GOVERNMENT PROCUREMENT AND INTERNATIONAL TRADE

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We model the bidding for a government contract in which there is imperfect competition; each bidder is better informed about his own costs than either his rival bidders or the government; and the distribution of the domestic firms' costs differs from the distribution of foreign firms' costs because of comparative-advantage effects. We find that the government minimizes its expected procurement cost by operating a price-preference policy, not necessarily purchasing from the lowest bidder.

1. Introduction

Governments are conspicuous actors in any modern economy. Government purchases of goods and services typically account for about 10 percent of GDP. It follows that, by their choice between purchasing overseas and favoring domestic suppliers, governments can have a marked impact on international trade patterns. Worldwide, preferential government-procurement policies affect several hundred billion dollars' worth of trade each year [Graham (1983)]. The significance of government-procurement policies as nontariff barriers to trade was recognized by the General Agreement on Tariffs and Trade (GATT), whose Agreement on Government Procurement came into effect in 1981. This sets out rules on how government purchases should be tendered, designed to ensure that governments' procurement practices do not protect domestic suppliers and do not discriminate among different foreign suppliers. It also seeks to ensure what GATT calls 'transparency' of the laws and procedures of government procurement.[1]

[1]The GATT agreement is described in GATT (1985) and Graham (1983). The agreement excludes defence contracting. Also, the agreement covers only national governments: it does not bind subnational governments.

The GATT agreement defines what policies should exist. What policies actually exist? Under the Buy-American Act, the United States Government offers a 6 percent preference for domestic suppliers: if the lowest domestic bid is no more than 6 percent higher than the lowest foreign bid, the contract is awarded to the domestic firm. This preference is raised to 12 percent in the case of small businesses and firms in regions of high unemployment, and 50 percent for military procurement. In addition, certain specified commodities must be purchased within the United States [Graham (1983), OECD (1976)]. The Canadian Government offers a 10 percent preference based on Canadian content. It also has a sourcing policy: foreign firms are allowed to bid only if there is insufficient competition among Canadian-based firms, where 'sufficient competition' is taken to mean three or sometimes only two firms [Supply and Services Canada (1983a, 1983b)]. The Australian Government gives a 20 percent preference for Australian content, while the New Zealand government gives a 10 percent preference [Joson (1982), New Zealand Government (1985)]. The European and Japanese governments do not explicitly state formulae by which foreign bids are to be compared with domestic bids. Instead, these governments achieve favoritism by more covert methods: allowing only a short time for the submission of bids; applying residence requirements on bidders; or defining technical requirements in such a way that it is difficult or impossible for foreign firms to comply [Baldwin (1970, pp. 63–68), Lowinger (1976)].

As the existence of the GATT Agreement suggests, procurement preferences are commonly interpreted as protectionist devices, similar in their effects to tariffs [Lowinger (1976)]. While undoubtedly the political origins of these policies reflect protectionist intent, the analysis to be developed in this paper will show that, unlike tariffs, policies such as the 6 percent buy-American preference may have another justification, one which is more reasonable from the economist's perspective. The procurement preferences can serve, by increasing bidding competition, to lower the expected price paid by the government for the item. It should be stressed that our argument is purely normative. It does not explain the existence of procurement preferences; their existence is more likely to be due to the political power of certain interest groups. What will be shown, however, is that the procurement preferences have unexpected, and sometimes beneficial, side-effects. Discriminatory procurement policies are not as costly as they appear. The analogy with tariffs is misplaced: unlike the zero tariff, the zero preference is not the appropriate benchmark for evaluating the effects of these preferences.

The analysis to be developed is based on a theorem on the design of optimal auctions due to Myerson (1981).[2] It is an essential aspect of the procurement problem that the government does not know the expected costs

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[2]For a review of the theory of auctions, see McAfee and McMillan (1987a).

of any particular firm. If the government had this information, there would be no need to organize a sealed-bid tender; instead, the government could simply order the item from the lowest-cost supplier. Therefore, any analysis of procurement policies must take account of informational asymmetries. We suppose that any of the bidding firms can predict its own cost of supplying the item being procured. The rival firms and the government cannot, however, observe this cost. Instead, they perceive it to be drawn from some probability distribution. Moreover, because of comparative-advantage effects, firms' costs differ systematically from country to country. We model this by assuming that firms from different countries draw their costs from different probability distributions. We find that the government policy that minimizes expected procurement cost involves discriminating across the different countries' bidders by offering price preferences.

In section 2 we present a more general optimal-auctions theorem and explicate the optimal discriminatory auction. In section 3 we discuss who gains and who loses from discriminatory procurement policies and examine alternative objective functions for the government. In section 4 we use simulations to examine the relevance of our results for existing government policies. Section 5 contains concluding comments.

