Chapter 71

PROCUREMENT CONTRACTING

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Purchases by government agencies from private sector firms are often initiated by solicitation of bids to supply the desired items. Payment to the firm that is awarded the supply contract may be determined by (a) the bid price or (b) bid price plus a share of the difference between observable production cost and the bid price or (c) observable production cost plus an additional fee that may be a function of costs. Interest in the theory and behavior of procurement contracting stems mainly from two features of the political economy: (a) government may have multiple, possibility-conflicting objectives in procurement; and (b) there may be an asymmetry in knowledge of some components of firms' production costs.

One objective that government is likely to have in procurement contracting is minimization of the budgetary cost of making the purchases. Another objective that the government may have in conducting its economic activities, including procurement, may be the promotion of allocative efficiency. As we shall see, budgetary cost minimization and economic efficiency maximization can be conflicting objectives when there is a cost information asymmetry.

Potential suppliers may not all have the same production costs. In addition, government typically cannot observe firms' expected production costs before awarding the contract; hence, the government may not award the contract to the lowest cost producer even if it is attempting to promote allocative efficiency. Accepting the bid of an inefficient producer is known as "adverse selection." Other inefficiencies can occur when a firm's realized cost of supplying the desired items to the government agency are not predetermined but, rather, depend on the effort that the firm's employees make to hold down production costs. Such efforts are costly to the employees and, furthermore, some elements of effort costs are typically not observable by others. When a firm's effort costs are not observable by others, they cannot be reimbursable under the enforceable terms of a procurement contract and profit-maximizing behavior can result in inefficiently low effort to reduce costs. If this occurs, costs are inefficiently too high because of "moral hazard."

1. A Model of Cost Information Asymmetry

Let n denote the number of potential suppliers that bid on the procurement contract. If firm i is granted the contract, its production cost can be assumed to have three distinct

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components,

$$c_i = c_i^* + w_i - \xi_i, \tag{1}$$

where c_i^* is certain base cost, w_i is a random variable that represents the part of production cost that is uncertain at the time of contracting, and ξ_i is the amount of discretionary cost reduction. Total production cost, c_i, is observable by both the buyer and the seller after delivery of the contracted product. But the separate components of cost, c_i^*, w_i and ξ_i, are observable only by the selling firm (and the experimenter in a controlled experiment).

The discretionary cost reduction comes at the expense of an effort cost, $h(\xi_i)$, such that zero effort has zero cost and marginal effort cost is positive and increasing for all positive effort levels.

2. Linear Contracts

The contract is awarded to the firm that submits the lowest bid. If the contracting market institution is a first (lowest) price sealed bid auction then the "bid price" of the contract is the amount of the lowest bid. If the market is a second price sealed bid auction then the bid price is the second lowest bid.

Let b denote the bid price of the contract and let α be the cost-sharing rate. Then payment to the contracting firm with total cost, c_i, is

$$p_i = b + \alpha(c_i - b). \tag{2}$$

A "fixed price contract" is one in which $\alpha = 0$. A "cost-sharing contract" is one in which $0 < \alpha < 1$. Finally, a "cost plus contract" with zero economic profit is one in which $\alpha = 1$. The form of the payment equation (2) makes it clear that fixed price, cost-sharing, and cost plus contracts are all linear contracts.

If firm i is awarded the contract then its profit, π_i, equals the difference between the contract payment given by Equation (2) and the sum of observable cost, c_i, and unobservable cost, $h(\xi_i)$; hence, Equations (1) and (2) imply:

$$\pi_i = p_i - c_i - h(\xi_i) = (1 - \alpha)(b - c_i) - h(\xi_i). \tag{3}$$

3. Testable Hypotheses

Given that corner solutions are ruled out by the assumption that $h'(0) < 1 - \alpha$, expected utility maximization by the low bidder on the contract implies that the chosen cost-reducing effort level, ξ_i^0, satisfies the equation (McAfee and McMillan, 1986),

$$h'(\xi_i^0) = 1 - \alpha. \tag{4}$$

Since marginal effort cost is positive and increasing, Equation (4) implies that the amount of discretionary cost reduction varies inversely with the cost-sharing rate.

