The empirical model and estimates

Appendix A presents a formal theoretical model of the A-'76 competition process, and appendix B presents details of our model estimation techniques. This section gives an overview of the empirical model. Interested readers should consult the appendices for more background and de tail.

The empirical model

Consider the following three-equation log-linear model:

$$\ell n\,(Y_{1i}) = X_i\beta_1 + u_{1i} \tag{1}$$

$$\ell n\,(Y_{2i}) = X_i\beta_2 + u_{2i} \tag{2}$$

$$\ell n\,(Y^*_{3i}) = X_i\beta_3 + u_{3i}\ , \tag{3}$$

where

$$Y_{3i} = \min(\,Y^*_{3i}, Y_{\ell i})\ . \tag{3a}$$

In equation (1), the baseline cost of function i, Y_{1i}, is modeled as a function of X_i (a vector of exogenous variables including a constant term), β_1 (a vector of parameters to be estimated), and u_{1i} (an error term). The minimum contractor bid, Y_{2i}, is modeled similarly in equation (2). Modeling the in-house team's bid, Y_{3i}, is slightly more complicated since it is bounded above by the baseline cost. Equation (3) gives the in-house team's unconstrained bid Y^*_{3i}. According to equation (3a), the in-house team's bid Y_{3i} equals Y^*_{3i} if Y^*_{3i} is less than baseline cost; the in-house team's bid equals baseline cost otherwise.

The dependent variables are expressed as natural logarithms. The error terms u_{1i}, u_{2i}, and u_{3i} are jointly normally distributed with covariance matrix Σ.

The dependent variables are expressed as natural logarithms. The error terms u_{1i}, u_{2i}, and u_{3i} are jointly normally distributed with covariance matrix Σ.

The restriction given by equation (3a) is necessary because the in-house team cannot bid more than the baseline cost given by Y_{1i}. As the expression in equation (3a) shows, the in-house teams bid (Y_{3i}) equals Y_{3i}^{*} if Y_{3i}^{*} is less than the baseline cost and equal to the baseline cost otherwise.

The parameters in equations (1) and (2) can be estimated consistently with Ordinary Least Squares (OLS), but unless u_{1i} and u_{3i} are independent, the parameters in equation (3) must be estimated with a Maximum Likelihood (ML) procedure. Since the likelihood function for equation (3) includes the parameters in equation (1), the easiest way to proceed is to estimate equation (2) with OLS and then obtain ML estimates of equations (1) and (3). The likelihood function and estimation procedure for equations (1) to (3) is given in the appendix.

Empirical estimates

Table 3 presents the empirical estimates of the equations describing the baseline cost, minimum contractor bid, and in-house bid given by equations (1), (2), and (3), respectively.

All three equations include the same explanatory variables: number of billets, number of billets squared, number of military billets, a linear time trend, and a series of dummy variables for branch of service and type of function. We are taking an A-76 competition conducted by the Navy for the Installation Services function as the base case. Hence, we will not define dummy variables for the Navy or for Installation Services. The dependent variables and the three independent variables-billets, billets squared, and military billets-are in natural logarithms. The billets squared term was included to account for potential nonlinear effects of the logarithm of billets on the logarithm of the dependent variable.

Table 3. Empirical estimates of baseline cost and bids[a]