2. Discrimination in auctions

Suppose the government wishes to acquire some commodity. There are two sets of bidders, domestic and foreign, identified by subscripts 1 and 2, respectively. Let there be n_i bidders from country i, $i=1,2$. Each n_i is assumed to be small enough that there is imperfect competition in the bidding: if the competition were perfect ($n_i \to \infty$) there would be no need for the competition-stimulating policies about to be analyzed.[3]

The essential feature underlying the results of this model is that the amount of competition faced by a domestic firm is different from the amount of competition faced by a foreign firm. A domestic firm competes with $n_1 - 1$ domestic firms and n_2 foreign firms, whereas a foreign firm faces n_1 domestic firms and $n_2 - 1$ foreign firms. It is this difference, together with the systematic cost difference between domestic and foreign firms, that the government can exploit in designing its optimal procurement mechanism.[4]

Let the (constant) average cost to a firm from country i of supplying the item being procured be c_{ij}, $j=1,\ldots,n_i$; $i=1,2$. The value of c_{ij} is assumed to be known to the firm itself. The other firms and the government perceive this

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cost to be independently drawn from a probability distribution G_i, $i = 1, 2$. Assume G_i is continuously differentiable, with derivative g_i. Let $c_i^\ell > 0$ be the lowest possible cost and c_i^h be the highest possible cost of firms from country i. (More precisely, $c_i^\ell = \inf\{c_{ij}|g_i(c_{ij}) > 0\}$ and $c_i^h = \sup\{c_{ij}|g_i(c_{ij}) > 0\}$.) Suppose that, for $c_i^\ell < c_{ij} < c_i^h$, $0 < G_i(c_{ij}) < 1$. The government and the suppliers are assumed to be risk neutral.

Assume that arbitrage among the bidders after the auction can costlessly be prevented by the government: this means that the successful bidder cannot later subcontract the whole project to some other bidder. (This would sabotage the government's optimal mechanism which is about to be described.)

We initially assume that the government seeks to maximize the value to it of the item in question net of its procurement costs. Thus the government is indifferent about whether profits go to domestic or foreign firms. (In section 3 we shall assume that domestic firms' profits enter the government's objective function.) Suppose the government attaches a monetary value of $V(q)$ to the q units of the good that it purchases (with $V' > 0$ and $V'' \leq 0$), so that it chooses its purchase policy to maximize the expected value of $V(q) - P$, where P is its total payment.

Define a function J_i by

$$J_i(c_{ij}) = c_{ij} + \frac{G_i(c_{ij})}{g_i(c_{ij})}, \quad j = 1, \ldots, n_i; i = 1, 2. \tag{1}$$

Assume throughout that J_i is a strictly increasing function.[5] As will be seen, $G_i(c_{ij})/g_i(c_{ij})$ is the expected unit profit of the successful bidder in the optimal auction (this profit arising from the privacy of the bidder's information about his cost). Thus $J_i(c_{ij})$, the sum of unit production cost and unit profit, is the expected price paid by the government. The monotonicity assumption therefore says simply that the government's expected payment increases with the supplier's production cost.

How should the government design its procurement policy so as to maximize its expected surplus subject to the constraints imposed by its lack of knowledge of the bidders' costs? By the Revelation Principle [Myerson (1985)] we can without loss of generality analyze this problem by imagining that the government simply asks each of the firms to report its cost, having announced the rules determining which bidding firm will be selected and how much it will be paid. Moreover, by judicious choice of these rules, the government can ensure honest reporting. The Revelation Principle states that

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[5]This amounts to a weak assumption on the shape of the distribution G_i. See McAfee and McMillan (1987a) for more details.

the best the government can do with this hypothetical way of proceeding is the same as the best it can do using any realistic procedure like sealed bidding. Thus, the results to follow (the proofs of which are in the appendix) are expressed in terms of the bidding firm's costs, which can be interpreted as having been revealed to the government either directly (in the hypothetical mechanism just described) or implicitly (via the bids in a sealed-bid mechanism).

Theorem 1.   The government's optimal policy is to purchase, if at all, from the bidder having the lowest value of $J_i(c_{ij})$ $j=1,\ldots,n_i$; $i=1,2$. The quantity purchased satisfies

$$V'(q) = \min J_i(c_{ij})), \quad j=1,\ldots,n_i, \ i=1,2. \tag{2}$$

This generalizes the theorem of Myerson (1981): whereas Myerson assumed a fixed quantity demand, the above theorem allows downward-sloping demand.[6] Myerson showed that, with a fixed quantity to be purchased, the buyer should award the contract to the bidder with the lowest $J_i(c_{ij})$ value. Note that implicit in Theorem 1 is a reserve-price policy: if (2) cannot be satisfied, the buyer rejects all bids. Eq. (2) simply equates marginal benefit $V'(q)$ to the lowest available marginal cost, where marginal cost consists of not only the marginal production cost c_{ij} but also the cost to the buyer of inducing the bidders to reveal their private information about their costs $G_i(c_{ij})/g_i(c_{ij})$. In order to induce the bidders to reveal their private information, the government offers them rents equal to G_i/g_i [McAfee and McMillan (1987a)].

Theorem 1 shows that the policy that is optimal for the government will in general be discriminatory, in that there will be a possibility that one bidder wins despite another bidder's having a lower cost. To understand the nature of this discrimination, define a function[7] $z(c_1)$ to compare a domestic bidder with a foreign bidder: a domestic bidder with cost c_1 wins against a foreign bidder with cost c_2 if and only if $z(c_1)<c_2$. Thus, for example, $z(c)<c$ for some c means that foreign bidders are discriminated against in favor of domestic bidders, in the sense that it is possible for a domestic bidder to beat a foreign bidder despite having a higher cost. It follows from Theorem 1 that the optimal z function is implicitly defined by

$$J_1(c_1) = J_2(z(c_1)). \tag{3}$$

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[6]However, this is more special than Myerson's analysis in that Myerson did not require monotonicity of the J_i functions. In McAfee and McMillan (1987b) we show that Myerson's result also generalizes to the case in which the bidders do not know at the time of bidding who they are competing against.