Given some additional assumptions, several other testable hypotheses can be derived from the theoretical model (Cox et al., 1996). Thus, if each bidder's base cost is independently drawn from the uniform distribution on an interval, and all bidders are either risk neutral or have the same constant relative risk averse preferences, then Nash equilibrium bid functions can be derived for bidding in first-price and second-price auctions of contracts. These bid functions, together with Equation (4), imply several hypotheses. These hypotheses involve the predicted effects on performance of the procurement contracting market of varying the cost-sharing rate, of the presence or absence of post-auction cost uncertainty (w_i in Equation (1)), and of the form of the auction market used to award the contract.

Hypotheses: (1) Discretionary cost reduction varies inversely with the cost-sharing rate. (2) With post-auction cost uncertainty, expected procurement payments for first-price auctions of contracts vary inversely with the cost-sharing rate. (3) Expected procurement payments for second-price auctions of contracts vary inversely with the cost-sharing rate for either post-auction cost certainty or uncertainty. (4) Expected procurement payments are not higher for first-price auctions than for second-price auctions of contracts.

4. Experimental Results

The figures show some of the experimental results reported in Cox et al. (1996). Figure 1 shows the incidence of moral hazard costs in the experiments in which contracts were awarded with first-price auctions. Results are reported for experiments with post-auction cost uncertainty and for experiments with post-auction cost certainty. The moral hazard costs are measured by calculating the average actual discretionary cost reduction in the experiments with a given value of the cost-sharing parameter (α), dividing by the efficient (or optimal) level of discretionary cost reduction, and multiplying the result by 100 to get a percentage. As shown in Figure 1, these percentages vary inversely with α; thus, the actual efficiency cost due to moral hazard increases with the cost-sharing rate in the procurement contract. This result is predicted by the theory.

Figure 2 reports pairwise treatment comparisons for both experiments with post-auction cost uncertainty and experiments with post-auction cost certainty. The green bars report the differences between mean procurement payments for fixed-price ($\alpha = 0$) contracts awarded with second-price auctions and those awarded with first-price auctions. These differences are positive as predicted by the theory for risk averse bidders. The theory predicts zero difference for risk neutral bidders. For the certain cost environment, the difference is significantly different from zero by both the difference of means t-test that assumes independence across experiments and the test that assumes independence across periods. For the uncertain cost environment, the difference is significant only for the test that assumes independence across periods.

