Pay for Performance in Procurement

Juan-José Ganuza, Fernando Gómez (Universitat Pompeu Fabra)

Makoto Hanazono (Nagoya University)

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Procurement and Incentives

- Governments and firms procure products/services, which often involves customization.

- In doing so, they face info/contracting problems:
  - [**Selection**] Which supplier is suitable to contract?
  - [**Performance**] How to improve performance incentive?
  - [Incomplete Contracts] Unforeseen contingences. Holdups.
  - [Other concerns] Collusion, corruption, etc.

- In procurement contracts, **the use of powerful pay for performance** seems to be rare. Why?

“Inefficiently” Low Penalties

- **Lewis and Bajari (2011,14)**:
  - An estimate of commuter damage caused by a construction delay in US 101 is $1.75 million per day while highway contractors in California are penalized with damages of up to $40,000 per day.
  - They report similar facts on the penalty system for Minnesota highway construction contracts.

What We Do

- This paper provides **a rationale for the poor incentive mechanisms** used in procurement.

- We analyze a procurement setting, in which **a project with ex-post moral hazard is competitively allocated**
  - Firms differ in costs and in assets (capitalization, solvency).
  - Contractors are protected by **limited liability**.

Main Findings

- **Competitive mechanisms adversely select undercapitalized firms** for undertaking projects with ex-post moral hazard.

- **Powerful incentive mechanisms backfire:** *with more powerful incentive scheme, the winning firm is likely to be less solvent and less efficient in undertaking the project.*

Takeaway: Dual Roles of Performance Pay

- The Power of Incentive Schemes affects
  - **Effort provision** at performance stage
  - **Contractor selection** at bidding, since the contractor's expected cost changes.

- **Adverse selection** in terms of (in)solvency arises when firms are protected by limited liability. Insolvent firms are more aggressive in bidding stage and more likely to be selected.

- **A new tradeoff**: Incentives and Efficient Selection. *Powerful incentive schemes may exacerbate adverse selection*.

Literature

Auctioning Incentive Contracts: Holt (79), McAfee-McMillan (86,87), Laffont-Tirole (87), Chakraborty et al. (21).

Procurement/Auctions w/ Limited Liability: Manelli,Vincent (95), Zheng (01), Calveras,Ganuza,Hauk (04), Board (07), Chillemi,Mezzetti (10), Burguet,Ganuza,Hauk (12).

Judgement Proofness: Shavell (86); Miceli,Segerson (03); Ganuza,Gomez (08,11)

Model Formulation

- **A sponsor** procures a project.
- **A contractor** is chosen among N risk-neutral firms:
  - **Private info**: (w_i, c_i); wealth and production cost.
  - **Ex Post Moral Hazard:** Performance: $\theta \in \{\underline{\theta}, \overline{\theta}\}$

    Effort: $x \geq 0$. unobserved, non-pecuniary.

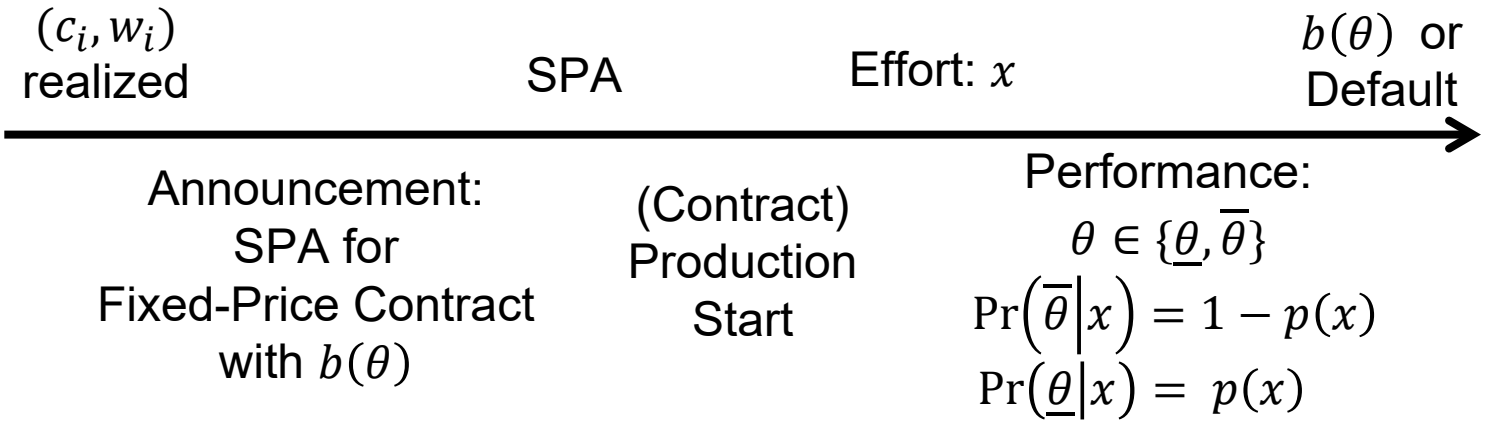
    $\mathbf{Pr}(\underline{\theta}|x) = p(x)$; $p'(x) < 0$ $p''(x) > 0$
  - **Protected by limited liability**.
- **Pay for performance**: $b(\theta)$

  first consider **penalty**: $b(\underline{\theta}) = -b, b(\overline{\theta}) = 0.$

