Past Performance and Procurement Outcomes

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Background

Background

This paper is a case study of an experimental auction design, performed in 2007 by a large private utility company ACEA (the buyer), in Italy.

Traditionally, ACEA outsources part of utility works to local contractors and smaller firms using a simple tender, that is reverse first-price auction.

The goal of the reform was to increase contractual performance by means of a scoring auction where past performance (as opposed to ex-post performance) was used as part of the awarding mechanism.

Background

The outcome was

- lasting increase in performance
- no noticeable increase in price
- bidders did not like it

The prices seem to actually go down for the buyer.

Today I will try to explain this empirical puzzle.

Background

But before that, you should probably ask yourself

- what is a scoring auction?
- why is it so experimental?
- why is this an empirical puzzle?

What is a scoring auction

Scoring auction

A scoring auction is a variation on the procurement (reverse first-price auction), where instead of awarding the contract to the supplier with highest discount, it is awarded to the supplier with the highest score

$$\mathit{score} = \alpha \cdot \text{quality} + (1 - \alpha) \cdot \text{discount}$$

where quality is typically a weighted average of certain parameters of the contract design (e.g. speed of delivery) or firm's observed characteristics (e.g. experience, years on the market, access to special equipment).

The theory of a scoring auction is traditionally attributed to Che (1993) and Asker and Cantillon (2010).

Scoring auction

Consider the baseline model, as in Che (1993).

- q for quality, r for reserve $(r = 1)$
- b for bid, $d = r - b$ for discount
- c for costs, $\theta = r - c$ is the efficiency type
- α is the weight

Furthermore, denote

- $s := \alpha q + (r - b)$ as the score
- $\rho := \alpha q + (r - c)$ as the pseudo-type

Thus the player's interim profit is

$$\pi = (b - c)Pr(win|b, q) = (\rho - s)Pr(win|s)$$

Scoring auction

Turns out, the solution is isomorphic to that of classic first-price auction:

$$\textit{envelope conditions: } s = \rho - \frac{\int^{\rho} F^{n-1}(x|\alpha)dx}{F^{n-1}(\rho|\alpha)} \tag{1}$$

$$\textit{first order conditions: } \rho = s + \frac{G(s|\alpha)}{(n-1)g(s|\alpha)} \tag{2}$$

where F is the pseudo-type distribution, and G is the score distribution, as long as the reserve price is not binding. This also allows for a non-parametric estimation a-la Guerre Perrigne Vuoung (2000).

Crucially, it is the distribution of pseudo-type that matters for the calculation of strategies and informational rents.

This distribution of pseudo-type is endogenous and depends unpredictably on the scoring weight α.

Why is it so experimental

Experimantal

Many countries (Italy, Russia, China...) have a hard time contracting ex-post performance, so the performance is often unsatisfactory.

- in Italy, several workers in ACEA's contracts were electrocuted due to poor standards at the work site (probably not wearing special gloves)
- In Italy, average bid auctions were used
- in Russia, bids that are below 25% of the reserve price are subject to additional scrutiny (anti-damping regulation)

Scoring past performance solves this problem. How?

- controlling for hidden ability
- giving new incentives to increase performance

Also, it is is more credible due to the absence of moral hazard on the buyer's side (work now - score tomorrow).

Experimantal

To achieve this, a special system of audits was introduced by ACEA, where auditors would randomly visit a worksite and take notes. The firm's performance would be evaluated and used as part of the score in "future" auctions, giving incentives to show better performance.

And for a while, this sounded like a very good idea.

However, a formal analysis of the temporal link between the auctions is far from obvious. For example, by the time the "future" auction happens, all the extra investments made in the past are effectively sunk.

We can try to hammer this into the model...

Experimental

An appropriate model would not be

$$\pi = (b - C(q))Pr(win|b, q)$$

but rather

$$\pi = (b - c)Pr(win|b, q) - C(q)$$

in other words, a scoring auction with sunk costs.

Indeed, one could argue that pastness is an extreme form of sunkness.

The paradox

The paradox

Auction data shows that quality has increased across all parameters, the higher the weight in the scoring formula, the bigger the increase.

But the prices did not increase. To the contrary, it appears that higher quality came at a somewhat lower price for the buyer, which seems to violate the theory of the firm.

After all, the supply curve is increasing (recall micro 101) so the price should have increased.

This is the paradox.

The paradox

My solution to this paradox is to argue that, while the firm's costs have increased, the informational rents (profit margins) have decreased, creating an illusion of cheaper and better procurement.

$$\textit{quality} \uparrow, \quad \textit{cost} \uparrow, \quad \textit{price} \downarrow = \textit{cost} \uparrow + \textit{margin} \Downarrow$$

In other words, there was a transfer of wealth towards the buyer.

This also explains why the firms were so dissatisfied. While the reform was optimal for the buyer, but not a Pareto improvement.