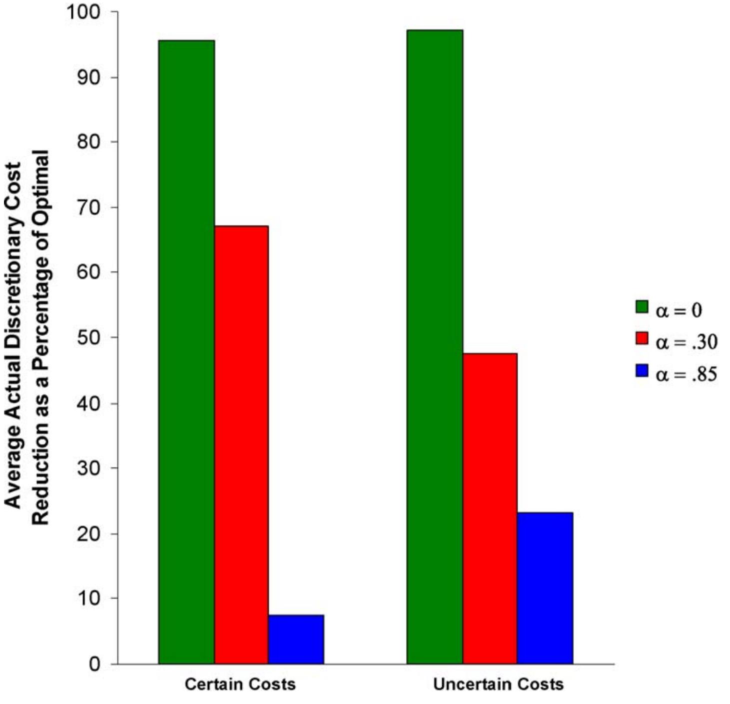

Figure 1. α is the cost-sharing rate in a contract awarded with a first-price sealed-bid auction. The figure shows the average actual discretionary cost reduction as a percentage of the optimal discretionary cost reduction for three values of the cost-sharing rate for experiments with and without post-auction cost uncertainty. Moral hazard costs increase with the cost-sharing rate, as predicted by the theory.

The red bars in Figure 2 show the positive differences between mean procurement payments for contracts with $\alpha = 0$ and $\alpha = .30$ cost-sharing rates, both awarded with first-price auctions. For the certain cost environment, the theory yields no prediction for risk averse bidders but it predicts a positive difference for risk neutral bidders. Theory predicts a positive difference for the uncertain cost environment. These differences are significantly different from zero by both types of t-test for both cost environments.

The blue bars in Figure 2 report positive differences between mean procurement payments for contracts awarded with first-price auctions and having cost-sharing rates of $\alpha = 0$ and $\alpha = .85$. Theoretical predictions are the same as for the red bar comparisons. For the certain cost environment, the difference is significantly different from zero by the t-test that assumes independence across experiments but not by the test that assumes independence across periods. The difference is significant for both types of t-test with data for the uncertain cost environment.

