{\Delta\left[b(1) - b(0)\right]}{c}\left[\pi - \Delta\left[b(1) - b(0)\right]\right] \\ -\gamma(0)\, b(1) - (1 - \gamma(0))\, b(0).$$

- Then we have: the optimal contract sets $b\left(0\right)=0$ and

$$b\left(1\right)=\max\left\{0,\frac{\pi\Delta-\gamma\left(0\right)c}{2\Delta^{2}}\right\}.$$

- The corresponding effort level is

$$e=\max\left\{0,\frac{b(1)\Delta}{c}\right\}.$$

- This result is intuitive. It is optimal to reduce $b\left(0\right)$ down to the minimum possible level (given limited liability), i.e., 0, as extra effort can be elicited while reducing the principal's cost. The interesting issue is whether it is worthwhile to offer a bonus when the verifiable signal $\sigma=1$ is observed.

- Here, Proposition 1 says that, if the output is sufficiently well-measured, then there is positive incentive pay to elicit effort.

- Specifically, this will be the case if

$$\frac{\pi}{c} \geq \frac{\gamma\left(0\right)}{\Delta}.$$

- This is more likely to be satisfied the higher is $\gamma(1)$ and the lower is $\gamma(0)$. In particular, it will always hold when $\gamma\left(0\right)$ is close enough to zero.

- If this condition does not hold, it is not worthwhile for the principal to use any incentive pay at all.

Multi-Tasking

Holmstrom-Milgrom, 1991

- If the agent performs several tasks, and the performance measures of these tasks are not equally good, then it may not be efficient to give explicit incentives

- For example, teachers can invest effort to improve the test scores of their students, but also to impart skills such as curiosity, values that are hard to measure but important nevertheless

- If you reward teachers only on exam performance measures of their students, they will cut down the second type of effort and overall the outcome may be less desirable than when they are paid a flat wage.

- Modify the basic model in the following way:

- two tasks, requires efforts e_1 & e_2

- the cost of effort for each task is

$$\begin{aligned} c(e_1) &= \frac{1}{2}e_1^2 + \gamma e_1 e_2 \\ c(e_1) &= \frac{1}{2}e_2^2 + \gamma e_1 e_2 \end{aligned}$$

- $\gamma > 0$ means the tasks are substitutes, $\gamma < 0$ means they are complements

- assume $|\gamma| < 1$.

• the bonuses for performance measure in each task is b_1 and b_2

• task two is noisy as in previous model

• for simplicity $q = 1 - p$

- agent's IC for the two tasks

$$\max_{e_1,e_2} b_1 e_1 + b_2\{pe_2 + (1-p)(1-e_2)\} - \frac{1}{2}e_1^2 - \frac{1}{2}e_2^2 - \gamma e_1 e_2$$

$$\begin{aligned} b_1 &= e_1 + \gamma e_2 \\ b_2(2p-1) &= \gamma e_1 + e_2 \end{aligned}$$

- This yields

$$\begin{aligned} e_1 &= \{b_1 - \gamma(2p-1)b_2\}\tau \\ e_2 &= \{(2p-1)b_2 - \gamma b_1\}\tau \end{aligned}$$

where $\tau \equiv \frac{1}{1-\gamma^2}$

- the principal's problem:

$$\max_{b_1,b_2} (1-b_1)e_1 + e_2 - \{pe_2 + (1-p)(1-e_2)\} b_2$$

subject to the ICCs

- solving the first-order conditions yields

$$
\begin{aligned}
b_1 &= \frac{1}{2}\left[1 - \frac{\gamma(1-p)}{(2p-1)\left(1-\gamma^2\right)}\right] \\
b_2 &= \frac{1}{2}\frac{1}{2p-1}\left[1 - \frac{(1-p)}{(2p-1)\left(1-\gamma^2\right)}\right].
\end{aligned}
$$

- If $p = 1$ then $b_i^* = \frac{1}{2}$

- Otherwise, noise in second task measure is making incentives in first task flatter so long as $\gamma > 0$

- That is, if tasks are substitutes, incentives are flatter.

- The intuition is: giving more incentives in one task, makes reduces effort in the other task and so do it at a lower level

- If tasks are complements, incentives are sharper and the result goes the other way.

- Question
  - why can't the tasks be unbundled? technology, expertise
  - why can't agent be made full residual claimant? limited liability.
  - in H-M's original model (1991) if you set the risk aversion parameter $r = 0$ then get first-best

- Alternative version based on some intrinisic motivation on the part of the agent

- Outcome of task 1 is very hard to measure, so set $b = 0$ by earlier argument.