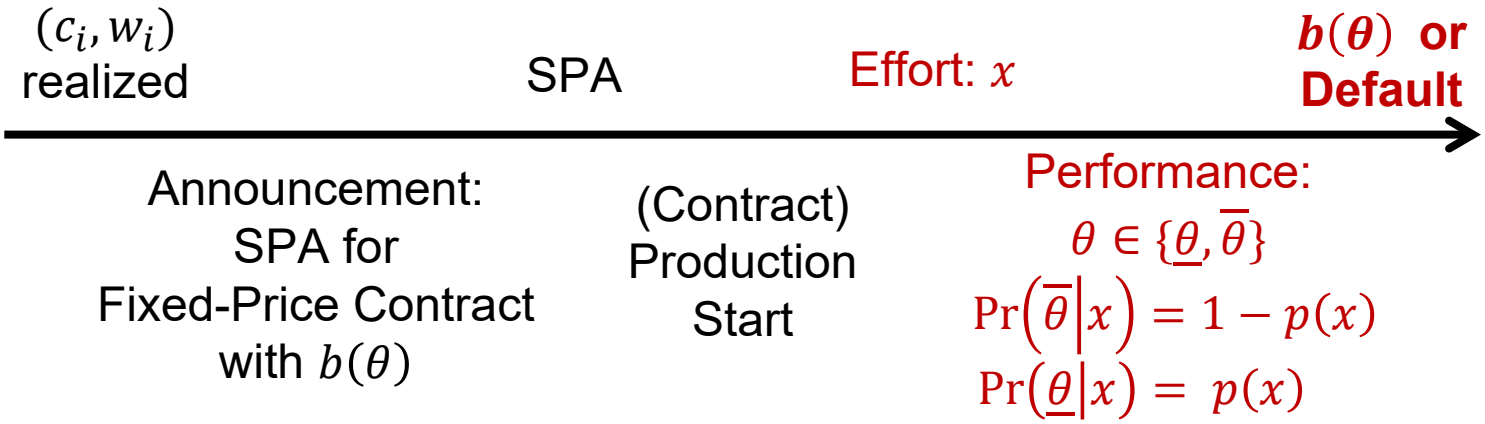
Model Formulation (cont'd)

- **Selection**: Second-Price Auction.
- **Winning Firm (contractor)**
  - Incurs production cost c to start.
  - **Limited Liability**: $P - c + w < b \Rightarrow$ default. Pay $P - c + w$.
- **Sponsor's payoff:**
  - $V + \theta - b(\theta) - P$ without default
  - $V + \theta - c + w - K$ with default

Time Line


(c_i, w_i)
realized
SPA
Effort: x
$b(\theta)$ or
Default
Announcement:
SPA for
Fixed-Price Contract
with $b(\theta)$
(Contract)
Production
Start
Performance:
$\theta \in \{\underline{\theta}, \overline{\theta}\}$
$\Pr(\overline{\theta}|x) = 1 - p(x)$
$\Pr(\underline{\theta}|x) = p(x)$

Performance Stage



Performance Stage

- Recall: $b(\underline{\theta}) = -b, b(\overline{\theta}) = 0$
- If $\theta = \underline{\theta}$ and $b > P - c + w$, contractor defaults.
- Effective penalty for $\theta = \underline{\theta}$: $z = \min\{P - c + w, b\}$.

