DELEGATED PROCUREMENT AND THE PROTEST PROCESS

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by

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Abstract

The Competition in Contracting Act of 1984 has given excluded and/or losing bidders in certain federal procurements the right to protest the actions of procurement officials before a quasi-judicial board. In this paper it is shown that the protest process can obviate agency problems and, consequently, result in higher expected surplus for the government. In addition, we show that our procurement mechanism is rich enough to capture the salient features of procurements both before and after the 1984 legislation.

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The federal government spends approximately $55 billion each year on automated data processing and telecommunication equipment (ADPTE).\(^1\) This equipment is typically procured by either competitive means (first price sealed bid auctions) or by sole source negotiations. The competitive process for procuring ADPTE involves a sequence of interactions between the procuring agency and potential suppliers. After exchanging information about existing product lines and the ADPTE services demanded bid solicitations are issued by the agency. These solicitations will contain minimum specifications (min-specs) for the equipment to be procured along with evaluation criteria contained in a scoring function. Many procurements involve much more than cost considerations --- often an extensive set of technical tests are delineated that the equipment must pass to be acceptable. Selecting the winner may involve a comparison by the procurement official\(^2\) (PO) of products of differing quality and cost.

Nearly every phase of the process described above involves discretionary action by the PO. A range of complaints regarding the behavior of POs were voiced by firms prior to 1984. Min-specs were written so that only one firm or only a very small proportion of the potential bidders could participate (called a "lock-out spec" in the procurement vernacular). Only well-known firms would be selected for participation in negotiations with the PO. Product evaluation tests would be conducted in a manner that placed great emphasis on technical merit relative to cost.

The misalignment of the PO's objectives with those of the government is the key problem that motivates oversight of the procurement process. Throughout this research we assume that the objective of the government is to maximize the buyer's expected surplus.\(^3\) There are two major factors
contributing to the divergence of the PO's objectives from that of the government. First, POs seem to display a technology bias by placing greater weight on technical quality than expected surplus maximization would require. Second, they are not fully rewarded for surplus gains from the procurement while at the same time they bear the full cost of the effort designed to raise this surplus. We call the consequent underinvestment in effort by the PO the appropriability problem. Low effort by the PO is not as problematic for well-established firms, with whom the PO has a great deal of familiarity, as it is for new entrants. A PO may simply decide to exclude a potential new entrant because of the significant effort involved in ascertaining the salient properties of its product.

In response to these perceived problems in 1984 Congress included a provision in the Competition in Contracting Act (CICA) that invested the General Service Administration's Board of Contract Appeals (GSBCA) with ADPTE protest jurisdiction. Potential and actual bidders at federal ADPTE procurements now have the right to protest the actions of POs. The GSBCA, unlike the General Accounting Office (GAO) which heard most protests (external to agencies) prior to 1984, is a quasi-judicial body and, consequently, has the right to subpoena documents, depose government officials, and conduct de novo review of agency decisions.6

The right of bidders to protest the actions of a PO to the GSBCA has resulted in a fundamental change in the procurement process for ADPTE. Discretionary decisions by POs that are contrary to government surplus maximization have been significantly curtailed by Board rulings.6 Simultaneously, these rulings have encouraged the entry of new vendors.

The objective of this research is to explain the effect of specific agency problems on discretionary decisions of POs and to analyze the impact of
GSBCA protests in controlling PO discretionary behavior that is contrary to the objectives of the government.

In our model, once a protest has been instigated the GSBCA can monitor the actions of POs. In particular, the GSBCA can detect both the misuse of scoring functions and inappropriate inclusion choices by the PO. In addition, the GSBCA can monitor the effort exerted by POs in implementing a competitive procurement. In other words, the GSBCA can detect a technology bias and/or an appropriability problem. The Board corrects procurements that have been conducted in a manner inconsistent with the objectives of the government and penalizes the procuring agencies. Furthermore, the Board's actions serve to deter POs from conducting future procurements in a manner that is inconsistent with the objectives of the government.

In addition to the corrective and deterrent effects, the GSBCA protest process has certain negative side-effects that emerge as part of the equilibrium in our model. Since protests are costly to a procuring agency firms might file a protest even when the PO has acted correctly in order to extract a payment from the agency. This kind of protest has become known as "fedmail". In addition, when the PO has not acted in a manner consistent with the government's objectives, it might be the case that a protestor is paid by the procuring agency as a settlement. In such circumstances, the "buy-off" has eliminated the role of the protestor as a private attorney general. Third, in an effort to avoid a protest a PO might "bend over backwards" to include or favorably score a certain kind of firm, such as a new entrant. This latter effect we call "overdeterrence". Our analysis provides a positive explanation for these features of the protest process and also permits us to propose alterations to key policy parameters that would reduce the negative aspects of the protest process.
The paper progresses as follows. In Section I we provide a description of the typical procurement process for ADPTE. Section II provides an enumeration of the stylized facts that emerge from this description. In Section III we analyze an optimal procurement auction and the impact of agency problems on a procurement. Section IV compares protests and testing as mechanisms for producing verifiable quality information that might otherwise not be observable by the PO. Section V discusses control of the appropriability problem through protests. Section VI describes the impact of the technology bias on inclusion and the scoring function. Section VII analyzes protests and the technology bias in an incomplete information setting. Section VIII contains concluding comments.

I. Description of the Federal Procurement Process

This section contains two parts -- a chronological description of a typical ADPTE procurement and a general description of the protest process.

I.A. Chronology of a Procurement

The Federal Acquisition Regulations (FAR) distinguish two types of competitive solicitations relevant to ADPTE procurement, Requests for Proposals (RFP) and Invitations for Bids (IFB). Both an RFP and an IFB must contain a statement of mandatory specifications. For an IFB, among the firms complying with the specifications the firm bidding the lowest cost is the winner for the amount of their bid. An RFP involves a more complicated evaluation process since it contains a "scoring" function in addition to min-specs. The scoring function essentially maps the multi-dimensional components
of the bid into a single number by which firms are then ranked. The firm with highest score wins the procurement and provides the item for the amount of their bid. The scoring function will typically specify weights which are to be placed on salient characteristics such as cost, technical merit, delivery, warranty, etc. If technical merit is part of the score then the RFP will identify a number of benchmark tests that must be conducted to evaluate the product.

Prior to the issuance of an IFB or RFP firms will stress the salient characteristics of their product lines. In fact, emphasis will be placed on those features of a product that few other competitors possess. This information enables a favorably inclined PO to have these characteristics included in the min-specs, thereby eliminating a large number of potential competitors.\(^9\)

After issuance of an IFB or RFP participating firms incur significant bid preparation costs. Numerous third party vendors must be contacted concerning components, especially for integrated systems. When service or warranties are involved the bidder must provide documentation regarding the qualifications of their personnel. The bidder must demonstrate compliance with applicable legislation, such as the Buy American Act. Overall, the preparation of a bid, especially for an RFP, can be a relatively involved task.

After receipt of bids the PO conducts technical tests that are specified in the IFB or RFP. The outcomes from these tests are then used to assess compliance with the min-specs or to generate technical data used as an input in the scoring function. The implementation of the tests creates one more degree of discretion for the PO.\(^9\)
I.B. Protests

If a losing bidder believes that a procurement has been conducted improperly then that bidder can protest the relevant actions of the PO. Within the context of an auction it might appear strange to permit protests. For example, when a single object is being sold by means of an English, Dutch, first or second price auction the high bidder wins the object. Since all losers are present and since they each had an opportunity to be the winner it seems obvious that there is no basis for protests by losers.

To procure large quantities of homogeneous products a PO can conduct a straightforward auction via an IFB. Alternatively, he could conduct an English auction (descending bid for procurement). Since the supplier with lowest costs would win the auction there is again no basis for protests by losers.

For most procurements, bidders will offer heterogeneous products in their bids. If a solicitation specifies 386 PC technology then, say, Compaq and Everex each bid their product lines. The valuations placed on these different brands of PCs by the PO involves substantial discretion. If Everex PCs cost less but the award is made to Compaq then it might be the case that the Compaq has substantially greater value to the PO's agency and, consequently, surplus from the procurement of Compaq exceeds that from Everex. However, it is also possible that the PO is not acting as a good agent, for whatever reason. In such a case, procuring Everex would yield higher surplus to the government but the PO's incentives are such that he chooses to purchase Compaq. If challenged on the procurement by Everex the PO could exaggerate the value of Compaq to his agency and give the appearance of surplus maximizing behavior.