- Offer bonus b for success in task 2 which has a good performance measure

- Agent cares about success in both tasks to some degree: θ

- Agent solves

$$\max_{e_1, e_2} \theta e_1 + (\theta + b)\, e_2 - (\frac{1}{2} e_1^2 + \frac{1}{2} e_2^2 + \gamma e_1 e_2)$$

- First order conditions

$$\begin{aligned} \theta &= e_1 + \gamma e_2 \\ \theta + b &= e_2 + \gamma e_1 \end{aligned}$$

- Solving simultaneously:

$$
\begin{aligned}
e_1 &= \frac{1}{1-\gamma^2}\{\theta(1-\gamma)-\gamma b)\} \\
e_2 &= \frac{1}{1-\gamma^2}\{\theta(1-\gamma)+b\}
\end{aligned}
$$

- Assume $\gamma < 1$

- Implication: if $\gamma > 0$, then a high bonus reduces e_1

- Also, unless agent has some intrinsic motivation ($\theta > 0$), $e_1 = 0$

- Principal solves

$$
u^p = \max_b \pi_1 e_1 + (\pi_2 - b)\, e_2.
$$

- Use the incentive-compatibility constraints to express this in terms of b

$$\frac{1}{1-\gamma^2} \max_b \pi_1 \{\theta(1-\gamma) - \gamma b\} + (\pi_2 - b)\{\theta(1-\gamma) + b\}$$

- Solving first-order condition w.r.t. b :

$$b^* = \max\left\{\frac{\pi_2 - \gamma\pi_1 - \theta(1-\gamma)}{2}, 0\right\}$$

- If principal does not care very much about task 1 (π_1 low) or cares a lot about task 2 (π_2 high) then b^* more likely to be positive

- If agent is highly motivated in task 2 (α high) or not at all motivated in task 2 (β low) then more likely to use bonus

Multiple Principals

Dixit, 1996.

- Several principals are simultaneously trying to influence the actions of an an agent

- For public goods, an agent's action affects several parties & these payoffs are not all aggregated through a net profit measure

- For example a school principal is accountable both to parent's bodies, the teacher's union, & to owners of the school

- Modify the basic model in the following way:
  - One agent undertakes two actions, e_1 and e_2

- all tasks are well measured
- The cost function of the agent is $\frac{1}{2}e_1^2 + \frac{1}{2}e_2^2 + \gamma e_1 e_2$ ($\gamma > 0$ means actions are substitutes, complements otherwise)
- Two principals, 1 & 2 who derive payoffs π_1 & π_2, offer bonuses b_1 & b_2

- Agent solves

$$\max_{e_1, e_2} b_1 e_1 + b_2 e_2 - (\frac{1}{2}e_1^2 + \frac{1}{2}e_2^2 + \gamma e_1 e_2)$$

- Yields (upon simplification)

$$\begin{aligned} e_1 &= (b_1 - \gamma b_2)\,\tau \\ e_1 &= (b_2 - \gamma b_1)\,\tau \end{aligned}$$

where $\tau \equiv \frac{1}{1-\gamma^2}$

- Principal 1 takes the bonus of principal 2 as given when choosing b_1, & likewise for principal 2.

- Principal i solves

$$\max_{b_i} (\pi_i - b_i)(b_i + \alpha b_j)\tau$$

- Yields

$$\begin{aligned} b_1^* &= \frac{2\pi_1 + \gamma\pi_2}{4 - \gamma^2} . \\ b_2^* &= \frac{2\pi_2 + \gamma\pi_1}{4 - \gamma^2}. \end{aligned}$$

- Note that with $\gamma < 0$ (complements) bonus lower than if the tasks were independent, & for $\gamma > 0$ (substitutes) the opposite holds.

- Intuition: since tasks are complements, principal 1 knows agent will put in some e_1 for free due the incentive scheme in place for task 2. Free riding.

- However, if the two principal's maximized joint surplus we would get $b_1^* = \frac{\pi_1}{2}$ and $b_2^* = \frac{\pi_2}{2}$

Motivated Agents

Besley & Ghatak, AER 2005.

- Three key departures
  - Motivation: agents intrinsically care about project outcome (dedicated teachers, doctors)
  - Mission preferences: Principals & agents differ in terms of preferences over "how to run the project" (e.g., whether to have a religious component in education)
  - Matching: Endogenous matching of principals and agents - different notion of competition.
- Projects differ in terms of their missions.
- Mission: attributes of a project that make some principals & agents value its success over & above any monetary income they receive in the process.

- Could be based on:
  - what the organization does (charitable versus commercial)
  - how they do it (environment-friendly or not)
  - who is the principal (kind and caring versus strict profit-maximizer) etc.

- Mapping from effort to outcome is same for all projects

- Agents have the ability to work on any project

- Basic model: missions are exogenously given attributes of a project associated with a given principal.

- Three *types* of principals and agents labelled $i \in \{0, 1, 2\}$ and $j \in \{0, 1, 2\}$

- If project successful, a type i principal receives $\pi_i > 0$. If project fails, receives 0.