	OLS		Joint maximum likelihood			
	ln(min. contractor bid)		ln(baseline cost)		ln(in-house bid)	
Independent variable	Coeff.	(Std. err.)	Coeff.	(Std. err.)	Coeff.	(Std. err.)
Constant	4.386	(0.068)	4.044	(0.051)	4.711	(0.067)
ln(billets)	0.768	(0.040)	1.020	(0.030)	0.762	(0.039)
(ln(billets))	0.022	(0.007)	-0.007	(0.005)	0.023	(0.006)
ln(military billets)	-0.076	(0.015)	0.003	(0.012)	-0.063	(0.013)
Time trend	-0.026	(0.005,	-0.015	(0.004)	-0.044	(0.004)
Service dummies						
DoD Agencies	0.250	(0.104)	0.145	(0.078)	0.056	(0.091)
Army	0.201	(0.041)	0.157	(0.031)	0.112	(0.037)
Air Force	0.138	(0.038)	0.185	(0.028)	0.190	(0.033)
Marines	-0.039	(0.108)	-0.011	(0.086)	-0.081	(0.098)
Function dummies						
Social Services	-0.786	(0.054)	-0.402	(0.041)	-0.287	(0.050)
Health Services	0.210	(0.130)	-0.082	(0.098)	0.070	(0.118)
Intermediate Maintenance	0.080	(0.060)	0.072	(0.046)	0.077	(0.054)
Depot Maintenance	0.130	(0.269)	-0.067	(0.199)	-0.165	(0.235)
Real Property Maintenance	0.036	(0.049)	0.071	(0.037)	0.085	(0.043)
Warehousing	-0.133	(0.070)	-0.183	(0.053)	-0.197	(0.062)
Air Transportation	0.845	(0.211)	0.676	(0.159)	0.616	(0.186)
Research Support	0.137	(0.194)	0.018	(0.129)	0.074	(0.153)
Training	-0.129	(0.234)	-0.204	(0.177)	-0.171	(0.208)
Data Processing	-0.376	(0.073)	-0.405	(0.055)	-0.366	(0.067)
Audio-visual	-0.052	(0.078)	-0.126	(0.059)	-0.262	(0.069)
Switchboard	-0.707	(0.075)	-0.598	(0.057)	-0.777	(0.066)
Telecommunications	-0.229	(0.139)	-0.201	(0.106)	-0.194	(0.122)
Administrative Support	-0.598	(0.062)	-0.585	(0.047)	-0.673	(0.055)
Other Nonmanufacturing	0.075	(0.066)	-0.040	(0.050)	-0.141	(0.059)
Adjusted R2	0.862		n.a.			
Log likelihood	n.a.		-1.158			
N	2,069		2,069			

a. The omitted service dummy is Navy; the omitted function dummy is Installation Services. Dependent variables are natural logarithms of quantities measured in thousands of FY 1996 dollars on an annual basis. The military billets variable has been transformed by adding one before taking logs.

Baseline cost equation

Discussing the equation for baseline cost first, we see that among the continuous variables, only billets and the linear time trend are statistically significant. The interpretation of the positive coefficient on billets is intuitive and obvious: Larger tasks in terms of number of employees have a higher baseline cost. The negative coefficient on the linear time trend suggests that the baseline cost of the competed functions, after controlling for size and inflation, has been decreasing over time. Among the service dummies, we see that DoD Agencies, the Army, and the Air Force all have a statistically significant larger baseline cost than the Navy,

Among the function dummies, Social Services, Data Processing and Other Nonmanufacturing all have a statistically significant lower baseline cost relative to Installation Services, whereas Intermediate Maintenance and Real Property Maintenance have a statistically significant higher baseline cost than Installation Services.

Contractor bid equation

In the equation describing the minimum contractor bid, all four continuous variables are statistically significant. The positive sign on the billets squared term indicates that the contractor bid increases at an increasing rate as the size of the function increases. The negative sign on the number of military billets means that for a given number of total billets, the contractor bid is lower as the number of military billets increases. The negative sign and magnitude on the linear time trend variable indicate that the dollar amount of the contractor bid has been decreasing faster than baseline cost over time. Among the Service dummies, with the exception of the Marine Corps, functions for all three services have higher contractor bids than do similar functions for the Navy. Among the Functions dummies, Social Services, Data Processing, and Other Nonmanufacturing, all have statistically significant lower contractor bids relative to the base case of Installation Services, whereas only Health Services functions have statistically significant higher contractor bids.

In-house bid equation

Finally, in the equation describing the in-house team bid, we again see that all four continuous variables are statistically significant. The interpretation of these coefficients is the same as with the contractor bid. The dollar amount of the bid increases at an increasing rate with the number of billets and decreases with the number of military billets. The in-house bid has decreased faster over time than either baseline cost or contractor bid. Unlike the contractor bid, only those functions for the Army or Air Force have significantly higher bids than similar functions for the Navy. Among the function dummies, only Data Processing and Other Nonmanufacturing are statistically significant. The negative coefficients for these functions indicate that the in-house team bid for these functions is lower than similar bids for Installation Services.

Total savings elasticities

An advantage of this model is its more structural form which allows greater insight into' the process that generates savings. However, one disadvantage is that the overall impact on savings of changing an explanatory variable is not immediately obvious.

We have calculated the impact of changing the number of civilian and military billets on total savings. Our model implies that:

- A l-percent increase in the number of civilian billets in a competition leads to a Z-percent increase in savings.
- A l-percent increase in the number of military billets leads to a 5-percent increase in savings.