[7]In what follows, the second subscript on c_{ij}, denoting a particular firm from country i, will be dropped without causing ambiguity.

For example, if both distributions are uniform, it can be shown that the optimal discriminatory rule in effect adds a constant term to the costs of the nonfavored class of firms: the optimal policy satisfies

$$z(c) = c + \frac{c_2^\ell - c_1^\ell}{2}. \tag{4}$$

Condition (3), which gives the optimal price discrimination policy in the auction, can be rearranged into a more familiar-looking form. $G_i(c_i)$ is the probability that a bidder from country i has a cost of c_i or less. Define η_i to be elasticity of this probability with respect to c_i: that is, $\eta_i(c_i) = c_i g_i(c_i)/G_i(c_i)$.

Corollary 2.   The optimal discriminatory policy satisfies

$$\frac{z(c_1)}{c_1} = \frac{1 + 1/\eta_1(c_1)}{1 + 1/\eta_2(z(c_1))}. \tag{5}$$

This looks exactly like the standard formula for optimal price discrimination in the elementary monopoly or monopsony model, highlighting the analogy between the optimally discriminatory auction and more familiar notions of price discrimination. Note the simplicity of the optimal price discrimination formula (3) or (5): in particular the optimal z function is independent of the number of firms that submit bids, n_1 and n_2.

Which bidders receive preferential treatment? From (5), $z(c) < c$ (that is, domestic bidders are favored) if and only if $\eta_2 < \eta_1$: the discrimination works in favor of the country's bidders with the higher probability elasticity.

Theorem 3. $z(c) < c$ if and only if $G_2(c)/G_1(c)$ is strictly decreasing in c.

Corollary 4. $z(c) = c$ if and only if $G_1(c) = \theta G_2(c)$ for some $\theta > 0$.

Thus, no preferential treatment should be given to either country's bidders if and only if the distributions of costs are related in a very special way. It can be concluded therefore that in most cases the buyer should offer favoritism, either to domestic bidders or to foreign bidders. Thus, the government minimizes its expected payment by having a policy that in some circumstances awards the contract to a bidder other than the lowest-cost bidder. In other words, it is in the government's interest sometimes to distort the allocation of resources away from efficiency.

There is a sense in which the government's optimal policy works by discriminating against the low-cost country's suppliers, as the following result shows.

Corollary 5.   Suppose $G_i(c_i)/g_i(c_i)$ is strictly increasing in c_i, $i=1,2$. Suppose G_1 and G_2 are related by[8] $G_2(c)=G_1(c+a)$ for some $a>0$. Then $z(c)<c$ for all c.

This says that if the distribution of domestic costs and the distribution of foreign costs are related by a spread-preserving change in mean such that on average a domestic bidder has a higher cost than a foreign bidder, then the government should discriminate in favor of the domestic bidders. (Note that the first sentence of this corollary states a stronger version of the monotonicity condition on J_i.)

Suppose that the extent of cost variation among domestic firms is the same as the extent of cost variation among foreign firms, but that foreign firms have on averge lower costs than domestic firms. Then the domestic and foreign cost distributions would be related by $G_1(c+a)=G_2(c)$ for some $a>0$: the foreign industry might be said to have a stochastic comparative advantage over the domestic industry. Corollary 5 shows that the government optimally gives preferential treatment to the domestic firms, the firms with the comparative disadvantage. Conversely, with a comparative-advantage industry, payment minimization has foreign firms being favored. There is a trade-off. Favoring high-cost firms raises the probability that a high-cost firm will win. But it also increases the competitive pressure on the low-cost firms, forcing them to bid lower. The former effect tends to raise procurement costs and the latter tends to lower it. The resolution of this trade-off always involves some favoritism to the high-cost firms.

Note once again that the purpose of these procurement preferences is to stimulate competition within an imperfectly competitive industry. If the industry from which the government is purchasing is perfectly competitive (i.e. $n_1 \rightarrow \infty$ and $n_2 \rightarrow \infty$), zero preferences are optimal.

The foregoing results are expressed in terms of the bidders' costs, which the government cannot observe. In McAfee and McMillan (1985) we show how to implement the optimal mechanism via a sealed-bid auction. Corresponding to the discrimination function z (which is defined over costs and therefore cannot be directly implemented by the government) is a discrimination function δ based on bids. Each of the firms submits sealed bids after being told that, if b_1 is the lowest bid received from a domestic firm and b_2 is the lowest bid received from a foreign firm, then the domestic bid will win if $\delta(b_1)<b_2$. Thus, for example, with the 50 percent price preference used in U.S. military contracting, $\delta(b)=0.67b$: the government inflates the foreign firms' bids by 50 percent before comparing them with the domestic firms' bids.

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[8]That is, in the terminology of Feller (1966, pp. 44, 134), the two distributions differ only by a location parameter.

3. Effects of discriminatory procurement

Who benefits from the use of the optimal discriminatory policy instead of a simple nondiscriminatory auction? Clearly the government benefits, because the discriminatory auction was designed to maximize its expected surplus. It is also the case, however, that at least some of the bidders in the favored class benefit.