- For type 0 principals, payoff is entirely monetary

- For type 1 & 2 principals, payoff may have a non-monetary component. Assume $\pi_1 = \pi_2 \equiv \hat{\pi}$ to focus on horizontal sorting.

- Like principals, all agents are assumed to receive 0 if the project fails.

- Agents of type 0 have standard pecuniary incentives.

- An agent of type 1 (type 2) receives a non-pecuniary benefit of $\overline{\theta}$ from project success if he works for a principal of type 1 (type 2) & $\underline{\theta}$ if matched with a principal of type 2 (type 1), where $\overline{\theta} > \underline{\theta} \geq 0$. *Motivated* agents.

- The payoff of an agent of type j who is matched with a principal of type i when the project succeeds can be summarized as:

$$\theta_{ij} = \begin{cases} 0 & i = 0 \text{ and/or } j = 0 \\ \underline{\theta} & i \in \{1,2\}, j \in \{1,2\}, i \neq j \\ \overline{\theta} & i \in \{1,2\}, j \in \{1,2\}, i = j. \end{cases}$$

- Economy is divided into a *mission-oriented sector* ($i = 1, 2$) & a *profit-oriented sector* ($i = 0$). The latter is exactly like benchmark model.

Optimal Contracts

- Optimal contract (w_{ij}, b_{ij}) for an exogenously given match of a principal of type i & an agent of type j.

- Agent's reservation payoff $\overline{u}_j \geq 0$ is exogenously given (endogenize later)

- **First-best** (effort contractible). Solve

$$\max_{e_{ij}} \left(\pi_i + \theta_{ij}\right) e_{ij} - \frac{1}{2} e_{ij}^2.$$

  - effort: $\pi_i + \theta_{ij}$
  - expected joint surplus: $\frac{1}{2}(\pi_i + \theta_{ij})^2$.

- **Second best.** Solve:

$$\max_{\{b_{ij}, w_{ij}\}} u_{ij}^p = \left(\pi_i - b_{ij}\right) e_{ij} - w_{ij}$$

  subject to:

(i) *limited liability constraint* (LLC):

$$b_{ij} + w_{ij} \geq \underline{w}, w_{ij} \geq \underline{w}.$$

(ii) *participation constraint* (PC):

$$u_{ij}^{a} = e_{ij}\left(b_{ij} + \theta_{ij}\right) + w_{ij} - \frac{1}{2}e_{ij}^{2} \geq \overline{u}_{j}.$$

(iii) *incentive-compatibility constraint* (ICC):

$$\begin{aligned} e_{ij} &= \arg\max_{e_{ij}\in[0,1]}\left(e_{ij}\left(b_{ij} + \theta_{ij}\right) + w_{ij} - \frac{1}{2}e_{ij}^{2}\right) \\ &= b_{ij} + \theta_{ij} \end{aligned}$$

- **Effort** less than first-best level $\pi_i + \theta_{ij}$, otherwise principal earns negative expected payoff

- $\overline{v}_{ij} \equiv$ value of reservation payoff of an agent of type j s.t. a principal of type i gets zero expected profits under an optimal contract

- $\underline{v}_{ij} \equiv$ value of reservation payoff such that for $\overline{u}_j \geq \underline{v}_{ij}$ the agent's PC binds.

- For *a given reservation payoff* $\overline{u}_j \in \left[0, \bar{v}_{ij}\right]$ an optimal contract exists.

- Fixed wage is set at subsistence level $\underline{w}$ (no risk sharing issues, & has no effect on incentives). Anything else is paid as a bonus

- Due to limited liability in choosing b principal faces trade-off between providing incentives to agent (b higher) & transferring surplus from agent to himself (b lower).

- Accordingly, reservation payoff of agent plays an important role in determining b (higher it is, the higher is b)