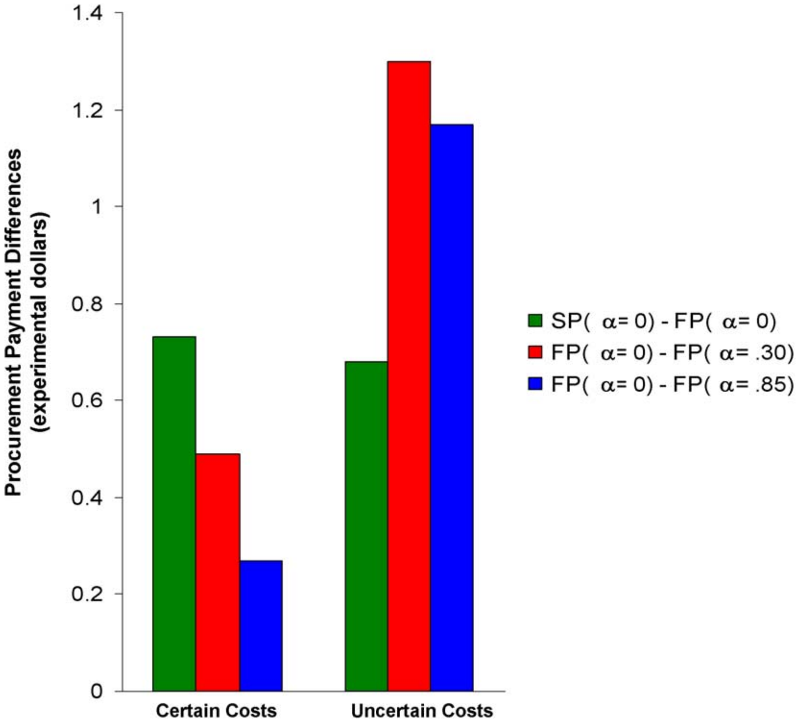

Figure 2. The figure shows procurement payment pair-wise treatment comparisons. SP denotes contracts awarded with the second-price auction. FP denotes contracts awarded with the first-price auction. α is the cost-sharing rate in a contract. The mean difference, $\mathrm{SP}(\alpha = 0) - \mathrm{FP}(\alpha = 0)$, is predicted to be positive for risk averse bidders. With certain costs, the theory yields no prediction for the mean differences, $\mathrm{FP}(\alpha = 0) - \mathrm{FP}(\alpha = .30)$ and $\mathrm{FP}(\alpha = 0) - \mathrm{FP}(\alpha = .85)$, for risk averse bidders. With post-auction uncertain costs the mean differences, $\mathrm{FP}(\alpha = 0) - \mathrm{FP}(\alpha = .30)$ and $\mathrm{FP}(\alpha = 0) - \mathrm{FP}(\alpha = .85)$, are predicted to be positive for risk averse or risk neutral bidders. All of the positive differences are significantly different from zero by either a t-test that assumes independence across experiments or one that assumes independence across periods.

Figure 3 portrays the relationship between the rank of the contracts based on their procurement payments and the rank based on their overall allocative efficiencies. The lower the total procurement payment in an experiment, the higher the procurement payment rank (because the assumed objective is budgetary cost minimization). Overall efficiency in an experiment is measured by the ratio of the lowest possible cost of fulfilling the contract to the actual cost of the low bidder. An efficiency number less than 1 can include inefficiencies from both moral hazard costs and adverse selection costs. The higher the efficiency in an experiment, the higher the efficiency rank (because the assumed objective is allocative efficiency maximization). Observe in Figure 3 that there is a predominantly inverse relation between the efficiency rank and the procurement payment rank of the experiments. In other words, lower procurement payments are as-

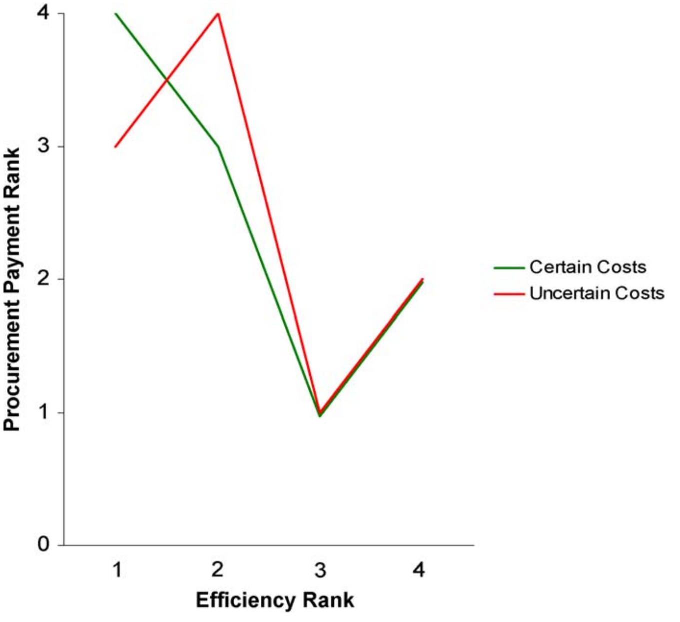

Figure 3. This figure shows that lower procurement payments are associated with lower production efficiencies. There are four experiments with post-auction cost uncertainty and four with post-auction cost certainty. Within each cost environment, the experiments are ranked in terms of their average procurement payment and their overall efficiency, as measured by the ratio of the lowest possible cost of fulfilling the contract to the actual cost of the low bidder. The lower the total procurement payment in an experiment, the higher the procurement payment rank (because the assumed objective is budgetary cost minimization). The higher the efficiency in an experiment, the higher the efficiency rank (because the assumed objective is allocative efficiency maximization). For the most part, cost-sharing contracts have both lower procurement payments and lower efficiencies than do fixed price contracts.

sociated with lower efficiencies. The effects of positive cost-sharing rates stands out in the rankings: for both certain and uncertain cost environments, the efficiency ranks of the $\alpha = .30$ and $\alpha = .85$ contracts are 3 and 4 and their procurement payment ranks are 1 and 2. Thus, cost-sharing contracts have both lower procurement payments and lower efficiencies than do fixed price contracts.

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