With standard auctions there does not appear to be any grounds for
protests by losing bidders. Intuitively, since the bidders possess only one
piece of private information (values or costs) and since the auction reveals
this information the behavior of the auctioneer is perfectly monitorable by
either a consignor or the government. However, when procuring heterogeneous
products the bidders possess two pieces of private information, only one of
which is revealed in the auction in a non-manipulable manner. Specifically,
the cost component of the bids is readily understood by everyone but the
assessments of product value via benchmark testing involve a substantial
amount of PO discretion. If the PO is not acting as a good agent he can
manipulate evaluations to alter the procurement results. The critical issue
is whether the government can monitor value assessments by the POs. If so
then the government can rank bids by surplus and perfectly monitor PO
behavior. If not then the government can not rank bids by surplus and can not
detect a PO who is acting as a bad agent.

Monitoring is possible in the protest regime because of the quasi-
judicial powers of the GSBCA.\textsuperscript{11} POs can be deposed and agency records can be
subpoenaed. In addition, the judges of the GSBCA engage in de novo review.
Although the Board recognizes that POs must exercise discretionary judgement
in conducting a procurement this judgement is subject to the scrutiny of the
Board.\textsuperscript{12}

If the procuring agency is found to have improperly conducted a
procurement a number of different actions can be taken by the Board. If the
protest concerns restrictiveness of specifications the GSBCA can order the
procuring agency to relax the min-specs to allow the entrance of the
protesting firm in the procurement. An improper scoring function can be
altered by the Board. If the protest concerns the final award the Board can
order the agency to either reevaluate bids or to discard all bids and conduct
the procurement again. Furthermore, the GSBCA can constrain or suspend the Delegated Procurement Authority of the agency. Successful protestors will not only receive the benefits described above (inclusion, new procurement, etc.) but, in addition, they will be reimbursed for bid preparation and legal fees from the Permanent Indefinite Judgement Fund (PIJF) of the Department of the Treasury. The Board can order the procuring agency to reimburse the PIJF.

Many protests are settled before the GSBCA reaches a decision. One kind of settlement involves an alteration by the PO in the RFP or IFB to appease a protesting firm. Other settlements entail cash payments. The payments can be made by either the procuring agency or the awardee. Payments by the procuring agency to the protestors are quite controversial. If the PO has conducted a good procurement he may still confront a protestors who hopes to extract a payment so that the procuring agency does not incur both the delay in acquiring the commodity and the expense of preparing a defense. This kind of settlement has become known as "fedmail". In addition, if the PO has conducted a bad procurement he might settle with protestors to avoid a negative decision from the Board.13

II. Stylized Facts

The focus of our subsequent analysis concerns the impact of GSBCA protests on the procurement of ADPTE. Below we provide an enumeration of the salient characteristics of ADPTE procurements both prior to and after CICA.

1. Restrictive min-specs. "Lock-out" specs were common prior to CICA. Typically, min-specs were written to permit participation of a small subset of feasible bidders. Since the passage of CICA, specifications that exclude some subset of horizontally differentiated products are
rarely observed; when they are observed they are successfully protested.  

2. Biased evaluations. Prior to CICA, even if new firms could comply with min-specs they were evaluated harshly. Furthermore, a bias toward high-tech items is well documented, especially in the Department of Defense. Since CICA, incumbency is much less of an advantage in ADPTE procurements.  

3. No Challenge to PO Discretion Prior to GSBCA Protests. Prior to CICA, the incentives of POs suffered from both the appropriability problem and technology bias. The GAO rarely questioned the discretionary judgement of the PO. Since the GAO was the primary external forum for protests the PO's actions were never monitored outside his agency. Currently, although the GSBCA recognizes that POs must necessarily exercise discretion throughout a procurement the GSBCA will, when protests occur, review the decisions made by the PO. If the judges of the GSBCA feel that additional information is required to render a decision they will independently acquire evidence. This evidence would augment that provided by the protesting firm and the PO.  

The ABA (1989, page 73) report includes an insightful statement by an unnamed counsel who represents protestors.  

We have found agency personnel much more willing to consider agency protests seriously since the GSBCA forum became available. Prior to the passage of CICA, agencies had little, if any, incentive to provide meaningful redress for vendor claims of illegal procurement actions. After the passage of CICA, agencies gradually realized that their actions would be reviewed by a strong bid protest forum if they failed to either correct problems on their own or provide a meaningful denial of a protestor's claim.  

4. Inappropriate Settlements. An unfortunate consequence of the protest
process is the availability of cash settlement payments used by POs to avoid GSBCA decisions. Such settlements subvert the deterrent effect of protests and stimulate inappropriate protests by "fedmailers."

III. The Basic Model

Our model of procurement and protests contains several stages. In the first stage activities are undertaken by potential bidders and/or the procurement official that produce an expectation of the cost and quality attributes of the products that will be bid. Next, the procurement official makes inclusion decisions and announces a scoring function for the procurement auction. A disgruntled firm then has an opportunity to protest these decisions to the GSBCA. The Board decides on the merit of the protest and remedies inappropriate behavior by reversing an exclusion decision or altering a scoring function. Finally, the procurement auction is run, and a post-award protest may occur.

To begin our analysis we will examine the pre-CICA world in which there was no effective protest forum. We will describe the optimal inclusion decision and auction design by a procurement official whose objective function differs from the government's. The PO's objective function is $\lambda Q - \mu C - R$,\textsuperscript{18} where $Q$ is the expected benefit to the government from the procurement, $C$ is the direct expected cost of purchasing the ADPTE, and $R$ is the expected cost of running the procurement. The government's objective function is $Q - C - R$. In general, $\lambda \geq \mu \geq 0$, and $1 \geq \mu$.

The costs $R$ should be envisioned as being borne directly by the PO, while $Q - C$ represents procurement surplus to the government. We say that the PO suffers from an appropriability problem if he bears the full cost of
conducting the procurement, but captures only a fraction of the surplus. In
terms of the objective function above, when $\mu = \lambda < 1$ there is an
appropriability problem. The problem grows more severe as $\lambda$ falls.

A second troubling feature of the PO's objective function is a bias
toward high-tech items. As discussed in Section I, from a social perspective,
the PO may place relatively too much weight on the expected benefit of the
good or service to be procured compared to the expected cost. This bias can
be represented by $\mu < \lambda$. The technology bias grows more severe as the gap
between $\lambda$ and $\mu$ grows.

For our analysis in sections III through VI, we assume that the
procurement official implements the procurement decision via an "optimal"
auction.\textsuperscript{19} The auction is designed by the PO to be optimal from his
perspective but not necessarily from taxpayers'. We follow Myerson (1981) who
showed that an auctioneer maximizes expected revenue subject to informational
and rationality constraints by implementing a variant of a second price
auction.\textsuperscript{20} By invoking the revelation principle it can be shown that the
optimal auction comes from the class of direct revelation mechanisms,
therefore, equilibrium bids consist of truthful reports of bidders' types.

We extend Myerson's framework to incorporate private information about
cost and quality in a procurement context. For each bidder the procurement
official chooses a "priority" function that is additively separable in cost
and quality. Each bidder $i$'s priority function depends only on data about $i$
and data about the objective function of the procurement official. We
associate the priority function with the scoring function that is typically
used in ADPTE auctions.

The optimal auction selects the firm with the highest positive priority
level and makes an award to that firm which depends on the second highest
priority level. In the case in which firms are ex ante identical and quality is fixed, the priority level auction reduces to a second price auction with an optimal reserve.

The environment that we study has two bidders $i=1,2$ who are characterized by types $t_i$ which are distributed uniformly over $[0,1]$. The realization of $t_i$ is privately observed by firm $i$ and the distribution is common knowledge. The value or quality of a good or service provided by firm $i$ is $q_i$, while cost is $\theta_i + t_i$, where both $q_i$ and $\theta_i$ are common knowledge, independent of $t_i$. Each firm nominally bears a bid preparation cost, $\alpha$, if they participate in a procurement auction. The PO bears a handling cost of $\beta$ for each firm included in the auction.

An optimal auction for this environment is stated in the following proposition.

**Proposition 1.** In the optimal auction the PO first chooses an inclusion set, allowing either or both firms to participate. Next, an included firm truthfully reports $t_i$ to the PO. An award is made to the firm with the highest positive priority level. The priority function for firm $i$ is:

$$c_i(t_i) = \lambda q_i - \mu (\theta_i + 2t_i).$$

(1)

If no firm has a positive priority level, then no award is made.