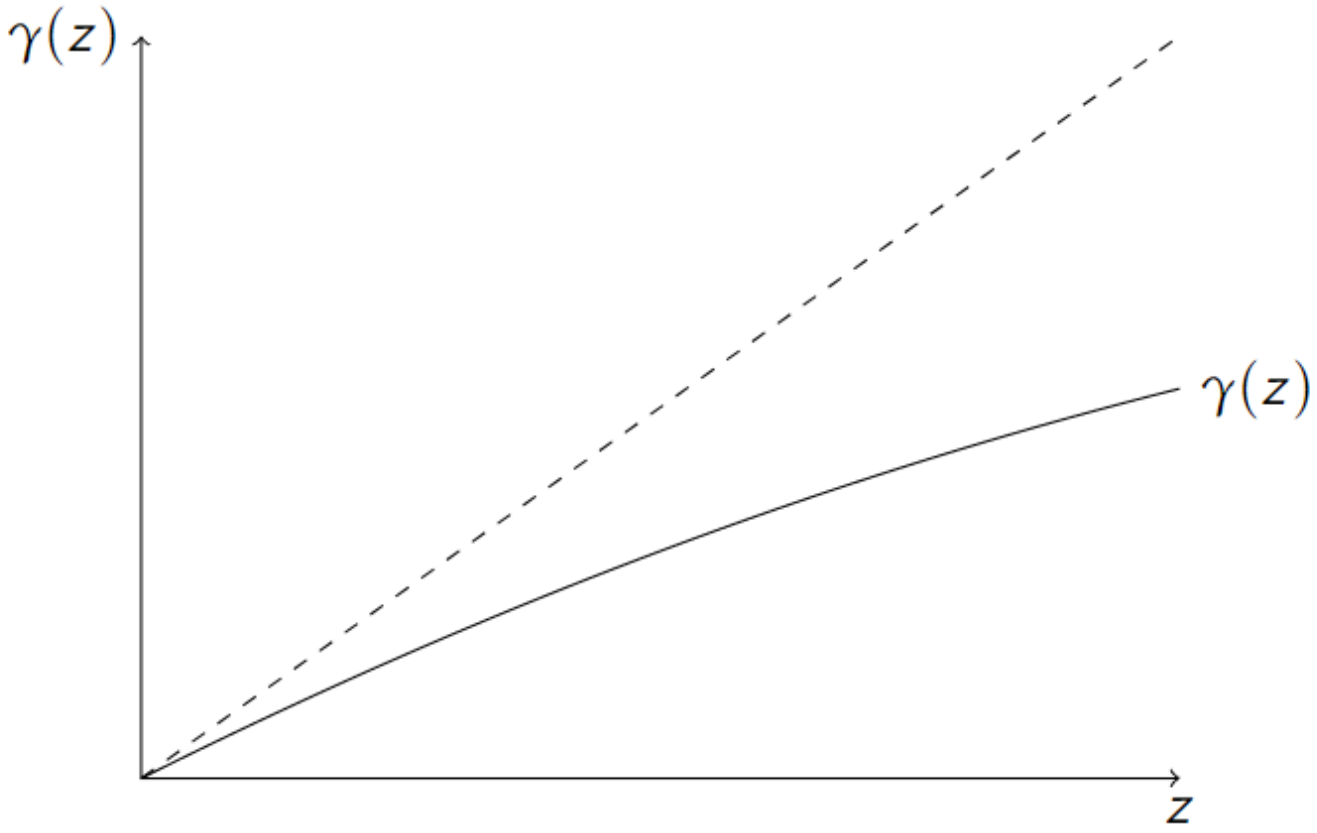
- Given z, the contractor's **optimal effort:**

$$x^*(z) \in \arg\min p(x)z + x$$

- **Expected cost of performance:**

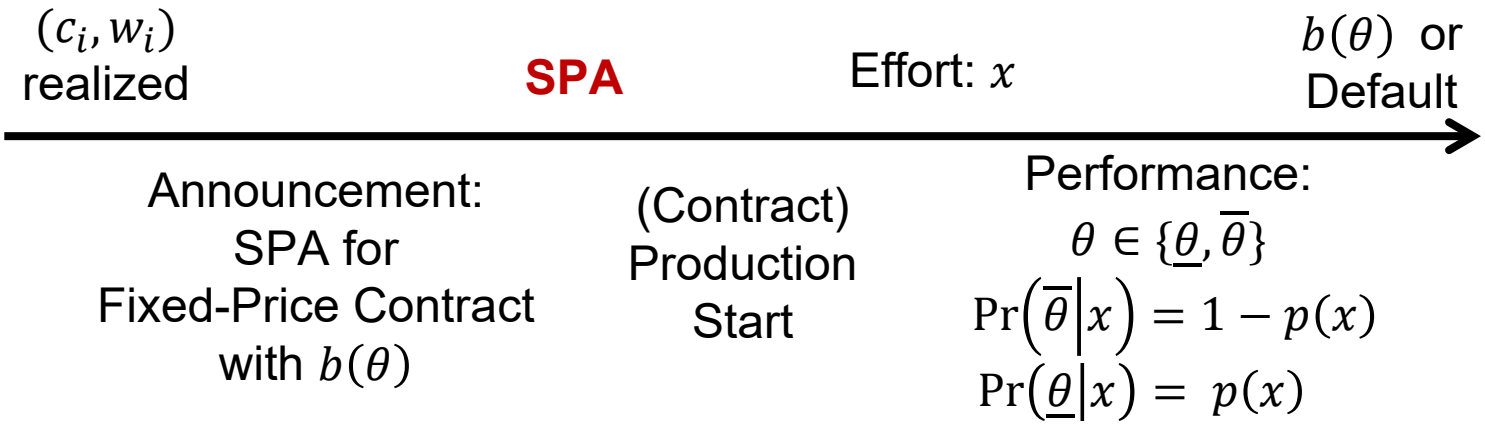
$$\gamma(z) = p\big(x^*(z)\big)z + x^*(z)$$

Expected cost of performance



$\gamma(0) = 0, 0 < \gamma'(z) = p(x^*(z)) < 1$ and $\gamma''(z) \leq 0$.