Policy analysis and conclusions

Projecting savings into the DoD CA Inventory

Based on parameter estimates of equations (1) to (3a), one can project the annual savings that would be realized if all the remaining functions in the DoD CA inventory were successfully competed. Since equations (1) to (3a) are estimated by first taking natural logarithms of the respective explanatory and independent variables, in order to project savings, we must undo the logarithm. Also, equation (3) must be adjusted to account for the censoring at baseline cost. This yields the following three equations:

$$Y_{1i} = \exp(X_i\beta_1 + u_{1i}) \tag{4}$$

$$Y_{2i} = \exp(X_i\beta_2 + u_{2i}) \tag{5}$$

$$Y_{3i} = \min[\exp(X_i\beta_3 + u_{3i}), Y_{1i}], \tag{6}$$

where exp is the exponential function. The savings for function i is then given by

$$\begin{aligned} S_i &= Y_{1i} - Y_{3i} \text{ if } Y_{3i} \leq (1 + A)\, Y_{2i} \\ S_i &= Y_{1i} - Y_{2i} \text{ if } Y_{3i} > (1 + A)\, Y_{2i}, \end{aligned} \tag{7}$$

where A is the bidding advantage given to the in-house team, currently set at 10 percent. If the in-house bid is less than the contractor bid scaled up by A, then the in-house team wins and the savings are $Y_{1i} - Y_{3i}$; otherwise, the contractor wins and the savings are $Y_{1i} - Y_{2i}$.

Equations (4) to (7) combined with estimates of the parameters β_1, β_2, β_3 and an estimate of the error covariance matrix Σ can be used to predict potential savings in the A-76 CA inventory. Let u_j be the j^{th}

draw from a normal distribution with covariance matrix Σ. Substituting u_j and β into equations (4) to (7) yields the j^{th} draw of savings for the i^{th} function in the A-76 inventory, denoted by S_{ij}. If this process is repeated R times with Rseparate draws of u_j, an estimate of savings for a completed A-76 competition for function i is

$$S_i = \frac{1}{R}\sum_{j=1}^{R} S_{ij} \tag{8}$$

This process can be repeated for each of the Nfunctions in the A-76 inventory. Total predicted savings if all Nfunctions in the A-76 inventory are successfully competed is given by

$$S_{tot} = \sum_{i=1}^{N} S_i \ . \tag{9}$$

These projected savings are presented below.

Projecting the savings into the 1995 DoD CA Inventory

The simulation methodology just presented can be used to analyze the effects of various policy changes. The first such projetion we computed was to project the savings from competing the entire 1995 DoD CA Inventory using the current A-76 rules for competition. These projected savings are broken down by function type and service branch in table 4.

The remainder of the section will focus on the savings projection summarized in table 5. The total simulated savings from the CA inventory is $5.96 billion. This figure is only slightly lower than the estimate of $6.2 billion in [2] . Interestingly, while the in-house team won about half of the A-76 competitions historically, the in-house team is predicted to win a large majority, about 56 percent, of the tasks in the CA inventory. Relative to the tasks involved in the completed A-76 studies, the characteristics of the CA-inventory tasks make them better suited, on average, for in-house performance. It would be a mistake to conclude from this statement that the gains from competing tasks in the CA inventory are small. The simulated savings per billet for the CA inventory tasks are virtually identical to the $18,600 for the completed studies, and the simulated savings per task, at $534,000, are close to the $686,000 for the completed studies. The results highlight the point that, even if the in-house team wins the bidding, savings still arise from competitive pressures provided by the threat of losing to outside contractors.

Table 4. Projected savings from competing the entire 1 995 DoD CA Inventory[a]

Function type	Army	DoD Agencies	Air Force	Marines	Navy	Total
	Service branch					
Installation Services	307.5	379.9	405.9	173.4	409.6	1,676.3
Social Services	74.4	213.7	50.9	19.6	112.8	471.3
Health Services	501.7	a	49.0	0.5	375.3	926.5
Intermediate Maintenance	77.6	2.3	251.3	15.1	486.4	832.7
Depot Maintenance	85.2	4.2	11.2	35.6	120.4	256.6
Real Property Maintenance	90.5	6.9	98.0	34.7	103.2	333.4
Warehousing	22.3	25.0	6.8	12.3	a	66.4
Air Transportation	0.2	a	a	0.5	15.2	15.9
Research Support	9.9	a	80.4	a	57.8	148.1
Training	32.2	0.7	72.6	29.1	277.2	411.9
Data Processing	60.3	27.3	9.7	10.7	42.4	150.4
Audio-visual	16.8	0.9	8.6	5.4	3.8	35.5
Switchboard	6.9	0.4	3.1	3.3	2.1	15.7
Telecommunications	26.8	0.8	2.8	10.2	68.2	108.7
Administrative Support	15.4	2.1	5.9	2.7	10.9	36.9
Other Nonmanufacturing	111 .0	54.2	48.4	21.8	239.6	475.1
Total	1,438.7	718.4	1,104.6	375.0	2,324.8	5,961.5

a. Figures are in millions of FY 1996 dollars. Entries marked a have no counterparts in the 1995 CA inventory. Simulations are performed setting time trend to 1983, the mean for completed A-76 competitions.