**Proof.** We sketch the outline of a proof here. A more formal presentation can be found in Marshall, Meurer and Richard (1990). In that version, quality and cost are arbitrary functions of type, any number of bidders are permitted, and heterogenous and interdependent entry and bid preparation costs are allowed.
Following Bulow and Roberts (1989), a priority level procurement auction can be constructed by viewing the PO as a price discriminating monopsonist. Let \( \gamma_i = \theta_i + t_i \) be the production cost for each firm. Interpret the distribution function for \( \gamma_i \) as a quantity variable, \( X_i = F_i(\gamma_i) \). Find marginal cost by taking the derivative of \( X_i F_i^{-1}(X_i) \) with respect to \( X_i \). Since \( F_i(\gamma_i) = \gamma_i - \theta_i \), we have a marginal cost of \( 2\gamma_i - \theta_i = 2t_i + \theta_i \). Treating different bidders as different "markets" in the fashion of Bulow and Roberts, we construct effective marginal benefit minus effective marginal cost in each market. The former is \( \lambda q_i \) and the latter is \( \mu(2t_i + \theta_i) \), and together they yield the priority function above. Q.E.D.

We can now describe the payoffs consistent with the optimal auction. A firm that is excluded from the auction receives no payment. A losing bidder is compensated an amount \( \alpha \) to cover bid preparation costs.22

A winning bidder earns

\[
\alpha + \theta_i + t_i + \int_{0}^{t_i} \int_{0}^{1} p_i(r_i, t_j) dt_j dr_i \tag{2}
\]

where \( p_i(r_i, t_j) \) is the probability given reports \( r_i \) and \( t_j \) that \( i \) wins the award, i.e., the probability that \( c_i(r_i) \geq \max \{0, c_j(t_j)\} \). Hence, the winner is compensated for bid preparation and production costs and in addition, receives an informational rent.23

The payoff to the PO if only firm \( i \) is included is:

\[
U^\gamma(i) = E_{t_i} \max \{0, c_i(t_i)\} - (\beta + \mu) \alpha. \tag{3}
\]

The expected payoff from including both firms is:

\[
U^\gamma(1,2) = E_{t_1, t_2} \max \{0, c_1(t_1), c_2(t_2)\} - 2(\beta + \mu \alpha). \tag{4}
\]
The inclusion decision made by the PO stems from the comparison of $U^\alpha(1,2)$ to $U^\alpha(1)$ and $U^\alpha(2)$.\textsuperscript{24}

The exclusion decision would be puzzling if not for the auction costs $\alpha$ and $\beta$. If these costs were set equal to zero, there would never be a reason to exclude a firm from a procurement competition. The agency problems do not create the exclusion phenomenon, but they do exacerbate it as we show below. Regardless of a PO's preferences, if $\alpha = \beta = 0$, all firms will be included. For example, a PO with a severe technology bias should include low benefit firms since they might draw very favorable costs while his preferred firms could draw unfavorable costs. Instead of exclusion, when $\alpha = \beta = 0$, the PO relies on the scoring function to bias the outcome in his preferred direction.

An interesting application of the discriminatory property of Myerson's model is to seemingly anomalous awards to low benefit, high cost firms. Consider an example with $\lambda = \mu = 1$, and $q_2 - \theta_2 > q_1 - \theta_1$. The anomalous result is that the contract might be awarded to a firm with lower benefit and higher realized cost. Define $s_i = q_i - \theta_i - t_i$ to be the ex post surplus from product $i$. Notice that $c_1(t_1) > c_2(t_2)$ as $s_1 - t_1 > s_2 - t_2$. Hence, it might happen that an award is made to firm 1 even though $s_2 > s_1$. The ex ante optimality of a potentially anomalous ex post award results from the fact that it is meant to induce aggressive bidding from the "better" firm (in this case, firm 2). If the award were always made to the highest surplus firm, firm 2 would not have an incentive to report draws of $t_2 < (1/2)[(q_2 - \theta_2) - (q_1 - \theta_1)] = \bar{t}_2$, since a report of $\bar{t}_2$ would guarantee the highest surplus level.

The following sections are organized to match the chronology of the procurement process. In next section we study the use of testing and protests to inform the PO about firms' quality levels. Subsequent sections examine the
impact of the appropriability problem on the inclusion decision when excluded firms can protest, the impact of the technology bias on inclusion decisions and the scoring functions, and finally the impact of agency problems and post-award protests on award decisions.

In Sections IV through VI we use the auction described in Proposition 1 to analyze the impact of agency problems on pre-award behavior of POs. In Section VII we explore the role of post-award protests in controlling agency problems. In that Section we depart from the auction framework to examine a model in which the PO, rather than the firms, has private information.

IV. Testing, Protests, and the Inclusion Decision

We will argue below that the protest process serves to deter and correct inappropriate behavior by POs resulting from agency problems. Here we emphasize that the protest process can also be used for a very different purpose: to produce information about product quality. If a firm has private information concerning its quality it cannot be elicited through an optimal auction like the one described in Section III. Quality does not enter the firm's profit function directly and is not correlated with \( t_i \), hence there is no way to keep a low quality firm from mimicking a high quality firm. We assume that a PO can learn about \( q_i \) directly by testing a product or indirectly through protest results. Alternatively, he can rely on prior beliefs about a product's quality when making an inclusion decision.

The protest is useful in cases in which an untested product that is believed to be low quality is excluded from a procurement. If the firm that has been excluded knows its product has \( q_i \) sufficiently large to warrant inclusion, then it can protest. A relevant example is provided by used
computer hardware. A PO who is a perfect agent might exclude used equipment because it is normally unreliable. The decision not to test the equipment can be justified if the expected cost of protest resulting from inappropriate exclusion is small.

The situation is analogous to the manufacturing problem of detecting defective products. A manager can either invest in quality control on the assembly line or provide warranties. By offering a warranty the quality control function is delegated to the consumer. If there is a fixed set-up cost associated with quality control, the warranties may be relied on exclusively. In the procurement context, protests play the informational role of warranties.

We provide an example to illustrate this point. Assume that \( \lambda = \mu = 1 \), so there is no agency problem. Suppose firm 1 offers a new product of high quality, while firm 2 offers a used product that may be of high or low quality. We have \( q_1 = q_H \) and \( q_2 = r q_H + (1 - r) q_L \), where \( q_H > q_L > 2 \), and \( r \) is the probability of high quality for the used product. Finally, let \( \theta_1 = \theta_2 = 0 \) and \( r_H - q_L > 2 \).

The payoffs to the PO from including firm 1, firm 2 and both firms is shown in Figure 1. Routine calculation shows that

\[
U^*(i) = \lambda (q_i - 1 - \alpha) - \beta, \text{ for any } r, \text{ and} \tag{5}
\]

\[
U^*(1, 2) = U^*(1) + \left( \frac{\lambda}{3} \right) (1 + \delta)^3 - \beta - \lambda \alpha, \tag{6}
\]

for \( r \geq r_B \), where \( \delta = (1/2) (q_2 - q_1) \) and \( r_B = 1 - 2/(q_H - q_L) \), while \( U^*(1, 2) = U^*(1) - \beta - \lambda \alpha \) for \( r < r_B \). On the horizontal axis we place \( r \), the PO's prior belief about the quality of used equipment. Notice that \( U^*(2) \) and \( U^*(1, 2) \)
Inclusion of a Used Product Under Testing and Protest

Figure One
increase with \( r \), and that \( U^\pi(1,2) > U^\pi(1) \) for \( r > r_E \). As \( r \) grows toward 1 the prior belief about the quality of the used product is sufficiently favorable that it is included without testing. In the absence of testing or protest the utility frontier for the PO is AEG.

Suppose that the PO can test product 2 at cost \( r \) and learn whether \( q_2 = q_L \) or \( q_H \). If \( q_2 = q_L \), then 2 will be excluded, otherwise 2 will be included. Figure 1 shows the payoff to testing assuming \( r = 0 \) and \( r > 0 \). Given testing, the ex ante utility to the PO is \( rU^\pi(1,2| q_2 = q_H) + (1 - r)U^\pi(1) - r \). If \( r = 0 \) testing is always used. For \( r > 0 \) the utility frontier in Figure 1 is ADFGC. Not surprisingly, testing is used for intermediate values of \( r \) where the PO is most uncertain about the value of the used product.