Bidding Stage



Bidding Stage

- The **net expected profits of the contractor:**

$$\pi(P, c, w, b) = P - c - \gamma(\min\{P - c + w, b\})$$

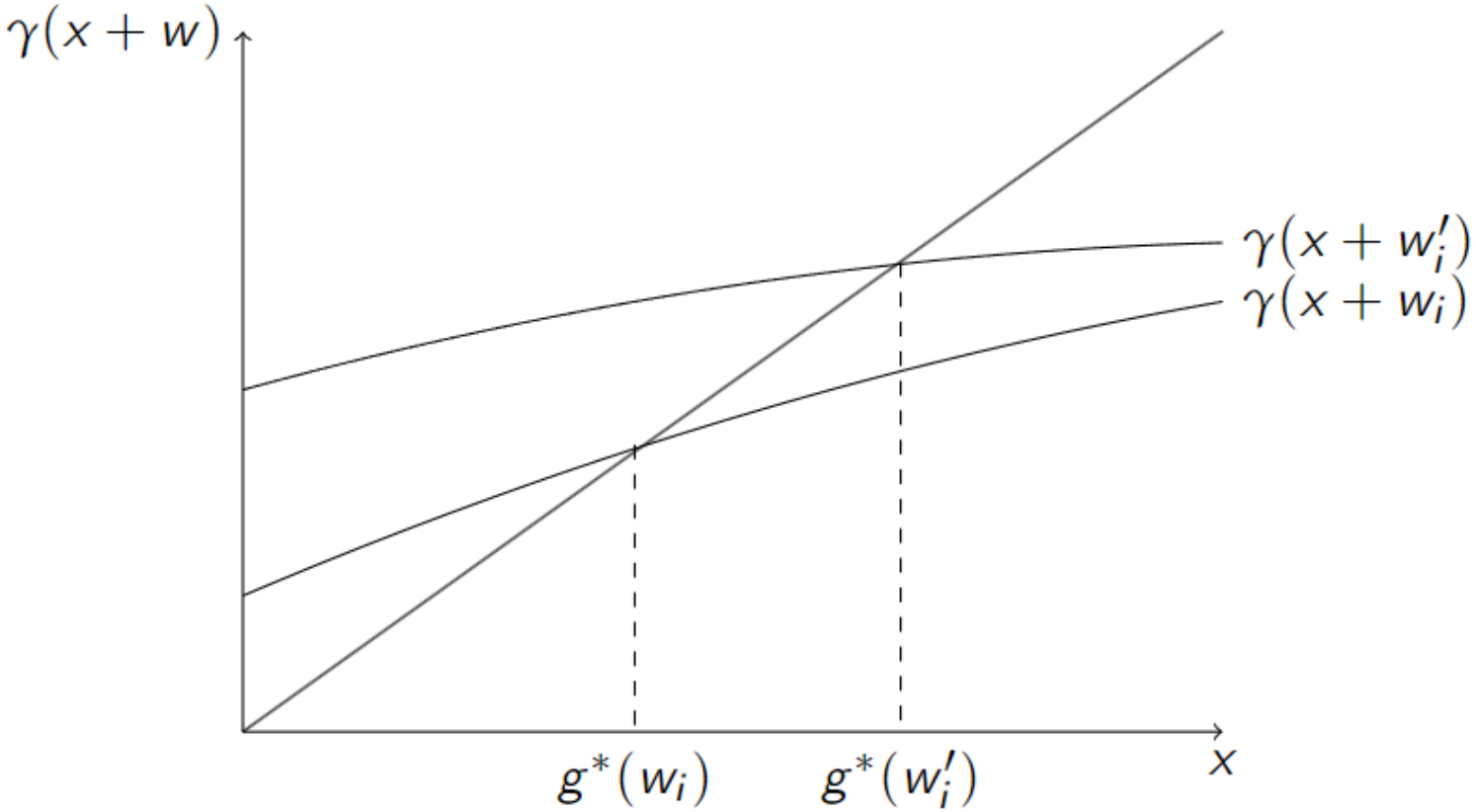
- **SPA**: for (c_i, w_i), : bid $\boldsymbol{P_i^*}$; $\pi(\boldsymbol{P_i^*}, c_i, w_i, b) = 0$.
  - If the firm has no risk of default: $P_{\mathrm{i}}^* = c_i + \gamma(b)$.
  - If default is expected, E[cost of perform] depends on bid price;

$$P_{\mathrm{i}}^* = c_i + \gamma(P_i^* - c_i + w_i)$$
$$\Leftrightarrow P_{\mathrm{i}}^* - c_i = \gamma(P_i^* - c_i + w_i)$$

  - **Equilibrium Default Markup:** $g^*(w_i) = \gamma(g^*(w_i) + w_i)$.

Equilibrium Default Markup

$$g^*(w_i) = \gamma(g^*(w_i) + w_i)$$



$g^{*\prime}(w_i) > 0, g^*(0) = 0$ and $g^*(b - \gamma(b)) = \gamma(b)$.