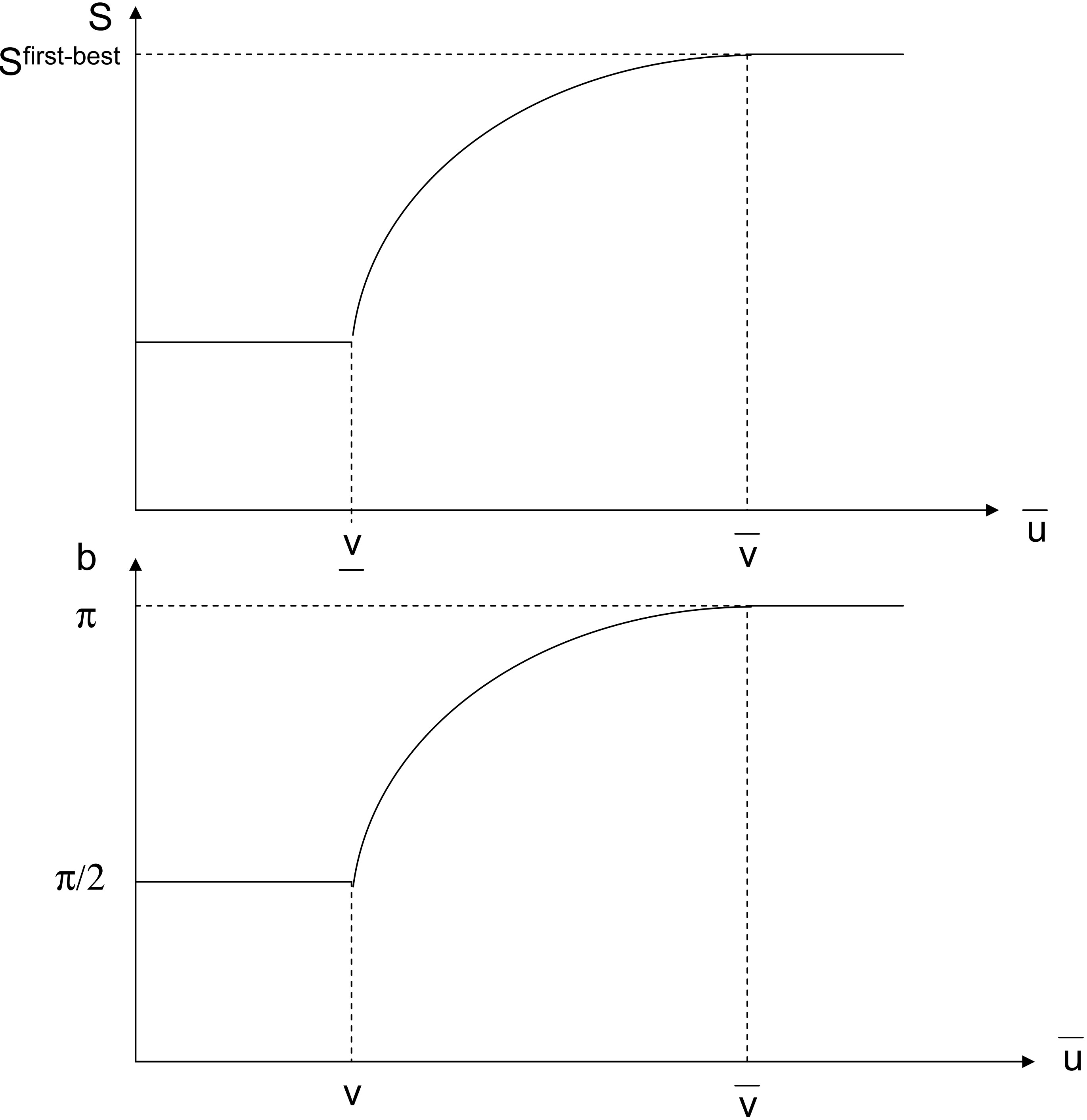
- Agent motivation plays a role as well in the choice of b: for same level of b, an agent with greater motivation will supply higher effort.

- To principal b is a costly instrument of eliciting effort. As agent motivation is a perfect substitute motivated agents receive lower incentive pay.

- Case 1 (PC does not bind as $\overline{u}_j$ low)
  - Principal maximizes $(\pi_i - b)(b + \theta_{ij}) - \underline{w}$
  - Bonus is $b^*_{ij} = \max\left\{\frac{\pi_i - \theta_{ij}}{2}, 0\right\}$
  - Case 1a: Agent is more motivated than principal ($\theta_{ij} \geq \pi_i$): $b^*_{ij} = 0$ (no incentive pay)
  - Case 1b: Principal is more motivated than agent ($\pi_i > \theta_{ij}$): $b^*_{ij} = \frac{1}{2}\left(\pi_i - \theta_{ij}\right)$ (decreasing in agent motivation)

- Case 2 (PC binds as $\overline{u}_j$ high) Agent's binding PC: $\frac{1}{2}\left(b_{ij} + \theta_{ij}\right)^2 + \underline{w} = \overline{u}_j$.
  - Yields $b^*_{ij} = \sqrt{2\left(\overline{u}_j - \underline{w}\right)} - \theta_{ij}$.
  - Bonus is set by the outside market with a discount depending on agent's motivation.

- Observations
  - Bonuses less than that in standard model
  - In case 1, the marginal cost of eliciting effort has gone down, so principal pays less bonus
  - In case 2, bonus is set by outside market, but principal gets a discount due to agent motivation
  - Effort is still less than the first-best
  - Negative correlation between effort and bonuses - surprise!
  - Not really, driven by selection: more motivated workers work harder, and are paid lower bonuses.



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$S^{\text{first-best}}$
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