Consider the impact of permitting protests. Let \( \pi \) be the cost of a protest to the PO.\(^\text{26}\) If \( \pi < r \), then testing is never used, so assume \( \pi > r \). Like testing, protests reveal whether \( q_2 = q_L \) or \( q_H \). If testing is not used and firm 2 is excluded (subject to possible reversal by protest), then the payoff to the PO is

\[
rU^\pi(1,2| q_2 = q_H) + (1 - r)U^\pi(1) - r \pi
\]

(7)

This is the same as the payoff from testing except for the term \( r \pi \) instead of \( r \). The utility to the PO from allowing protests appears in Figure 1 assuming \( \pi > r \). The new utility frontier is ADHG. In the interval \([0, r_D]\) product 2 is not tested and is included only after a successful protest. In the interval \([r_D, r_P]\) product 2 is tested and included if \( q_2 = q_H \). In the interval \([r_P,1]\) product 2 is included without testing.

A notable effect of protests is the promotion of entry of used products into the procurement. In the interval \([0, r_C]\) the used product is not tested
and, in the absence of protests, not included in the auction. The cost of testing is too large considering the low probability that \( q_2 = q_H \). However, protest costs are only paid when \( q_2 = q_H \), and assuming \( U^y(1, 2|q_2 = q_H) - U^y(1) > \pi \), the protest mechanism will assure appropriate inclusion in this interval.

In the discussion above, we assume that there is no agency problem. Now we relax that requirement and assume that \( \lambda = \mu < 1 \), meaning that the PO suffers from an appropriability problem. The choice between testing and relying on protests is not sensitive to the appropriability problem, i.e., \( \delta r_F / \delta \lambda = 0 \). This is true because payoffs to protest and testing differ only by the costs \( r \pi \) and \( r \lambda \); \( \lambda \) affects the benefit that can be appropriated but not the cost of effort required by protests or testing.

The boundary between automatic inclusion of firm 2 and testing at \( r_F \) is sensitive to \( \lambda \). At this boundary, the cost of testing is equal to unnecessary inclusion costs that are avoided by testing, i.e., \( r = (1 - r_F)(\beta + \lambda \alpha) \). A growing appropriability problem leads to less testing effort since \( \delta r_F / \delta \lambda > 0 \).

A similar result holds at \( r_C \) the boundary between testing and absolute exclusion of firm 2. The condition determining \( r_C \) is

\[
   r = r_C \left( \frac{1}{3} - \alpha \lambda - \beta \right)
\]

which gives \( \delta r_C / \delta \lambda < 0 \). The intuition behind this result is that testing, and the effort required from the second inclusion when the test is positive, is less sensitive to \( \lambda \), than the gains from inclusion of a high quality, second competitor. Combining these three comparative static results one can see that, with or without protests,\(^{28}\) as the appropriability problem grows there is less testing.

The final comparative static result concerns the impact of the appropriability problem in the absence of testing or protests. Recall that \( r_F \)
denotes the value of $r$ where the PO is indifferent between excluding or including firm 2. From (5) and (6) we equate $U^\star(1)$ and $U^\star(1,2)$ and solve for $r_E$

\[ 24(\beta + \lambda \alpha) = \lambda^2 + (1 - r)(q_L - q_H)^3 \]  

(9)

From (9) it is simple to show that $\partial r_E/\partial \lambda < 0$, so that $\lambda < 1$ leads to inappropriate exclusions for $r \in [r_E(\lambda < 1), r_E(\lambda = 1))$. Thus firm 2 is less likely to be included as the appropriability problem grows because benefits from inclusion fall more rapidly than costs as $\lambda$ declines.

Our primary interest in this section was to determine the impact of testing, protests, and the appropriability problem on inclusion of a newcomer to a federal procurement. We assume that there exists an incumbent, known to be of high quality, who is always included. The crucial issue concerns conditions for exclusion of a high quality entrant from the procurement. If protests are used, a high quality entrant will always be included. If they are not permitted, a high quality entrant will be excluded if $r < r_E$ in the case of testing, and $r < r_C$ in the case without testing. In these latter cases, entry becomes more difficult as the appropriability problem grows.

V. Controlling the Appropriability Problem through Protests.

Not only is the protest mechanism useful for producing information about the quality of products offered by new entrants, it also serves to regulate the exercise of discretion by POs that is not consistent with the objectives of taxpayers. As we argued in the Introduction, the appropriability problem may result in too few firms being included in a procurement auction. The problem arises because the PO bears the full cost of including firms, $\beta$, but
does not realize the full benefit of inclusion.

In this section we preserve most of the structure of the last section. Again we assume that \( \lambda = n \leq 1 \), allowing for an appropriability problem. In this section, however, we suppose that \( q_2 \) is known, and that \( q_2 = r q_H + (1 - r)q_L < q_1 = q_H \). We parameterize \( q_2 \) by \( r \) so that Figure 1 is still appropriate. Notice that \( r \) is now common knowledge. Since firm 2 offers less benefit than firm 1 \( (q_2 < q_1) \), firm 2 may be the victim of inappropriate exclusion by a PO with \( \lambda < 1 \). We maintain the assumption (footnote 27) that \( \lambda \) is large enough so that firm 1 is always included.

In this context testing plays no role and although protests no longer are used to produce information about \( q_2 \), the impact of the appropriability problem can be diminished by giving firm 2 the right to protest an inappropriate exclusion. Suppose that firm 2 can protest to the GSBCA which can verify perfectly whether an exclusion is wrongful. The protest process imposes costs on the protestor and the PO, therefore, considering the parties are fully informed about information relevant to an inappropriate exclusion, protests should never occur. An efficient bargaining solution implies that the combined surplus of the PO and firm 2 should be maximized in a protest regime with perfect information. The ex ante expected profit to firm 2 (before \( t_2 \) is learned) is

\[
\tilde{\pi}_2 = \int_0^{1+\delta} \int_{t_2}^1 \int_0^1 p_2(r_2, t_1) dt_1 dr_2 dt_2 = \frac{1}{6} (1 + \delta)^3,
\]

where \( \delta = \frac{1}{2} (q_2 - q_1) \),

and recall that \( p_2(r_2, t_1) \) is the probability of award to firm 2.

An efficient bargaining process will determine the settlement payment \( S \)
made by the PO to the firm. Individual rationality requires that

\[ U^*(1) - \lambda S \geq U^*(1,2) \quad \text{and} \quad S \geq \pi_2^* - p(W). \]

Here \( p(W) \) is the cost of protest to firm 2 given that it wins, and \( \pi_2^* - p(W) \) is the secure profit to firm 2. Since \( U^*(1) - U^*(1,2) = \beta + \lambda \alpha - 2\lambda \pi_2^* \), the buy-off settlement will occur if

\[ 3\lambda \pi_2^* \leq \beta + \lambda \alpha + \lambda p(W). \] (11)

This condition requires that the profit to firm 2 from inclusion is not too large compared to the cost of inclusion to the PO.\(^{29}\) If (11) fails to hold, then the possibility of protest forces the inclusion of firm 2 which is the result preferred by taxpayers. Notice that buy-offs become more likely as \( p(W) \) grows. This follows because settlement is less costly to the PO when potential protest costs reduce the secure profit of the would-be protestor.

VI. Technology Bias, Inclusion, and the Scoring Function.

The appropriability problem creates incentive problems at the testing and inclusion phase of a procurement, but not during the selection of a scoring function or making of an award because these latter activities require little or no effort. The appropriability problem is generated by an inappropriate trade-off between incremental benefit and the cost of effort.

In contrast, the technology bias affects all phases of procurement. Here we discuss the impact on inclusion and the scoring function. In the next section we discuss the impact on the award process.

A chief objective of CICA was enhancement of "free and open competition" in federal ADPTE procurement. The following example illustrates that the elimination of the technology bias will lead to substantial beneficial entry into this market, because the bias results in the inappropriate exclusion of
low-tech new entrants. Alternatively, if a new entrant is included, the
technology bias will alter the scoring functions in a manner favorable to
incumbents.

Consider an example with two firms: a low-tech entrant and a high-tech
incumbent. For convenience we will label the incumbent as firm 1 and refer to
it as IBM, and we label the entrant as firm 2 and refer to it as the clone.
Assume that \( q_1 > q_2 \), \( \theta_1 > \theta_2 \), and \( q_2 - \theta_2 = q_1 - \theta_1 \), so that IBM is higher
quality, has higher expected cost, and the same expected surplus.

It is instructive to compare the impact of the appropriability problem
and the technology bias on the scoring function. Given a pure appropriability
problem \( \lambda = u \leq 1 \), the priority function is linear in \( \lambda \), so
\[
c_i(t_i; \lambda < 1) = \lambda c_i(t_i; \lambda = 1).
\]

As a result the appropriability problem does not affect the individualized
reserves or bias the probability of award in either party's favor. These
claims follow immediately from linearity when one realizes that the reserve
facing firm \( i \) is the value of \( r_i \) solving \( c_i(r_i; \lambda) = 0 \), and that the scoring
function chooses firm \( i \) if \( c_i(t_i; \lambda) \geq \max \{0, c_j(t_j; \lambda)\} \).