If domestic firms have on average different costs from foreign firms, is the optimal preference strong enough to give bidders of the high-cost some chance of winning?

Lemma 6. With the optimal z function, $z(c_1^\ell) \leq c_2^h$ and $z(c_1^h) \geq c_2^\ell$.

Thus, it is never optimal completely to eliminate from contention a whole class of bidders. Even if, say, the lowest-cost foreign firm has higher costs than the highest-cost domestic firm, then at the very least the optimal z function as defined by (3) pairs off the lowest-cost foreign bidder with the highest-cost domestic bidder.

Should the favoritism be so marked that all members of the high-cost class have a chance of winning the contract, no matter how high their costs? Obviously, the answer must be no. Let c_1^m represent the cost of the highest-cost 1 firm with a nonzero probability of winning the contract.

Lemma 7. If $g_1(c_1^h) = g_2(c_2^h)$, then $c_1^m = c_1^h$ if and only if $c_1^h \leq c_2^h$.

This lemma shows which class of firm is optimally shut out of the market. If, for example, z is set such that $c_1^m < c_1^h$, then there may be some domestic firms (with cost $c_1, c_1^m < c_1 < c_1^h$) who have zero probability of winning the bidding. Thus, Lemma 7 shows the limits of the preference policy: although the government wants to stimulate bidding competition, it is not necessarily in its interest to encourage all firms to submit bids; in fact it usually will be the case that either the highest-cost domestic firms or the highest-cost foreign firms will not be induced to bid. [The condition $g_1(c_1^h) = g_2(c_2^h)$ would be satisfied, for example, if G_1 and G_2 were related as in Corollary 5.]

Nevertheless, firms in the favored class do, on average, benefit.

Lemma 8. Decreasing z(c) for all c causes both the probability of a domestic bidder winning and the expected profits of a domestic bidder to increase.

That is, the more favoritism is given to local firms, the more likely it is that a local firm is awarded the contract and the greater are local firms' profits on average. The price-preference policy does, therefore, have 'protectionist' effects, even though in this analysis the policy is not implemented for protectionist reasons, but instead simply to minimize the government's expected payment.

Since a country is unlikely to have a comparative disadvantage in all industries from which the government purchases, the foregoing analysis implies that, while the government should sometimes offer preferences to local industries, it should also often give preferences to foreign industries. This result follows from the assumption that the government aims to maximize the benefits from the item procured net of its procurement costs, regardless of whether the profits go to domestic or foreign firms. An alternative objective function, commonly used in the evaluation of trade policies, is expected domestic social welfare, including domestic firms' profits. The consumer-surplus implications of the government's purchase are incorporated in the $V(q)$ function. With the social welfare function assumed to be expected domestic producer plus consumer surplus minus expected government payment, the following result follows as a corollary of Theorem 1.

Corollary 9.   Expected domestic social welfare is maximized by choosing the cost-comparison function z to satisfy:

$$c = z(c) + \frac{G_2(z(c))}{g_2(z(c))}. \tag{6}$$

Note the strong implication of this result: domestic firms are always favored (that is, $z(c) < c$), regardless of the shapes of the cost distributions G_1 and G_2. Thus, if domestic firms' profits enter the social welfare function with the same weight as consumer surplus, the government should always offer a price preference to domestic industry. Moreover, by appropriate extensions of the results in section 2, the extent to which the government should favor domestic firms over foreign firms varies from industry to industry, being smaller in comparative-advantage industries and larger in comparative-disadvantage industries.[9]

4. Simulating procurement policies

In order to examine the relevance of the foregoing analysis for existing government-procurement policies, we now simulate a simplified version of the model of section 2. We assume that the government has fixed demand for

[9]The intuition of Corollary 9 is that, with the government attaching as much weight to a domestic firm's profit as the firm itself, the government need not pay the domestic firm in order to induce it to reveal its cost. Hence, the information cost $G_1(c)/g_1(c)$ on the left-hand side of (3) is not present in (6). [On the interpretation of $C_1(c)/g_1(c)$ as an information cost, see McAfee and McMillan (1987a).] The extra effect present in Corollary 9, and not in Theorem 1, is the increase in domestic social welfare that results from shifting profits from foreign to domestic firms. This consequence of the procurement preferences is analogous to the profit-shifting effect of tariffs in the model of Brander and Spencer (1984). In our model, this profit-shifting effect is distinct from the competition-stimulating effect on the procurement preferences isolated in Theorem 1.

Table 1

Optimal preference (with associated procurement cost in parentheses) with a 10% cost differential.

		Number of domestic firms			
		2	3	4	5
	0	NA (183.33)	NA (165.00)	NA (154.00)	NA (146.66)
	2	3.7% (116.25)	3.9% (140.59)	4.0% (163.43)	4.1% (133.24)
Number of foreign firms	3	3.9% (137.96)	4.0% (134.23)	4.1% (131.34)	4.2% (129.05)
	4	4.1% (132.19)	4.1% (129.58)	4.2% (127.49)	4.3% (125.78)
	5	4.1% (127.94)	4.2% (126.04)	4.3% (124.47)	4.3% (123.17)

Table 2

Optimal preference (with associated procurement cost in parentheses) with a 50% cost differential.