The equilibrium bidding markup:

$$g(b, w_i) = \begin{cases} \gamma(b), & w_i > \hat{w}(b) \\ g^*(w_i), & otherwise \end{cases}$$

$$where\ \hat{w}(b) = b - \gamma(b)$$

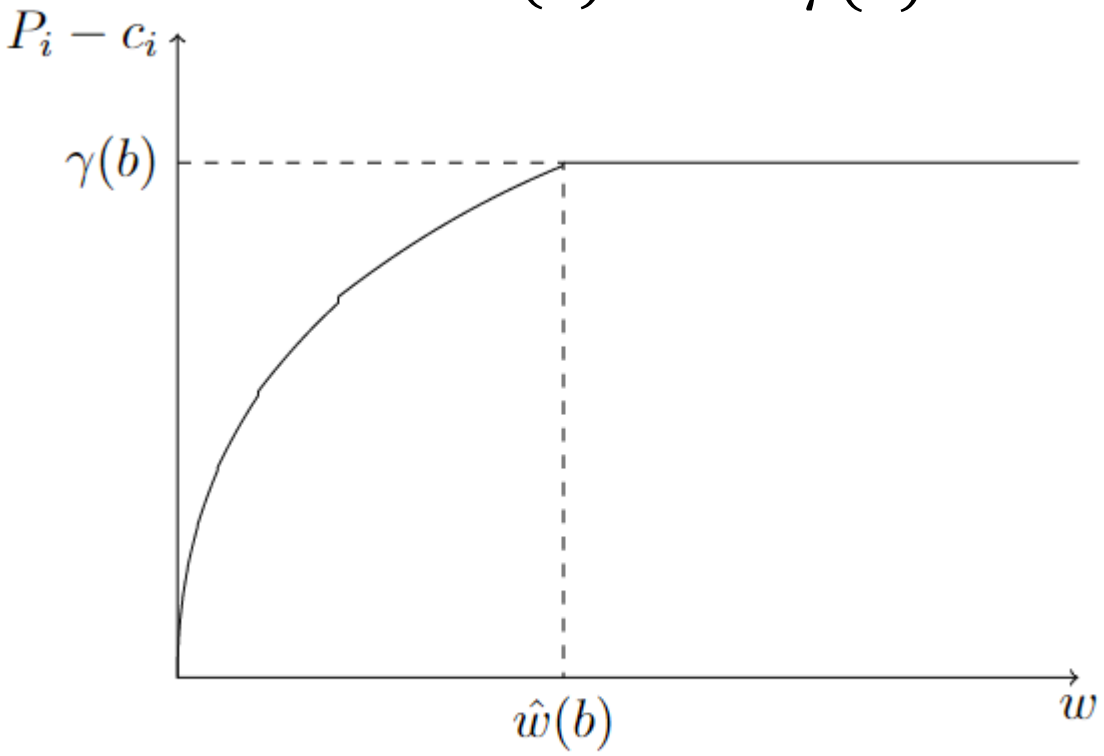
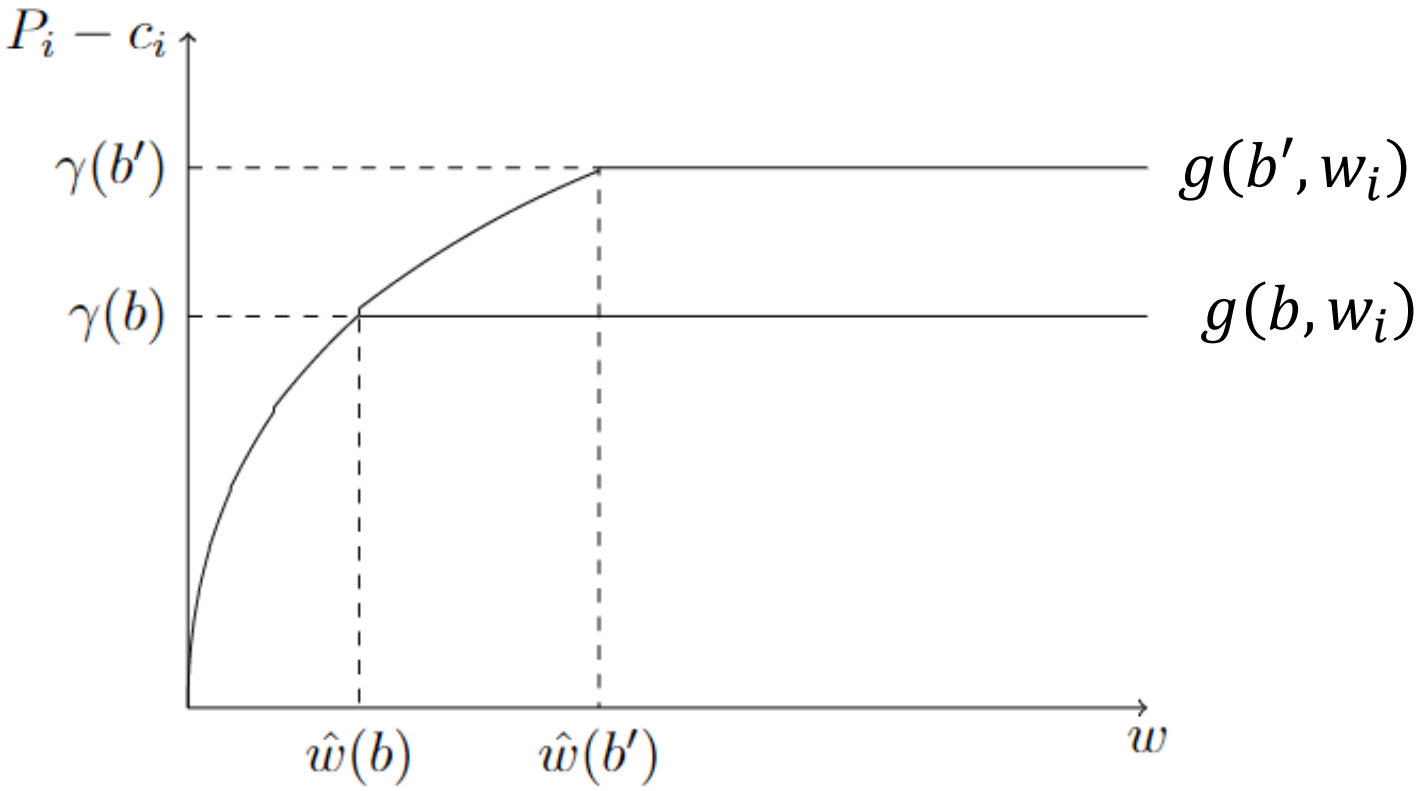