On the other hand, the technology bias which we represent by \( \lambda > u \),
affects both the comparison of \( c_i(t_i) \) to \( c_j(t_j) \) and the reserve values. Since
the reserve faced by firm \( i \) is
\[
r_i = \frac{\lambda}{\mu} \frac{q_1 - \theta_i}{2}
\]
when \( \lambda > \mu \), the reserve grows and the impact of the reserve is diminished
compared to the case with no agency problem. This result follows from the
greater emphasis the PO puts on benefit compared to cost. A reserve policy
reduces cost but also jeopardizes the possibility of making an award.

Given that both firms have positive priority levels, a second impact of
the technology bias is to favor firms with high values of $q_1$. Notice that

$$\frac{c_1(t)}{c_2(t)} = \text{when } \frac{\lambda}{\mu} \frac{q_1 - q_2}{2} = \frac{\theta_1 - \theta_2}{2}. \tag{13}$$

Growth of $\lambda/\mu$ implies a more severe technology bias and makes an award to firm 1 more likely.

These effects of the technology bias are illustrated in Figure 2. The curves are drawn under the assumptions that $\lambda = 1 \geq \mu$, $q_2 > \mu(\theta_2 + 2)$, and $1/3 > \beta + \alpha$. The payoffs from inclusion of firm $i$ are:

$$U^\alpha(i) = q_1 - \mu(1 + \theta_i) - (\beta + \mu \alpha) \tag{14}$$

and

$$U^\alpha(1,2) = U^\alpha(1) + \frac{\mu}{3}(1 - \gamma)^3 - (\beta + \mu \alpha) \text{ for } \mu > \mu_A, \tag{15}$$

where $\gamma = \left[\frac{1 - \mu}{\mu} \frac{q_1 - q_2}{2}\right]$.

Given these assumptions, this example yields a lock-in of IBM for $\mu$ sufficiently small. When $\mu < \mu_B$ the PO cares little about IBM's high cost - he locks-in IBM due to its high quality. As cost considerations become more important, the clone is also included. $\mu_B$ is found as the solution to $U^\alpha(1) = U^\alpha(1,2)$. When $\mu < \mu_A = (q_1 - q_2)/(2 + q_1 - q_2)$, the bias in the scoring function becomes so severe that even if the clone were included it could never win. Hence, this example mimics the pre-CICA practices of POs who could lock-out low technology firms either by exclusionary min-specs or by unfavorable scoring functions. The agency problems can be ameliorated by the protest process, but we will defer the discussion of protests and technology bias to
the following section.\textsuperscript{30}

VII. Technology Bias and Post-Award Protests.

In this section we develop a third and final example of federal computer procurement to analyze the protest process in an incomplete information setting. We set aside the procurement auction used above and assume that the PO can acquire a good with value $q_i$ at cost $x_i$ from firms $i = 1$ or $2$. Production costs to the firms are $c_i < x_i$, which are incurred only by the firm ultimately selected by the PO. We assume that $x_2 > x_1$ and construct the example so that only firm 2 can benefit from the technology bias.

As above, the technology bias is implemented by setting $\lambda = 1$ and $u < 1$. The degree of bias will be private information to the PO who observes $u$. The firms believe $u$ is drawn from $G[0, 1]$. The quality levels of the firms are also private information. $q_i$ is distributed $F[x_i, \bar{q}]$ and is known to both the PO and firm $i$, but not to firm $j = i$. $x_i$ and $c_i$ are common knowledge. In addition, $\pi(W)$ and $\pi(L)$ are protest costs to the PO given a win or a loss before the Board. Similarly, $p(W)$ and $p(L)$ are protest costs to the firm. $\pi(W)$, $\pi(L)$, $p(W)$, and $p(L)$ are all common knowledge.

The order of play calls for the PO to move first and make a tentative award to one firm and a cash settlement offer $S \geq 0$ to the other. The player offered the settlement either accepts it with probability $1 - \theta_i$ or rejects the offer and protests with probability $\theta_i$. The game ends after acceptance. After a protest is initiated the Board chooses which firm receives the award and allocates protest costs. The Board does not act strategically.

Awards will be designated as "appropriate" if they are the awards that would be made by a PO with $\mu = 1$, and "inappropriate" otherwise. The Board
selects an appropriate award if called upon to make a decision in a protest. It acts in a fully informed manner without error.

The payoff to the PO given an appropriate award to firm \( i \) is

\[
U_0 = q_i - ux_i - \theta_j n(W) - (1 - \theta_j)\mu S. \quad (15)
\]

The payoff to the PO given an inappropriate award to \( i \) is

\[
U_0 = (1 - \theta_j)(q_i - ux_i - \mu S) + \theta_j(q_j - ux_j - n(L)). \quad (16)
\]

The payoff of firm \( i \) given: a contract award, is \( x_i - c_i \); a successful protest, is \( x_i - c_i - p(W) \); and an unsuccessful protest is, \( -p(L) \).

We identify a Perfect Bayesian equilibrium which exhibits the features of the protest process described above. The protest process has a partial deterrent effect dissuading some types of PO's from making inappropriate awards. In other cases, an inappropriate award is corrected through a protest or goes undetected. Both buy-off and fedmail settlements occur. Recall that buy-offs occur when the PO has made an inappropriate award while fedmail occurs when the PO has made an appropriate award. Finally, overdeterrence occurs in cases in which an unchallenged award should be made to firm 2 but is instead made to firm 1.

We begin the analysis of the equilibrium by disposing of a straightforward case in which \( q_1 \geq \tilde{q} - x_2 + x_1 \). Here an award to firm 1 is always appropriate (and firm 1 knows that). There are no protests, but a buy-off settlement is possible. In equilibrium, either an award is made to firm 1, or if the technology bias is severe and \( q_2 \) is large an award is made to firm 2 accompanied by a payment \( S_1 = x_1 - c_1 - p(W) \) to firm 1. (When
$S_1 \leq 0$, the availability of protests has no effect and no settlement payments are made.)

In the absence of protests, the PO would award to firm 1 unless $q_2 - \mu x_2 > q_1 - \mu x_1$, in which case an inappropriate award would be made to firm 2. Given protests, $S_1$ must be paid to buy-off firm 1 if the PO intends to make an award to firm 2. Hence, the PO only awards to firm 2 if $q_2 - \mu x_2 - \mu S_1 > q_1 - \mu x_1$.

It is interesting to note that despite its deterrent value, the protest process might not benefit taxpayers. Although the protest threat creates deterrence benefits of $(q_1 - x_1) - (q_2 - x_2)$, the buy-off costs $S_1$. It is possible that the expected value of the latter exceeds the expected value of the former.

We come now to the more interesting case in which $x_1 < q_1$ and $\bar{q} > q_1 + x_2 - x_1$. Once again, if $S_1 \leq 0$, the protest process has no impact, therefore, assume that $S_1 > 0$. Since the example is constructed so that the technology bias works to the advantage of firm 2, we can examine the protest problem from firm 1's perspective. Firm 1 observes $q_1$ and all other data except $q_2$ and $\mu$. The firm knows that an award to 1 is appropriate iff $q_2 \leq q_1 + x_2 - x_1$. Since $q_2$ is not observed firm 1 does not know whether an award to 2 is justified or not.

In the Perfect Bayesian equilibrium constructed below the PO's choice of settlement payment and decision about initial award convey a signal to the firms about the values of $\mu$ and $q_j$. In equilibrium, given an initial award to firm 2, the PO either refuses to settle with firm 1 ($S=0$), or offers a settlement of $S^* > 0$ (which is defined below). Given an initial award to firm 1, no settlement is ever offered to firm 2. On the equilibrium path firm 1 constructs the belief $\omega_1$ that it could win a protest given no settlement
offer, and $\phi_1$ is the belief that it could win given $S^\star$. Firm 2 constructs a similar updated belief $\omega_2$ given an initial award to firm 1.\textsuperscript{31}

Figure 3 displays the features of the equilibrium in $(q_2, \mu)$-space.\textsuperscript{32} In region A, an appropriate award is made to firm 1. Firm 2 does not protest this award, and in fact never initiates a protest in equilibrium. Regions B1 and O represent deterrence and overdeterrence, respectively. An award is made to firm 1 in both cases, but it is inappropriate in region O. The deterrence label is applied because these are both regions in which an award would be made to firm 2 in the absence of protests. Regions B3 and F are settlement regions. In B3 an inappropriate award is made to firm 2 and firm 1 receives a buy-off payment. In F an appropriate award is made to firm 2 and firm 1 receives a fedmail payment. In regions B2 and C an award is made to firm 2, no settlement payment is offered, and the probability of protest is $q^\star \in (0,1)$. The difference between the two regions is that the award is inappropriate in region B2.