The paradox

But, there must be strong reasons for the decrease in profit margins...

$$\textit{price} \downarrow = \textit{cost} \uparrow + \textit{margin} \Downarrow$$

... otherwise, it is pure speculation.

The paradox

There will be three key ingredients in my solution:

- theory of scoring auction (classical, risk neutral)
- sunkness of costs (it helps but it is not necessary)
- some extra heterogeneity of firms (necessary)

The last ingredient is, perhaps, the most unexpected.

A stylyzed model

Setting

Consider n firms that have the following profit function:

$$\pi_i = (\rho - s)Pr(win|s) - C_i(q) \to \max_{s,q \geqslant \underline{q}_i}, \quad C_i(q) = \frac{(q - \underline{q}_i)^2}{2\beta}$$

in a scoring auction where

$$s = \alpha q + (r - b), \quad \rho = \alpha q + (r - c)$$

and the scoring weight α switches from 0 to 1 (to 1/3 in the data).

The quadratic term captures the opportunity cost of building up quality q via past performance, while β is a model tuning parameter.

Finally, $\underline{q}_i$ captures extra firm heterogeneity in their ability to invest in q.

No heterogeneity

No heterogeneity

Let there be no extra heterogeneity ($\underline{q}_i = 0$).

Below is an example where $\theta = 1 - c$ is the efficiency parameter, distributed uniformly on $[0, 1]$ and there are $N = 2$ firms.

design	total profits	profit margin	discount	quality
price-only	$\theta^2/2$	$\theta^2/2$	$\theta/2$	0
scoring	$\theta^2/2$	$(1+\alpha^2)\theta^2/2$	$(1-\alpha^2)\theta/2$	$\alpha\theta$

The firm's profit margins are higher in the scoring auction, because she has to compensate for the investments made. On the other hand, the firm's total profits (profit margin + investment costs) are the same.

No heterogeneity

I can prove this as a theorem.

Theorem: If there is no firm heterogeneity (all $\underline{q}_i$ are the same), the both expected quality and price increase when moving from the first price to the scoring auction.

In other words, the paradox is impossible.

Let's prove it.

No heterogeneity

Proof:

Without heterogeneity, for any weight α, the cost-efficient firm always wins. In a sense, a scoring auction is just another screening mechanism.

Thus, by Revenue Equivalence, the firm's expected interim (total) profits are the same across all auction designs:

$$\pi_i = (b - c)Pr(win|s) - C_i(q)$$

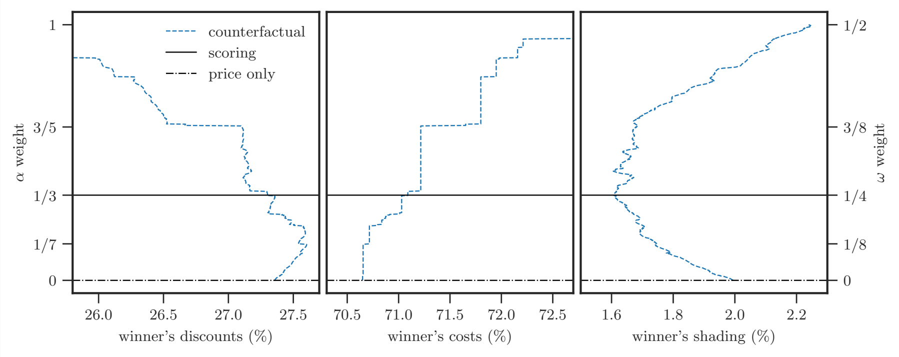
but they have paid their investment costs $C_i(q)$, thus their expected reimbursement must increase by that exact amount.

Which completes the proof.

Structural analysis

Equilibrium

I estimated the model with quadratic costs, quality fixed ($\beta = 0$), and simulated counterfactuals. Interestingly, for $\alpha = 0$, the counterfactual does not depend on β or the shape of the cost function.



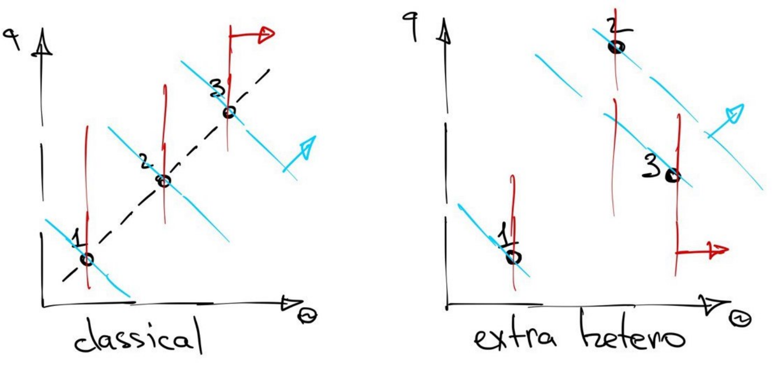
As you can see, winner's costs increase, but shading decrease, leaving the discounts virtually unchanged (statistically insignificant).