Figure 2 : The bidding equilibrium for b

$g(b, w_i)$ is weakly supermodular.



Equilibrium Bidding

Proposition 2: *Equilibrium SPA bid is*

$$P_i^* = c_i + g(b, w_i),$$

which is weakly increasing in b *and* w_i. *Moreover,* since $g(b, w_i)$ is *weakly supermodular in* (b, w_i), *so is the equilibrium bidding.*

- **[Adverse selection]** *Wealth is detrimental in competition, and*

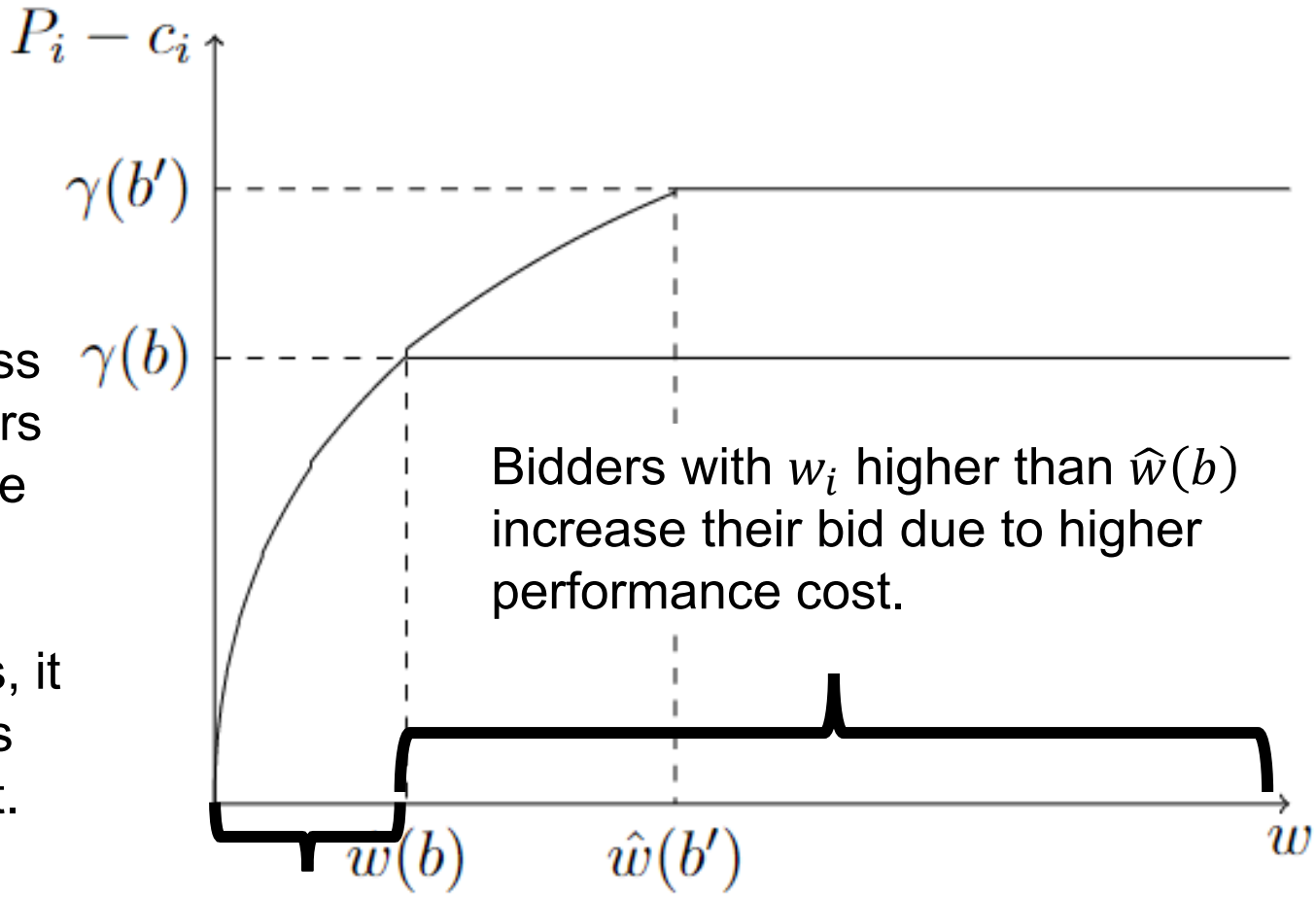
is *more detrimental as penalty (incentive) becomes severer.*