**Proposition 2.** A Perfect Bayesian equilibrium of the protest game is characterized assuming that $q > q_1 + x_2 - x_1$, $S_1 > 0$, $\pi(W)$ is close to zero, and certain regularity conditions given below. In regions A, B1 and O an award is made to firm 1 and firm 2 neither protests nor receives a settlement payment. In regions B2 and C an initial award is made to firm 2, firm 1 protests with probability $q^\star$, and the PO sets $S=0$. In region B2 a protested award is reversed. In regions B3 and F the award is made to firm 2 and firm 1 always accepts the settlement $S^\star = \phi_1 S_1 - (1 - \phi_1)p(L)$.

**Proof.** We begin by using Bayes' rule to derive the beliefs on the equilibrium path. Firm 2 is appropriately denied an award in regions in A and B1, and
Post-Award Protest

Figure Three
inappropriately denied in region O. Consequently,

\[ \omega_2 = \frac{\Pr(O)}{\Pr(O) + \Pr(A) + \Pr(B1)}. \]  

(17)

The expression for the probability of these regions is provided below.

Firm 1 receives a settlement offer $S=0$ in regions $B2$ and $C$. In $B2$, firm 1 wins and in $C$ it loses. Hence,

\[ \omega_1 = \frac{\Pr(B2)}{\Pr(B2) + \Pr(C)}. \]  

(18)

Given $S = S^\ast$, firm 1 knows that it could do better by protesting if the PO's type is in the $B3$ region, but the firm loses in the $F$ region. The updated probability of $B3$ is

\[ \phi_1 = \frac{\Pr(B3)}{\Pr(B3) + \Pr(F)}. \]  

(19)

Since firm 2 does not protest in equilibrium, the expected payoff from such a strategy must be non-positive. In region $O$ firm 2 gains

\[ S_2 = X_2 - C_2 - p(W) \]  

from a protest compared to a loss of $p(L)$ in regions $A$ and $B1$. The expected profit is non-positive if

\[ \omega_2 \leq \frac{p(L)}{p(L) + S_2}. \]  

(20)

In contrast, firm 1 is indifferent between protest and inaction given $S = 0$, hence the payoff to protest must be zero. A successful protest yields $S_1$ while a failed protest costs $p(L)$. Therefore,

\[ \Omega(S^\ast, \theta^\ast) = \omega_1 - \frac{p(L)}{p(L) + S_1} = 0. \]  

(21)

The dependence of $\Omega$ on $S^\ast$ and $\theta^\ast$ indicates that these variables are endogeneously determined in equilibrium to give firm 1 a posterior belief about winning that leaves him or her indifferent between protesting or not.
Given $S = S^\ast$, firm 1 always accepts $S^\ast$, but is left indifferent between that choice and protest because the PO pushes down $S$ as far as possible. Profit is equalized across the two strategies if

$$
\phi(S^\ast, \psi^\ast) = \varphi_1 - \frac{S^\ast}{S_1 + p(L)} = 0.
$$

(22)

To show that conditions (20) through (22) can be simultaneously satisfied in equilibrium we must derive expressions for the probabilities of the different regions. The determination of the equilibrium behavior of the PO allows us to specify the boundaries of the various regions in Figure 3. The payoff to the PO from award to firm 1 is

$$
U_0 = q_1 - \mu x_1.
$$

(23)

The payoff from award to firm 2 and $S = S^\ast$ is

$$
U_0 = q_2 - \mu x_2 - \mu S^\ast.
$$

(24)

The payoff from award to firm 2 and $S = 0$ given the award is inappropriate is

$$
U_0 = (1 - \theta_1)(q_2 - \mu x_2) + \theta_1(q_1 - \mu x_1 - \pi(L)).
$$

(25)

The payoff from award to firm 2 and $S = 0$ given the award is appropriate is

$$
U_0 = q_2 - \mu x_2 - \theta_1 \pi(w).
$$

(26)

The PO chooses optimally among these three strategies in such a way as to determine the boundaries of the regions depicted in Figure 3. For convenience define $Q = q_2 - q_1$ and $X = x_2 - x_1$. Then the boundaries are given by
\[ \mu = \frac{Q}{X} = \beta_1(q_2) \quad \text{A/B1} \]
\[ \mu = \frac{Q}{X + S^*} = \beta_2(q_2) \quad \text{B1/B3} \]
\[ \mu = \frac{Q}{X} - \frac{\theta^*}{1 - \theta^*} \frac{\pi(L)}{X} = \beta_3(q_2) \quad \text{B1/B2} \]
\[ \mu = \frac{Q + \pi(L)}{X + \frac{S^*}{\theta^*}} = \beta_4(q_2) \quad \text{B2/B3} \]
\[ \mu = \frac{Q - \frac{\theta^*}{1 - \theta^*} \pi(\omega)}{X} = \beta_5(q_2) \quad \text{O/C} \]
\[ \mu = \frac{\frac{\theta^*}{1 - \theta^*} \pi(\omega)}{S^*} = \beta_6(q_2) \quad \text{C/F} \]

Some comments about Figure 3 follow immediately from the equations. The boundaries between A and B1, B1 and B2, and O and C are parallel. Since \( \beta_5 > \beta_3 \) at \( q_2 = q_1 + X \), the O and C boundary is above the B1 and B2 boundary. The B1, B2 and B3 regions all meet at

\[ \hat{q}_2 = q_1 + \frac{\theta^* \pi(L)}{1 - \theta^*} \frac{S^* + X}{S_1} \quad (27) \]

\[ \hat{\mu} = \frac{\theta^* \pi(L)}{1 - \theta^*} \frac{S^*}{S^*} \quad (28) \]

Notice that \( \hat{\mu} > \beta_6 \).

From these boundaries we can specify the equilibrium probabilities
associated with various regions. In general, the probability of region Z is

\[ \Pr(Z) = \int_Z dG(\mu) dF(q_2), \] 

(29)
e.g., \( \Pr(B2) = \int_{q_1}^{q_2} \int_{\beta_3}^{\beta_4} dG(\mu) dF(q_2). \)

Finally, we must show that inequality (20) and equations (21) and (22) can be satisfied simultaneously. The inequality that guarantees that firm 2 will not protest is satisfied for \( \pi(W) \) sufficiently small. Firm 2 would only protest if the probability of overdeterrence is large. Since \( \Pr(0) \) and \( \omega_2 \) go to zero as \( \pi(W) \) goes to zero, firm 2 will not protest.

To find the unique pair \( S^* \) and \( \theta^* \) that satisfy equations (21) and (22) we must consider the properties of \( \Omega \) and \( \phi \). These functions are drawn in \( (S, \theta) \)-space in Figure 4. The interior of the shaded region contains values of \( (S, \theta) \) such that \( \omega_1 \) is positive. The strictly concave boundary contains the locus of points at which the B2 region vanishes.\(^{33}\) Along this locus and within the shaded area the probability of C is always positive.\(^{34}\) The probabilities of B3 and F are always positive except when \( \theta = 0 \). Therefore, we look for an equilibrium in the interior of the shaded region.

We impose a regularity assumption to guarantee that \( \partial \Omega / \partial S > 0 > \partial \Omega / \partial \theta \). In other words, \( \omega_1 \) grows in the southeast direction in Figure 4. We assume that the elasticity of \( \Pr(B2) \) is greater than the elasticity of \( \Pr(C) \) with respect to both \( \theta \) and \( S \). Given this assumption, the maximum value of \( \omega_1 \) occurs at \( \mu = 0, S = S_1 \). Let this value be \( \omega_{\text{max}} = \Pr(B) | \Pr(B) + 1 - P(q_1 + X)|^{-1} \).\(^{35}\) To assure an interior equilibrium we assume that \( \omega_{\text{max}} > p(L) | p(L) + S_1 |^{-1} \). The continuity of \( \Omega \) and the regularity condition assure that \( \Omega(S, \theta) = 0 \) is a strictly concave locus in the shaded region.\(^{36}\)

Sufficiency for a unique interior equilibrium is provided by assumptions
Protest Equilibrium

Figure Four
inducing a decreasing graph of $\Phi(S, \theta)$. Since $\phi_1 = \omega_{\text{max}}$ at $S = 0$ implies $\Phi > 0$, and since $\phi_1 < 1$ at $S = S_1$ implies $\Phi < 0$, it is natural to assume $\partial \Phi / \partial S < 0$. Notice that $\partial \Phi / \partial S = \partial \phi / \partial S - [S_1 + p(L)]^{-1}$. When $\pi(W)$ is small the first term is close to zero, hence the assumption will be satisfied. We also assume that $\partial \Phi / \partial \theta < 0$ which is natural given the assumptions about $\Omega$. It is equivalent to assuming that $\Pr(F)$ is more elastic with respect to $\theta$ than $\Pr(B3)$.\(^{37}\) This completes the proof that there exists a unique pair $(S^*, \theta^*)$ solving (21) and (22), and the construction of the Perfect Bayesian equilibrium.