		Number of domestic firms			
		2	3	4	5
	0	NA (250.00)	NA (225.00)	NA (210.00)	NA (200.00)
	2	16.5% (160.38)	17.0% (158.10)	17.0% (156.22)	17.5% (154.64)
Number of foreign firms	3	17.0% (147.12)	17.5% (146.02)	17.5% (145.07)	18.0% (144.26)
	4	17.5% (138.54)	18.0% (137.96)	18.0% (137.45)	18.0% (137.00)
	5	18.0% (132.55)	18.0% (132.22)	18.0% (131.93)	18.5% (131.68)

the item and that the distribution of foreign firms' costs G_2 is uniform on [100,200], while the distribution of domestic firms' costs G_1 is uniform on $[c^\ell, 2c^\ell]$, where we vary c^ℓ. We also vary the numbers of domestic and foreign firms, n_1 and n_2.

Tables 1 and 2 report procurement-cost-minimizing preferences and associated expected procurement costs for the cases in which domestic firms have on average 10 percent higher costs and 50 percent higher costs, respectively. In tables 1 and 2 and in other simulations not reported here, the optimal preference does not change much as we change the number of domestic or foreign bidders (except that it increases slightly as the number of each type of
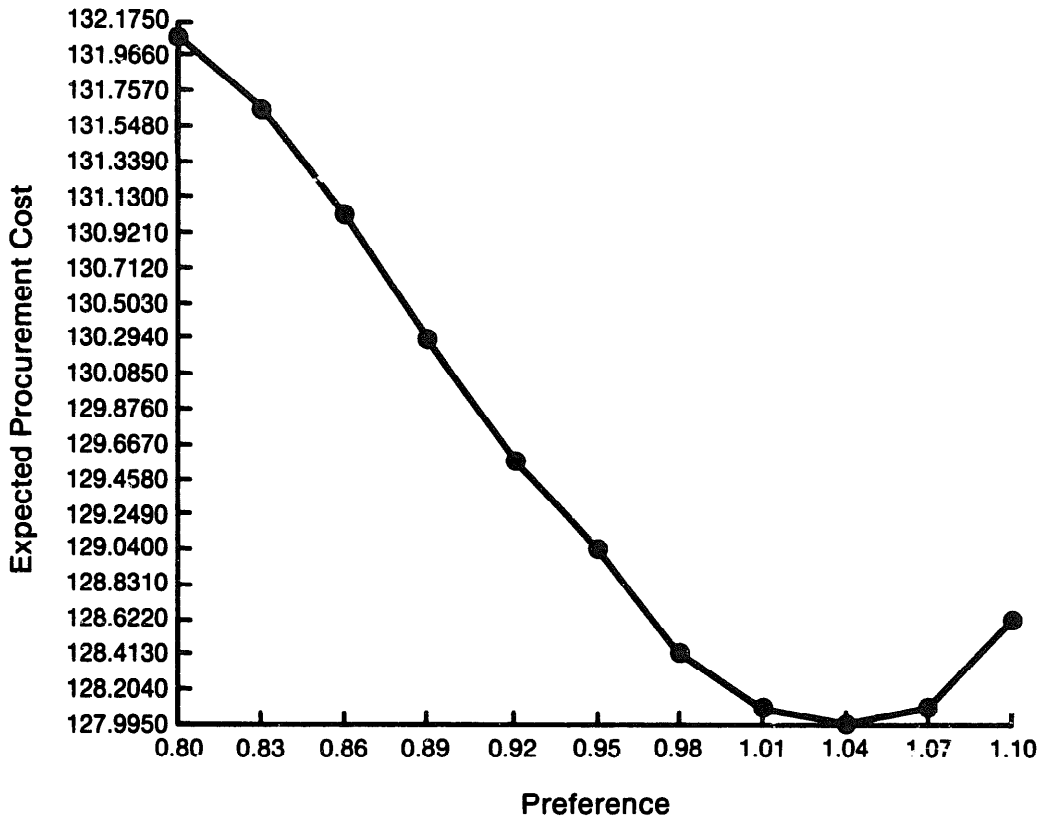
Fig 1. Procurement cost varying as preference ranges from −20% to 10%, with a cost differential of 10%, and two domestic and five foreign firms.

bidder increases).[10] As a rough rule of thumb for calculating the optimal preference, we can therefore ignore the number of bidders, and just consider the average difference in production costs between domestic and foreign firms: the optimal price preference is approximately one-third of the cost differential.

How does procurement cost vary as we vary the extent of preference? Figs. 1 and 2 give answers to this question. Fig. 1 assumes two domestic and five foreign firms, with the domestic firms' costs being 10 percent higher on average than the foreign firms', while fig. 2 assumes 15 domestic and 15 foreign firms, with a cost differential of 50 percent. In fig. 2, with many foreign and domestic bidders, the variation in procurement cost is small (for the range of preferences in fig. 2, at most 0.07 percent): strong competition means that the preferences have little effect on procurement cost. In fig. 1, with fewer bidders but a small cost differential, there is a 3.2 percent variation in procurement costs over the range of preferences simulated. In