Add heterogeneity

What to do?

Clearly, if I want to explain the paradox, I need to break the Revenue Equivalence, at the very least. But all classical models have RE.

To break RE, I need to make sure that the ranking of firms changes, when I switch from price-only to scoring (when I change the scoring weight α).



Heterogeneity

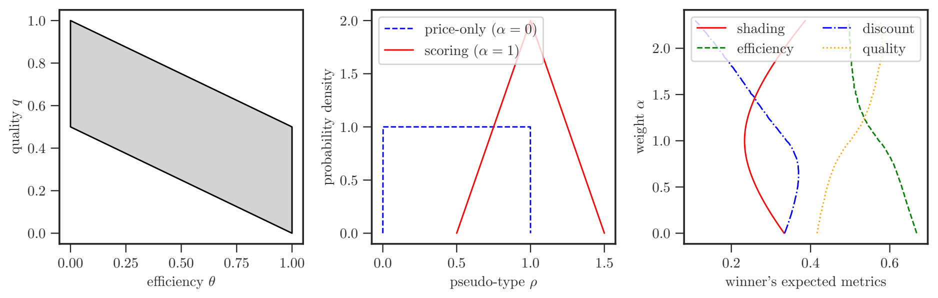
Finally, we need an example, where the shrinking of informational rents is greater than the rise in costs. This was not easy.

design (weight)	equilibrium pseudo-type distribution	expected winner's efficiency	expected winner's shading	expected winner's discount
price only ($\alpha = 0$)	$\rho, \ \rho \in (0, 1)$	40/60	20/60	20/60
scoring ($\alpha = 1$)	$\begin{cases} 2\rho^2 - 2\rho + 1/2 \\ -7/2 + 6\rho - 2\rho^2 \end{cases}$	37/60	14/60	23/60

But perhaps a visual representation is easier...

Heterogeneity

The idea is that the equilibrium distribution of cost $(c = 1 - \theta)$ and quality should be such that the pseudo-type distribution is more concentrated for $(\rho = q + \theta)$ than for $(\rho = \theta)$.



This will produce the necessary effect of shrinking profit margins.

Negative correlation

Heterogeneity

You probably noticed that the correlation between quality and cost-efficiency was somewhat negatively correlated.

It is a version of something which is referred to in the literature as

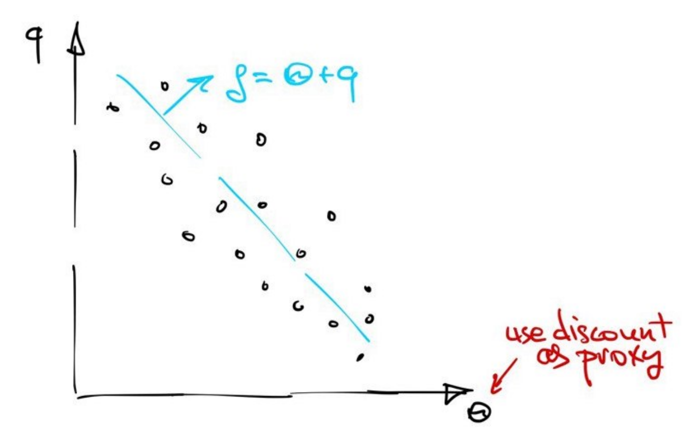
- adverse selection
- or quality considerations see Lopomo Persico Villa (2023).

In layman terms, it means that the firm which is cost-efficient is not necessarily the best in terms of quality.

Not only it does make sense, it was the whole point of running the reform in the first place!

Heterogeneity

This is cool, but are we ready to confront it with the data?



Heterogeneity

The data confirms this hypothesis...

	Dependent variable: discount					
	(1)	(2)	(3)	(4)	(5)	(6)
quality	0.442***	0.478***	0.477***	−0.320**	−0.355***	−0.357***
	(0.078)	(0.069)	(0.070)	(0.128)	(0.069)	(0.068)
rank				−3.272***	−3.575***	−3.609***
				(1.134)	(0.607)	(0.596)
quality * rank				0.017	0.019***	0.019***
				(0.013)	(0.007)	(0.007)
Constant	−18.733***	−22.202***	−23.496***	61.415***	63.462***	62.332***
	(6.780)	(6.122)	(6.825)	(11.404)	(6.073)	(6.077)
Auction FE		✓	✓		✓	✓
Lot FE			✓			✓
Observations	495	495	495	495	495	495
R^2	0.062	0.311	0.321	0.580	0.891	0.898
Adjusted R^2	0.060	0.291	0.284	0.578	0.888	0.892
Note:						$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Thank you!