Q.E.D.

Examination of some special cases is instructive. When the PO does not suffer a penalty following a favorable decision, so that $\pi(W) = 0$, then $\Pr(O) = \Pr(F) = 0$, $\phi_1 = 1$ and $S^* = S_1$. Two of the negative side effects of the protest process, overdeterrence and fedmail, disappear. Both of these phenomena depend on the threat felt by the PO from erroneous protests.

In the case of overdeterrence, the PO perceives a danger of protest from firm 1, but not firm 2 and makes an inappropriate award to firm 1 to avoid the possibility of incurring $\pi(W)$ in a protest. In the case of fedmail, the PO pays firm 1 not to protest rather than risk the payment of $\pi(W)$. In neither case can the PO convince firm 1 that a protest would be pointless, because the PO has no credible method of demonstrating the value of $q_2$ -- short of the protest process.

There is an important difference between the two regions; high values of $\mu$ result in overdeterrence while low values result in fedmail. Fedmail is possible because the settlement payment affects the PO indirectly. When $\mu$ is small the impact of $\mu S^*$ is negligible, while the direct payment $\pi(W)$ is unaffected by $\mu$. In contrast, overdeterrence occurs when $\mu$ is large, including $\mu = 1$, the case of no technology bias. The PO reasons that the
surplus loss from an inappropriate award is small compared to the expected cost of protesting.

If \( \pi(L) = \pi(W) = 0 \), so that the PO cannot be punished by the GSBCA through the protest process, then \( \Pr(B1) = 0 \) in addition to the results above. Eliminating the punishment faced by a bad PO removes the deterrent effect of protests. Notice that the regulatory power of protests is not entirely eliminated though. The PO still faces protests in the B2 region which will correct inappropriate awards. This highlights an important consideration -- protests operate both to deter and correct inappropriate awards.

Even though the PO does not face a penalty when found to have made an inappropriate award, \( S^\circ \) is still positive. The protestor can threaten the PO with the prospect of having to make an award to a less preferred firm. This threat explains why buy-off settlements still occur even if \( \pi(L) = 0 \).

Finally, consider the special case in which \( S_1 \) approaches zero. When the protestor's secure profit goes to zero the threat of protest loses its credibility. The probability of protest \( \omega_1 \) goes to zero, and the PO makes an award to firm 2 everywhere outside the A region.

In order to justify subsequent comparative static analysis we offer Proposition 3 which indicates that the equilibrium in Proposition 2 is unique when \( \pi(W) = 0 \). This is an interesting special case in which no penalty is assessed against a winning PO. Participants in the actual protest process strive to get \( \pi(W) = 0 \), but fail to the extent that protest engenders delay in procurement.
Proposition 3. Given appropriate restrictions on out of equilibrium beliefs, the Perfect Bayesian Equilibrium in Proposition 2 is unique.

Proof. Observe from Proposition 2 that the F and O regions vanish when \( \pi(W) = 0 \). Thus every type of PO that can make an appropriate award to firm 2 is in the C region. For these types making an award to firm 2 and setting \( S = 0 \) is a dominant strategy. Hence in any equilibrium a settlement offer to firm 1 signals that the PO making the offer is outside of the C region with probability 1. Furthermore, the only "reasonable" beliefs about off-the-equilibrium path settlement offers is that they came from a PO with type \( q_2 < q_1 + X \). Given such beliefs, firm 1 would accept \( S \geq S_1 \) and reject \( S \in (0, S_1) \). Therefore, a PO with type \( q_2 < q_1 + X \) would find an offer \( S > S_1 \) to be dominated by \( S_1 \). Furthermore, an offer \( S \in (0, S_1) \) would be treated exactly like a refusal to settle, leaving the outcome specified in Proposition 2 as the unique equilibrium outcome. Q.E.D.

Regardless of whether \( \pi(W) \) is zero certain comparative static results are immediate. From (21) and (22) it is clear that \( \omega_1 \) is independent of \( \pi(L) \) and \( \pi(W) \), and increasing in \( p(L) \) and \( p(W) \). These predictions are testable since \( \omega_1 \) measures the fraction of protests that are won by the protesting firm. The equilibrium probability of success by a protestor is chosen to make the protestor indifferent between protest and inaction, hence it does not depend on the protest costs of the PO. When either of the protest costs to the firm rise, would-be protestors select more promising cases for protest which implies an increase in \( \omega_1 \).

To get additional results invoke \( \pi(W) = 0 \). In equilibrium \( \Pr(F) = \Pr(O) = 0, \phi_1 = 1 \), and \( S^* = S_1 \). Condition (22) is vacuous and (21) becomes:
\[ S_1 \text{Pr}(B2) = p(L)\text{Pr}(C). \] (30)

Table 1 shows some comparative static results. An interesting finding is that increasing the penalty suffered by a losing PO does not alter the size of the B2 region, but it does reduce the probability of protest. In the context of this model an increase in penalty is matched by a reduction in the probability of detection leaving the probability of an inappropriate award without settlement unchanged. The normative implication is familiar from the economics of crime; high penalties and low probabilities of detection are the cost minimizing method of deterrence. See, e.g., Becker (1968).

Regarding \(p(L)\) and \(p(W)\), notice that deterrence as measured by the B1 region is inversely related to the firm's protest cost. This result follows because the firm finds protest more costly, and must have a higher probability of success to protest. A lower value of \(\theta^*\) is necessary to push up \(\omega_1\), yielding less deterrence. In the case of \(p(W)\) there is also an indirect effect reducing \(\text{Pr}(B1)\). The equilibrium settlement payment, \(S_1\), falls as \(p(W)\) rises, shifting the boundary B1/B3. Therefore, a portion of the parameter space that had resulted in correct awards shifts to buy-off settlements.

Finally, notice that it is possible for an increase in the firm's protest costs to increase the probability of protest. The direct effect is a reduction in protests since \(\partial \theta / \partial p(L)\) and \(\partial \theta / \partial p(W) < 0\). This effect is offset by the growth of the B2 region brought about by the weakened deterrent. Hence, the counterintuitive possibility exists that the probability of protest increases as \(p(W)\) or \(p(L)\) increases.
TABLE I

<table>
<thead>
<tr>
<th></th>
<th>Pr(B1)</th>
<th>Pr(B2)</th>
<th>Pr(B3)</th>
<th>Pr(C)</th>
<th>θ</th>
<th>Pr(Protest)</th>
</tr>
</thead>
<tbody>
<tr>
<td>p(L)</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>?</td>
</tr>
<tr>
<td>p(W)</td>
<td>-</td>
<td>+</td>
<td>?</td>
<td>0</td>
<td>-</td>
<td>?</td>
</tr>
<tr>
<td>π(L)</td>
<td>?</td>
<td>0</td>
<td>?</td>
<td>0</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Comparative statics with π(W)=0.
VIII. Conclusion.

It is widely believed by participants in the federal ADPTE procurement process with whom we have spoken that CICA and GSBCA protests have had two major effects on procurement. First, there has been a deterrent effect. POs are aware that inappropriate procurement actions raise the possibility of a successful protest and have altered their behavior in the direction of surplus maximization. Second, the Board has had a corrective role, establishing a reputation as a stringent enforcer of CICA by reversing discretionary acts of POs that are contrary to the public interest.

We believe that other developments observed in the federal computer market since 1984 can be attributed to the protest process; namely, greatly diminished advantages to incumbency and both a reduction in exclusionary specifications and inappropriate awards. While providing effective oversight, the protest process has also had undesirable side effects such as the cash settlements which we refer to as "buy-offs" and "fedmail" as well as overdeterrence.

Our models of procurement auctions and protests accord well with the details of ADPTE procurement. Priority levels with cost and quality components mimic the scoring functions used in RFPs. The choice of the inclusion set by the PO mimics the existence of exclusionary min-specs in RFPs. The use of protests by POs to produce quality information about new entrants is consistent with the entry promoting tendency of the GSBCA.