Changing the rules

Our model also allows us to change the rules of the competitions and re-estimate savings. We used the simulations for the base case (current policies and rules for competition) as a standard for comparison to the five policy alternatives. Each policy scenario specifies different rules under which tasks are competed. For each policy scenario, two sets of results are provided in table 5. The set of results reported in the first two columns of the table assumes the 2,076 completed A-76 studies are competed under the rules of each policy scenario. The results reported in the last two columns of the table assumes the 13,329 tasks in the CA inventory are competed under the rules of each policy scenario. As before, all figures are annual savings in FY 1996 dollars.

Table 5. Projected savings from different hypothetical policy changes[a]

	Prior A-76 competitions			Entire 1995 CA Inventory		
		Predicted annual savings			Predicted annual savings	
Policy	Percent in-house wins	Billion dollars	Percent of policy (1) savings	Percent in-house wins	Billion dollars	Percent of policy (1) savings
(1) Current conditions	49.9	1.43	100.0	56.4	5.96	100.0
(2a) Without in-house team's bid[b]	0.0	1.39	97.2	0.0	5.68	95.3
(2b) Without in-house team's bid (always outsource)	0.0	1.02	71.3	0.0	3.16	53.0
(3) Effects of competition on in-house team[c]	100.0	0.93	65.0	100.0	4.06	68.1
(4) In-house bidding Advantage = 0	39.0	1.45	101.4	46.3	6.05	101.5
(5) In-house bidding Advantage = 25%	64.9	1.35	94.4	69.8	5.60	94.0
(6) In-house team allowed to exceed baseline cost	34.8	1.19	83.2	38.7	4.47	75.0
(7) In-house overhead adjusted from 5% to 12%	42.4	1.75	122.4	49.5	7.40	124.2

a. Results for CA Inventory fix the time trend at 1983, the mean for completed A-76 competitions,

b. Assumes function continues to be performed by the in-house team at baseline cost if private contractors exceed this amount.

c. The in-house team always wins but bids like it will not. Assumes the in-house team bids as if private contractors are present.

Policy scenario number (2a) assumes that the in-house team is excluded from the bidding so that only outside contractors are allowed to participate. It is assumed that if the minimum contractor bid exceeds baseline cost, the function is not privatized but rather continues to be performed by the in-house team. In other words, the government is assumed to have a secret reservation value in the procurement auction equal to baseline cost. We will say that the in-house team never wins the bid (it cannot since it does not submit a bid itself) in this policy scenario even though it may end up performing the function. The tasks are always privatized under this scenario. Savings fall by 3 percent for the sample of completed studies and by 5 percent for the CA inventory. This figure should be regarded as a lower bound on the true reduction in savings that would result from the policy change. The reason is that the simulations are conducted under the assumption that bidding strategies do not change with the policy scenario. That is, the private contractors pursue the same bidding strategies whether the in-house team is bidding along with them (as under current policy conditions and in policy scenario (1)) or is excluded from the bidding (as under policy scenario (2a)) . It is likely, however, that contractors would bid less aggressively if a competitor were removed from the bidding process. This is especially true if the in-house team is removed from the bidding process since the in-house team is a unique competitor, with its lo-percent bidding advantage and possible inherent efficiency in performing certain tasks. Taking into account the additional strategic effect-that contractors should bid less aggressively if the in-house team were removed from the bidding process-savings would fall by more than the 3 to 5 percent predicted by the simulations.

Under policy scenario (2b), the in-house team was removed entirely. That is, the function was privatized even if the minimum contractor bid exceeded baseline cost. This caused a sharp fall in the savings. Completed A-‘76 competitions only saved $1.02 billion or ‘71 percent of the base case. Thus, it would be a mistake to conclude from a comparison of policy scenarios (1) and (2a) that the in-house team adds little to the A-‘76 process. At a minimum, DoD should use the in-house team as a fall-back in case the contractor bids are too high.