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[10] In these simulations there are at most five bidders. If we allow larger variation in the number of bidders, we would see significant changes in the optimal preference. In particular, with a very large number of bidders from each country, the optimal preference is zero.
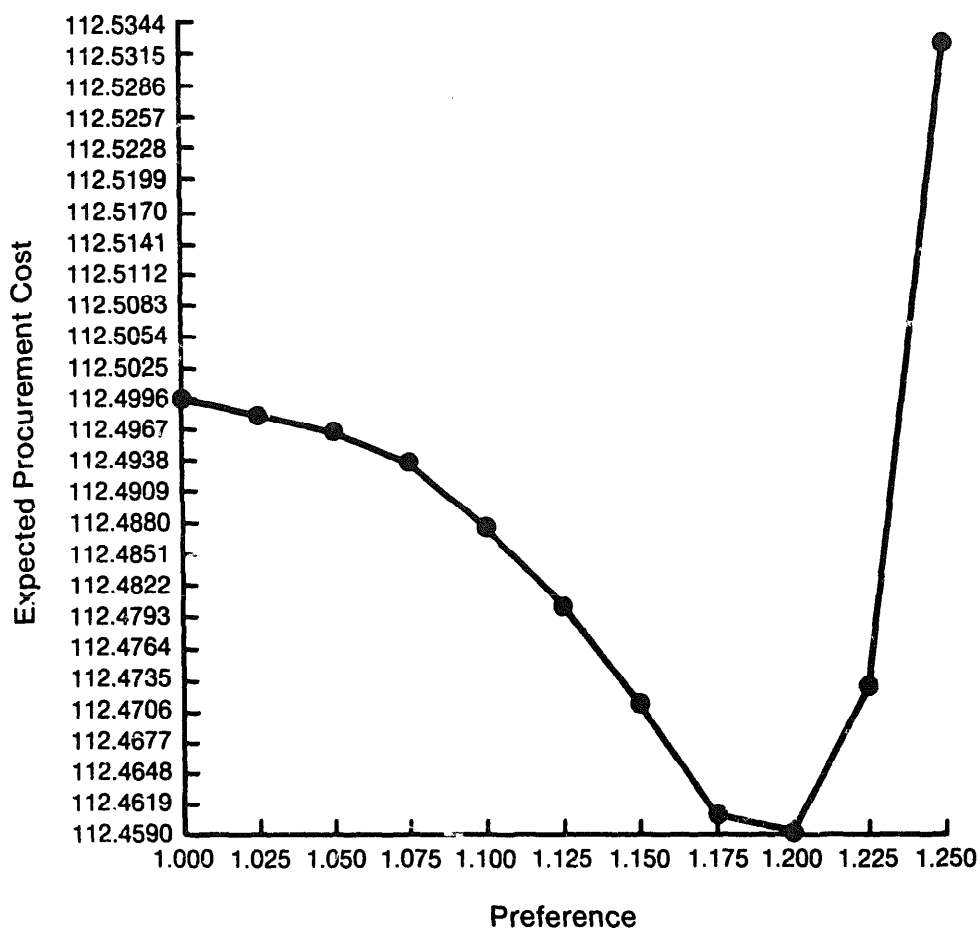
Fig. 2. Procurement cost varying as preference ranges from zero to 25%, with a cost differential of 50%, and 15 domestic and 15 foreign firms.

general, if there are few bidders but a large cost differential, procurement cost can vary sensitively with the extent of preference: for example, if we reversed the cost differential underlying fig. 1 and supposed that the domestic firms had a 10 percent cost advantage, we would find that offering a 25 percent preference to the local firms raises procurement cost 9.6 percent above what it would be with zero preference. A cost differential of 10 percent is relatively small; as the cost differential increases, the loss from setting the 'wrong' preference increases. A fortunate feature in figs. 1 and 2 is that each graph is quite flat around its minimum point: there is some margin for error in calculating the optimal preference. In fig. 1, the preference could be set between 17 and 21 percent, with trivial loss.

Governments do not in fact use finely-tuned preferences; instead, the preferences are fixed (6 percent in the United States, 10 percent in Canada). What is the effect of such a policy on procurement costs? Table 3 can be used to evaluate the Canadian 10 percent rule. In table 3, procurement cost

Table 3

Comparison of preference policies for various cost differentials and various numbers of domestic and foreign firms.

	Cost differential	Optimal preference	Cost at optimal preference	Cost at zero preference	Cost at 10% preference
Two domestic,	10%	3.8%	146.25	146.52	147.00
two foreign	25%	8.8%	153.24	154.46	153.26
firms	50%	16.6%	160.38	162.82	160.82
Two domestic,	10%	4.1%	132.19	132.43	132.85
four foreign	25%	9.5%	135.70	136.55	135.70
firms	50%	17.0%	138.54	139.47	138.40
Four domestic,	10%	4.0%	136.43	136.77	137.14
two foreign	25%	9.5%	145.80	147.47	145.81
firms	50%	17.0%	156.21	160.04	156.94
Four domestic,	10%	4.2%	127.47	127.88	128.33
four foreign	25%	9.8%	132.84	134.20	132.84
firms	50%	18.0%	137.45	139.05	137.91

does not vary much with the extent of preference provided the local firms have a cost disadvantage: with this cost disadvantage ranging between 100 percent and 50 percent, using a level of preference different from 10 percent would yield savings to the government of at most 1 percent. This provides partial justification for the Canadian policy. It is only partial justification, however, because if the domestic industry had a cost advantage, procurement cost would be lower with a zero preference than with the 10 percent preference; and it would be still lower in the unlikely event that the government gave foreign firms preference.