The technology bias we impute to POs accounts for the favoritism shown toward high-tech, low surplus products. The appropriability problem causes the PO to exert too little effort in evaluation of new entrants resulting in barriers to entry. The protest mechanism alleviates these problems.
Laffont and Tirole (1989) study a similar problem. In their model incentive contracts are auctioned to a pair of bidders with differing quality. The PO favors one of the bidders and can bias the award toward the favorite. The government has trouble controlling abuse of discretion because it cannot observe quality. They conclude that the government may respond to possible favoritism by manipulation of the procurement mechanism, for example, by replacing RFPs with IFBs.

In future work we hope to compare the normative properties of the protest process to random audits. We have some preliminary comments on the two schemes. Assuming that an audit and a protest produce equally good information about a procurement under investigation, there are still substantial differences between them. The selection process in protests is superior to audits because the firms that initiate a protest are likely to be better informed than an auditor. Furthermore, the incentives of protestors are apt to be stronger than those faced by an auditor. Aggrieved firms have a financial stake in protest success while a government auditor is susceptible to an appropriability problem.

On the other hand, the audit process avoids many of the protest problems described in this paper. Specifically, while buy-off and fedmail settlements disrupt the protest process, audits avoid them. In addition, no firm has an incentive to protest a procurement that should never have been initiated, while the auditor would flag such procurements. Finally, audits and protests both suffer from possible overdeterrence. Where this problem is more severe depends upon the mechanism used for the selection of procurements for audit.
REFERENCES


\(^1\)See Gabig (1987).

\(^2\)Typically, two types of individuals at a federal agency are directly involved in a procurement, technical advisors and contracting officers. The contracting officer conducts most negotiations while the technical advisors write the bid solicitation and evaluate products. We do not distinguish between these individuals but simply refer to them as the "procurement official."

\(^3\)Throughout the text the principal is referred to as either the "government" or "taxpayers," while the agent is the PO.

\(^4\)The emphasis by POs on quality over cost has been noted by Cansler (1980) and Scherer (1964), but, see Rogerson (1988) who explains apparent quality bias on other grounds.

\(^5\)According to Suchanek and Vergilio (1989, p.31):"Under de novo review the GSBCA is in no way committed by the findings of the contracting office, even if supported by the evidence, and can make independent findings of fact, drawing its own conclusions from the evidence."

\(^6\)Gabig (1987, p. 43) summarizes the impact of the protest process as follows. "The ominous threat of a GSBCA protest has had a prophylactic impact on the acquisition process. Federal agencies have become more conscientious about properly conducting procurements for information systems."
The "penalties" available to sanction agencies consist of suspension or modification of procurement authorization and delay of the procurement. The GSBCA cannot directly punish POs, but presumably they would suffer a reprimand from their agency because of protest costs incurred by the agency.

Cohen (1983) argues that the primary reason for CICA was to eliminate overly restrictive specifications. As an illustration, we have been informed that during the summer of 1988 system integrators who sold Everex 386 personal computers (PCs) placed a great deal of emphasis on the (genuine) advantages of memory caching when discussing hardware with POs. It is our understanding that at this time only three 386 PC product lines had memory caching. Consequently, a bid solicitation with a min-spec of memory caching would substantially reduce competition yet possibly survive a challenge before the GSBCA. However, in a recent (1987) Department of Defense procurement the min-specs stated that the keyboard buffer of the procured PCs could not be less than 20 keystrokes. No justification could be provided for this specification and, apparently, no PC other than those manufactured by Compaq possessed this characteristic. This is an excellent example of a "lock-out" spec.

For example, we have been informed of one procurement for laptop computers that specified a battery-life test. The RFP stated that the battery must have a charge duration not less than three hours. However, in testing Toshiba laptops, the preferred brand of the PO, the battery regularly discharged completely in less than three hours. The tests were conducted repeatedly until a single success was recorded then the PO declared that
Toshiba had passed the test.

10There are rare cases in which winning bidders protest an award. Grammco Computer Sales (Ref. # 8940-P) submitted two separate bids for an Army procurement and protested the fact their losing bid was improperly evaluated. The protest was granted by the GSBCA.

11We view the GSBCA judges as immune to the incentive problems plaguing POs. First, the judges are insulated from the particular procuring agencies and there is no reason whatsoever that they would suffer a technology bias. Second, regarding an appropriability problem, we believe a judge’s career is tied much more closely to the quality of judgments he or she renders than a PO’s career is tied to his purchase decisions. Furthermore, the adversarial system puts much of the burden of effort on the parties rather than the judge.

12“The Board allows protestors to gain access to agency personnel, to probe conclusions reached, and determine facts and attitudes which appear nowhere in the written record,” Webber (1987).

13One well-publicized case concerns payments exceeding $1 million made by the Bureau of the Census to three firms that jointly protested the ADPTE procurement for the 1990 census. The basis for these protests was the restrictiveness of the specifications in the RFP.

14As noted by Adkins and Daley (1988), “Many contractors who once relied heavily or exclusively on sole-source procurements are no longer able to do
so."

Gebig (1987, pg. 74) characterizes the prevailing attitude among POs prior to GICA as, "no one was ever fired for buying from IBM."

Richard Stubbing (1986, page 155) notes that the DOD typically purchases high-tech items that possess capabilities slightly in excess of more pedestrian items when the latter cost far less.

Adkins and Daley (1988) note with respect to ADPTE firms that, "The process of getting business and remaining an incumbent is getting more difficult." Sugawara and Tucker (1988) have pointed out that, "Protests allow small firms to compete on equal grounds (with large ones)."

The model below would be essentially unchanged if \( V(Q) \) replaced \( \lambda Q \) in the objective function, where \( V(Q) \) is increasing in \( Q \).

This assumption is not made for its realism. We make it so that our analysis will clearly separate the effects of the agency problems from the effects of choosing a suboptimal auction mechanism.

Myerson's auction is a second-price "priority" level auction. A priority level is formally defined in the context of Proposition 1.

In section IV we consider the possibility that \( q_i \) is private information known only to firm \( i \).
Alternatively, the losers might not receive compensation and the winner's compensation could be increased to leave ex ante profit unchanged.

The uniform symmetric independent private value procurement auction can be recovered from Proposition 1. Let $\alpha = \beta = \theta_i = 0$, and $\lambda = \mu = q_i = 1$. In this case the optimal reserve is $1/2$, the lowest bid wins and the winner receives the high bid as compensation.

We always assume that $U^w(i) > 0$ for at least one of the two firms.

This example is motivated by the Computer Marketing Corp. protest (GSBCA No. 8131-P-R) in which an agency refused to entertain bids from vendors of used tape drives. The Board found the used products of acceptable quality and ruled the exclusion unjustified.

Assume here that the cost to a winning firm of a protest is zero, and that all costs are shifted to the PO.

We do require that $\lambda$ is large enough so that firm 1 is always included and firm 2 is included if $r = 1$.

In the next section we will discuss the use of protests to alleviate the appropriability problem, but in this section protests are only used to produce information about $q_2$.

Here we assume that unlike $\beta$, $S$ is not incurred directly by the PO. If we assume otherwise, then buy-off settlements are less likely, as condition 11
Technology Bias and Lock-out

Figure Two
becomes $(2\lambda + 1)\pi_2^\ast < \beta + \lambda \alpha + p(W)$.

30 Analysis of a protest in this setting is particularly difficult because settlements negotiated between the PO and protestor may consist of alterations in the scoring function as well as cash payments. Furthermore, protests may not be effective in forcing the PO to use a stringent reserve policy since there will be cases in which both firms benefit from high reserves that are induced by the technology bias.

31 Off-the-equilibrium path beliefs are discussed in the proof of Proposition 3.

32 If no protests were permitted or if $S^\ast = 0$, then an award would be made to firm 1 in the A region and to firm 2 in all other regions.

33 $Pr(B2) = 0$ at $q_2 = q_1 + X$, or $\theta = SX[SX + \pi(L)(X + S)]^{-1}$.

34 $Pr(C) = 0$ when $S = \theta \pi(W)$. Notice that the slope of the locus of points such that $Pr(C) = 0$ is steeper than the locus for $Pr(B2) = 0$ at $S = 0$.

35 The probability of B, which is the combined regions B1, B2 and B3, depends only on parameters of the model.

36 Notice that we have an upper bound on $\theta^\ast$, it must be less than $S_1 X/[S_1 X + p(L)(S_1 + X)]$ to be in the shaded region.

37 It holds for example in the case in which $G(\mu)$ and $F(q_2)$ are uniform.