Policy scenario number (3) involves the exclusion of outside contractors from the bidding process, leaving the in-house team as the sole bidder. Within the sample of completed competitions, savings are predicted to fall by almost half; for the CA inventory, savings are predicted to fall by 7 percent. Note, however, that the simulation implicitly assumes that the in-house team bids as if the private contractors were present. The caveat made in the previous paragraph-that these figures understate the true effect of the policy change-applies even more strongly here: Facing no competition, there would be little reason for the in-house team to bid below its baseline cost, in which case the competitions would produce no savings. The fact that we do not account for strategic changes in bidding behavior can be viewed as a virtue. To see this requires some background discussion. Savings from A-76 competitions arise from three sources:

- Outsourcing: Private contractors may be more efficient than the in-house team at providing certain tasks. This may be due to random chance: A private contractor may happen to have employed a good manager or have developed a low-cost technology.

- The larger the number of private contractors involved in bidding, the greater the probability that at least one is more efficient than the in-house team.

- Competition: Even if private contractors are no more efficient than the in-house team, the threat of losing the competition may lead the team to submit a bid that is lower than its baseline cost, Cost reductions can come from innovation and elimination of waste.

The set of counterfactual assumptions embodied in policy scenario (3) can be used to separate the third component from the other two. Savings from competition can be read directly from row (3) of table 5: $930 million for completed A-76 competitions and $4.06 billion for the CA inventory. Recall that policy scenario (3) assumes the in-house team bids as if the outside contractors were present, thereby exerting competitive pressure, but assumes that the in-house team wins the competition. Competitive pressures on the in-house team thus account for 65 percent of total savings in previous competitions.

Policy scenarios (4) and (5) involve changing the in-house team's bidding advantage, removing the advantage entirely in policy scenario (4) and increasing it to '25 percent in policy scenario (5). Although these policy alternatives involve a significant change in the probability that the in-house team wins, the change in savings from the base case is fairly small. To explain this result, consider, for concreteness, the policy change of removing the in-house bidding advantage for the sample of completed A-76 competitions. This change affects about 7 percent of the tasks; i.e., with 7 percent of the completed tasks, removing the bidding advantage changes the identity of the winner from the in-house team to an outside contractor. For the remaining 93 percent of the tasks, removing the bidding advantage would have no effect (disregarding, for the moment, the effect of the policy change on bidding strategies). Even for the 7 percent of the tasks where the policy change has some effect, this effect is capped: The private contractor's bid must have been within 10 percent of the in-house bid. These statements are well illustrated in figure 3. Only those points between the two dark slanted lines would be affected by removing the in-house bidding advantage. For these points, the change in savings is bounded by the width of the narrow band.

With policy scenarios (4) and (5), it is important to remember the caveat that the simulations do not account for possible changes in bidding strategies. It is reasonable to suppose that removing the in-house bidding advantage would make it a more aggressive bidder and the private contractors less aggressive bidders.[18] On the other hand, it is reasonable to suppose that increasing the in-house bidding advantage to 25 percent would make it bid less aggressively and the private contractors bid more aggressively. It is difficult to predict which of these counteracting strategic effects is larger and, thus, difficult to assess the bias in our simulations.

The fifth policy alternative removes the requirement that the in-house team must bid no higher than its baseline cost. Relative to the base case, the in-house team wins less often and savings fall, by 17 percent for completed A-16 competitions and by 25 percent for the CA

18. On the other hand, this change could attract additional private bidders.

inventory. The reduction in savings comes from those tasks for which the private contractors do not provide much competitive pressure on the in-house team to reduce its bid. The predictions do not account for the fact that the private contractors' bidding strategies may well become less aggressive if such a policy change were enacted. Consequently, the simulated reduction in savings from the policy change should be regarded as a lower bound. Overall, this policy change has relatively more significant effects than changing the in-house team's bidding advantage.

The last policy alternative adjusts the overhead rate for baseline cost and the in-house bid upwards to reflect the new OMB policy. The number of in-house wins decreases noticeably as expected. Savings increases by about 22 percent for past competitions and 24 percent for the competing the 1995 CA inventory.

Conclusions

The policy alternatives in table 5 do not exhaust the set of possibilities. It would be a straightforward exercise to apply the simulation methodology to a wide range of proposed policy changes.

Again, we have not taken into account strategic effects in the simulation. It is likely that the in-house team would bid more aggressively and the private contractors less aggressively in response to the policy change. The net strategic effect is unclear.