As noted in the Introduction, some governments do not use a price-preference policy. Instead, they use policies that explicitly or implicitly exclude foreign bidders. It is obvious that such policies raise expected procurement costs because they reduce competition. By how much do they raise procurement costs? Table 4 provides illustrative answers, comparing the policy of excluding foreign bidders with the suboptimal policy of letting them compete subject to a 10 percent price preference for domestic bidders. (In all cases the local firms are assumed to have on average a cost disadvantage; clearly the effects of exclusion on procurement costs would be smaller if the local firms had a cost advantage.) It can be seen from table 4 that excluding foreign competitors can raise procurement costs substantially (by over 50 percent when there are few domestic bidders and the foreign/domestic cost differential is large). Even four domestic bidders is too small a number to exhaust the benefits from increasing bidding competition.

Table 4

Procurement costs when foreign bidders are excluded, and when foreign bidders can compete subject to 10 percent preference for local bidders.

Cost differential	Two domestic bidders		Four domestic bidders	
	Two foreign bidders	No foreign bidders	Two foreign bidders	No foreign bidders
10%	147.00	183.33	132.85	154.00
20%	151.32	200.00	134.80	168.00
30%	155.06	216.67	136.52	182.00
40%	158.23	233.33	137.86	196.00
50%	160.82	250.00	138.40	210.00

5. Conclusion

When there is imperfect competition in the bidding for a contract, each bidder is better informed about his own costs than either his rival bidders or the buyer, and there are systematic, observable differences among the bidders, the buyer minimizes his expected procurement cost by operating a discriminatory policy, not necessarily purchasing from the lowest bidder. If the aim of the government is to minimize its procurement costs, it should offer preferences to domestic firms when the industry has a comparative disadvantage; but when the domestic industry has a comparative advantage, the foreign bidders should be favored. If the domestic firms' profits enter the government's objective function along with procurement cost, the government should always offer preferences to the domestic firms; but these preferences should vary from industry to industry, being smaller in comparative-advantage industries than in comparative-disadvantage industries.

The main drawback of the foregoing analysis is that it is partial equilibrium, so that resource-allocation questions cannot be examined. The effects of procurement preferences in causing excessive investment in industries in which the country does not have a comparative advantage should be weighed against the bidding-competition effects examined above. How to embed an asymmetric-information model in a general-equilibrium setting is an open question in general.

We have assumed that domestic firms' costs differ systematically from foreign firms' costs. Underlying this could be any of the standard sources of international cost differences: country-specific technology, factor-price differences, etc. Although for our theory it is not necessary to specify the source of the cost differences, for practical interpretations it is necessary. Is a domestically located plant of a multinational corporation a foreign or a domestic bidder? If the source of cost differences is factor prices, then the foreign-owned plant draws its cost from the same distribution as the domestic

bidders. But if cost differences are due to technology, the foreign-owned plant is a foreign bidder in terms of Theorem 1.

It follows from our results that empirical studies of government procurement that attempt to estimate the cost of procurement preferences while ignoring their effects on bidding behavior [such at Joson (1985) and L.winger (1976)] produce biased estimates. These studies overestimate the e lent to which preferences raise procurement costs in the case of comparative-disadvantage industries; they underestimate it in the case of comparative-advantage industries. It also follows from our results that it is inappropriate in empirical studies to use the zero preference as benchmark with which to evaluate the welfare effects of procurement policies: a zero preference is not analogous to a zero tariff.

Favoring domestic firms is not the only end to which governments address procurement policy. It is also used to foster small business, firms in regions with high unemployment, disadvantaged socioeconomic groups such as minorities and women, firms developing new technologies, firms producing military equipment, and unionized over nonunionized firms [Holtz (1979), Jeanrenaud (1984)]. As a U.S. Government commission remarked: 'The Government procurement process is utilized as a powerful vehicle for social change. Some 80 socioeconomic programs affect the procurement process.'[11] These programs usually operate by excluding the nonfavored bidders. The foregoing analysis suggests that giving extra business to the favored firms could be achieved less expensively by using price preferences, which retain and even, as shown above, enhance the advantages to the government of bidding competition.

Appendix

Proof of Theorem 1. We prove the theorem in a slightly more general form than stated. We suppose that the ith bidder draws his cost c_i from his own distribution g_i. (In the theorem as stated, some of these $g_i's$ are identical.) Following Myerson (1981), we consider a direct revelation mechanism. Bidder i, $i = 1, 2, \ldots, n$, with actual cost c_i, reports its cost to be $\hat{c}_i$; then the buyer purchases the quantity $q_i(\hat{c}_i, c_{-i})$ and pays firm i the amount $p_i(\hat{c}_i, c_{-i})$, where $c_{-i} = (c_1, \ldots, c_{i-1}, c_{i+1}, \ldots, c_n)$ is the vector of other firms' costs. The firm's expected profit is therefore

$$\pi_i = E_{-i}[p_i(\hat{c}_i, c_{-i}) - c_i q_i(\hat{c}_i, c_{-i})], \qquad (A.1)$$

where E_{-i} is the expectation over c_{-i}. The Envelope Theorem implies that

[11] President's Private Sector Survey on Cost Control (1984, p. III-327).