Increasing Incentives, worsening Allocation

- **Proposition 3**: *Under a higher penalty, the winner will be weakly less solvent and* ***less cost efficient***.

- Let (w, c) be the type of the winner under the penalty b. Under a higher penalty b', the new winner (w', c') must be with $w' \leq w$ and $c' \geq c$.

Increasing Incentives



Relatively, less solvent bidders become more aggressive.

If swap occurs, it must be less cost efficient.

Bidders with w_i higher than $\hat{w}(b)$ increase their bid due to higher performance cost.

These bidders do not change their bid

2 by 2 Example

- Consider two bidders with perfect information,
  - Bidder 1's type : $(w, c) = (1,0)$; solvent, efficient
  - Bidder 2's type : $(w, c) = (0, c)$: insolvent, inefficient
- Penalty: $b < 1$.

- Bidding behavior
  - Bidder 1: $P_1 = \gamma(b)$
  - Bidder 2: $P_2 = c$

- Bidder 2 wins if $c < \gamma(b)$. Let $\bar{\boldsymbol{b}} = \boldsymbol{\gamma^{-1}(c)}$**; maximum penalty to induce Bidder 1 to win.**

Exerted Effort

- When bidder 1 wins, $x_1^*(b)$ increasing in b.
- When bidder 2 wins, $x_2^*(\bar{b}) = 0$, increasing in b.

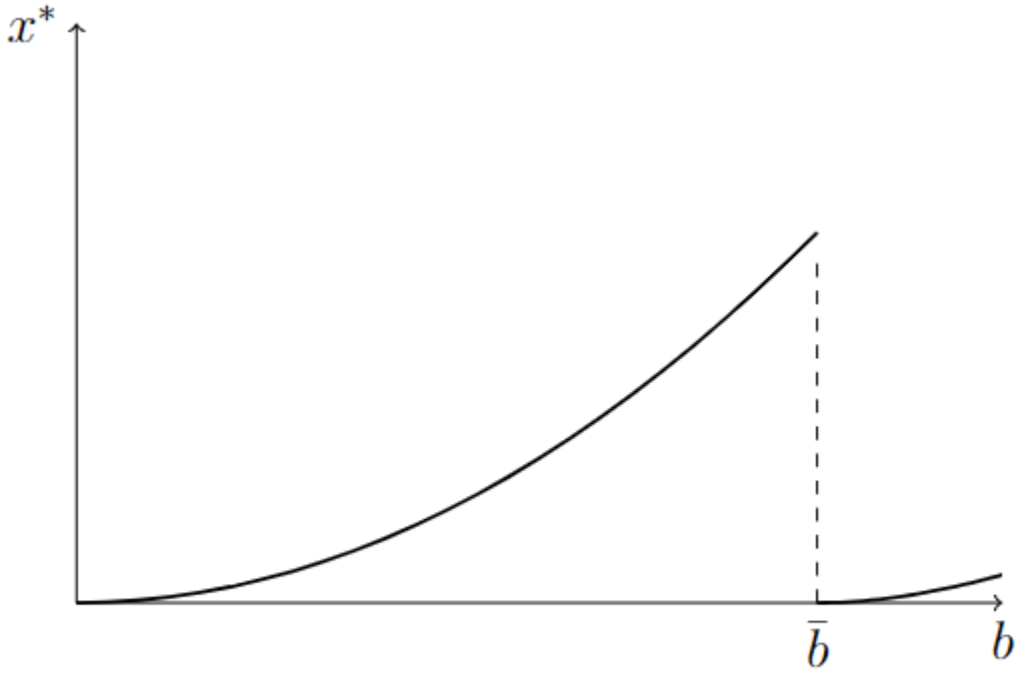


Figure 4 : Effort exerted in Equilibrium.

Bidder 2 increases effort due to a higher price (ex post wealth).