$$\frac{d\pi_i}{dc_i} = -E_{-i}q_i(\hat{c}_i, c_{-i}).$$ (A.2)

The buyer's objection function is

$$\phi = E\left\{V\left(\sum_{i=1}^{n} q_i(c_i, c_{-i})\right) - \sum_{i=1}^{n} p_i(c_i, c_{-i})\right\}$$

$$= E\left\{V\left(\sum_{i=1}^{n} q_i(c_i, c_{-i})\right) - \sum_{i=1}^{n} c_i q_i(c_i, c_{-i}) - \sum_{i=1}^{n} \pi_i\right\} \quad \text{[using (A.1)]}$$

$$= E\left\{V\left(\sum_{i=1}^{n} q_i(c_i, c_{-i})\right) - \sum_{i=1}^{n} c_i q_i(c_i, c_{-i})\right\} - \sum_{i=1}^{n} E_{-i} \int_{c_i^{\ell}}^{c_i^{h}} \pi_i g_i(c_i) \, dc_i$$

$$= E\left\{V\left(\sum_{i=1}^{n} q_i(c_i, c_{-i})\right) - \sum_{i=1}^{n} c_i q_i(c_i, c_{-i})\right\}$$

$$- \sum_{i=1}^{n} E_{-i}\left\{\pi_i G_i(c_i)\Big|_{c_i^{\ell}}^{c_i^{h}} + \int_{c_i^{\ell}}^{c_i^{h}} q_i(c_i, c_{-i}) G_i(c_i) \, dc_i\right\}$$

[integrating by parts and using (A.2)]

$$= E\left\{V\left(\sum_{i=1}^{n} q_i(c_i, c_{-i})\right) - \sum_{i=1}^{n} c_i q_i(c_i, c_{-i})\right\}$$

$$- \sum_{i=1}^{n} E_{-i} \int_{c_i^{\ell}}^{c_i^{h}} q_i(c_i, c_{-i}) \frac{G_i(c_i)}{g(c_i)} g_i(c_i) \, dc_i$$

(because $\pi_i(c_i^{h})$ may be set equal to zero without loss of generality, and $G_i(c_i^{\ell}) = 0$)

$$= E\left\{V\left(\sum_{i=1}^{n} q_i(c_i, c_{-i})\right) - \sum_{i=1}^{n} J_i(c_i) q_i(c_i, c_{-i})\right\}.$$ (A.3)

It follows that the buyer chooses the lowest $J_i(c_i)$ and buys

$$q_i(c_i, c_{-i}) = \begin{cases} V'^{-1}(J_i(c_i)), & \text{if } J_i(c_i) = \min_j\{J_j(c_j)\}, \\ 0, & \text{otherwise.} \end{cases}$$ (A.4)

By a theorem of Guesnerie and Laffont (1984), this is incentive compatible if and only if

$$\frac{\partial}{\partial c_i} E_{-i} q_i(c_i, c_{-i}) \leqq 0.$$ (A.5)

But

$$E_{-i} q_i(c_i, c_{-i}) = V'^{-1}(J_i(c_i)) \prod_{j \neq i} [1 - G_j(J_j^{-1}(J_i(c_i)))],$$ (A.6)

so (A.5) follows immediately from $V'' \leqq 0, J_i' \geqq 0.$ Q.E.D.

Proof of Theorem 3. Since $x + G_i(x)/g_i(x)$ is increasing with x, $z(c) \gtreqless c$ if and only if

$$c + \frac{G_2(c)}{g_2(c)} \gtreqless z \frac{G_2(z(c))}{g_2(z(c))} = c + \frac{G_1(c)}{g_1(c)}$$

$$\Leftrightarrow \frac{g_2(c)}{G_2(c)} \gtreqless \frac{g_1(c)}{G_1(c)}$$

$$\Leftrightarrow \frac{d}{dc} \log \left[\frac{G_2(c)}{G_1(c)} \right] \gtreqless 0$$

$$\Leftrightarrow \frac{d}{dc} \left[\frac{G_2(c)}{G_1(c)} \right] \gtreqless 0. \quad \text{Q.E.D.}$$

Proof of Lemma 6. If $c_1^\ell \leqq c_2^h$, then $c_2^h \geqq c_1^\ell = J_1(c_1^\ell) = J_2(z(c_1^\ell)) \geqq z(c_1^\ell)$. Otherwise, $c_1^\ell > c_2^h, z(c_1^\ell) = c_2^h$, as $J_2(c_2^h) = \infty$. Q.E.D.

Proof of Lemma 7. Recall that the density functions g_i are assumed to be continuous:

$$c_1^m = c_1^h \Leftrightarrow (c_1^h) \leqq c_2^h$$

$$\Leftrightarrow J_2(z(c_1^h)) \leqq J_2(c_2^h) \Leftrightarrow J_1(c_1^h) \leqq J_2(c_2^h) \Leftrightarrow c_1^h \leqq c_2^h. \quad \text{Q.E.D.}$$

Proof of Lemma 8. The probability that a firm of type 1 wins is $(1 - G_1(c_1))^{n_1 - 1}(1 - G_2(z(c_1)))^{n_2}$. Clearly this increases as the function z is decreased. Q.E.D.

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