Probability of Bankruptcy

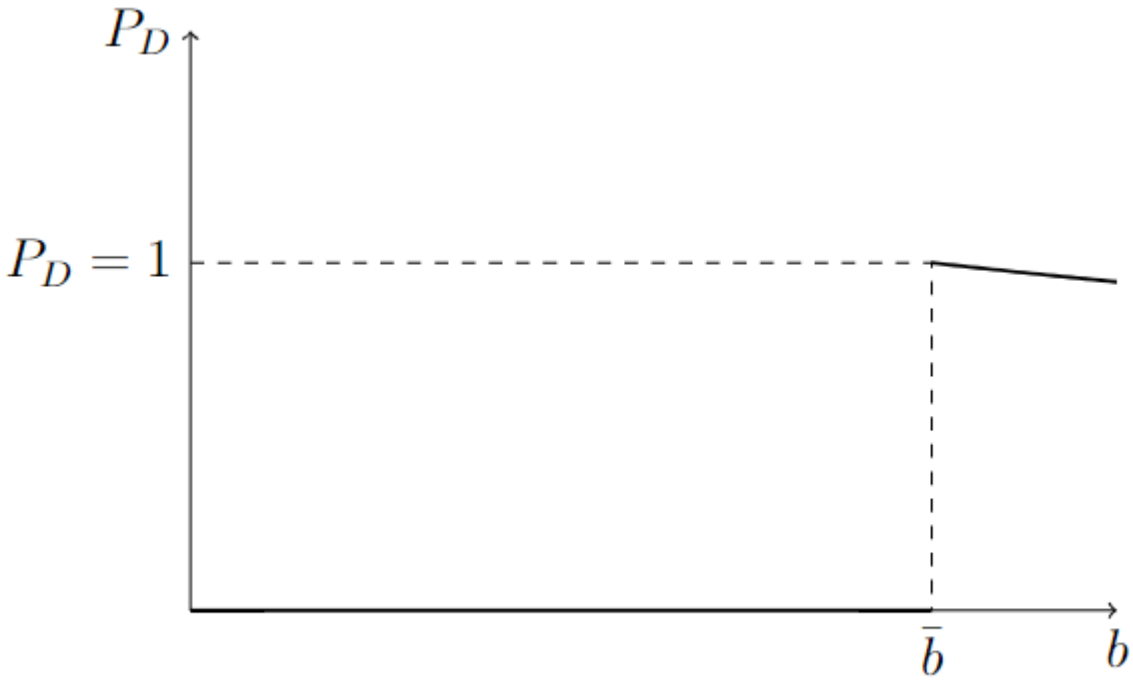


Figure 5 : The probability of bankruptcy in equilibrium

Efficiency of Low Powered Incentives

- Suppose θ measures the social value of performance.
  - In particular, $0 = \bar{\theta} > \underline{\theta}$
- If there's no risk of default, the first-best effort is attained by setting penalty $b^E = -\underline{\theta}$, i.e., $b(\bar{\theta}) = 0, b(\underline{\theta}) = \underline{\theta}$
- If bidder 1 wins under b^E, FB is attained.

Second-Best Penalty

- Suppose $b^E \leq \bar{b}$,
  - $b = b^E$ induces FB.
- Suppose $b^E > \bar{b}$.
  - FB is impossible.
  - $b = \bar{b}$ is mostly SB.
  - $b < \bar{b}$ is dominated.
  - $b > b^-$ induces misallocation, bankruptcy, etc.

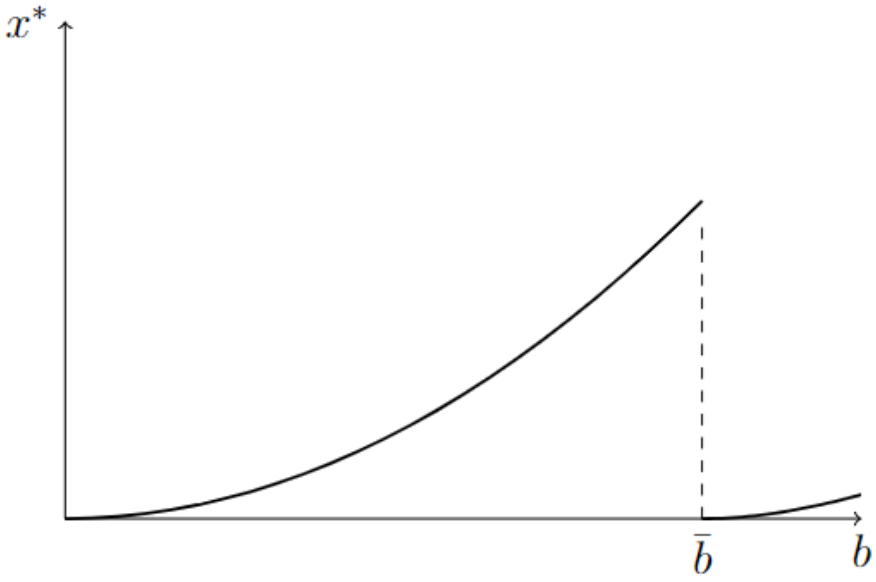


Figure 4 : Effort exerted in Equilibrium.

Conclusion

- Competitive mechanisms may select undercapitalized firms for undertaking projects with ex post moral hazard.
- More powerful incentives may lead to worse allocations and worse performance. This may explain why low penalties in procurement are observed.

- **General Implication**: Together with competitive selection, the use of powerful incentives is limited under fragile financial systems.
- **Possible Remedies**: Low powered incentives, less competitive mechanisms (Decarolis, 14), surety bonds (Calveras et al, 04).