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Bidding Behavior in DoD's Commercial Activities Competitions

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13. ABSTRACT ***(Maximum 200 Words)***
In a previous study, CNA analysts used data from past DoD A-76 competitions to construct a model of savings and projected the potential savings from additional DoD Commercial Activities (CA) competitions. In this paper, we use an alternative approach for estimating savings from future Dod CA competitions. We estimate two separate bidding equations - one for the in-house team bid and another for the minimum contractor bids - along with an equation for baseline cost. Based on these estimated equations, one could then indirectly project future savings in the A-76 inventory as the difference between predicted baseline cost and the predicted winning bid. Using the new approach, we project an annual savings of $6 billion if the entire 1995 DoD CA inventory were competed under A-76 rules.

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Contents

Summary

In 1955, the Office of Management and Budget (OMB) implemented a policy known as the Commercial Activities (CA) Program. Originally designed to encourage the use of the private sector, this program now enables the private sector to compete with government organizations in providing goods and services [1]. In CA competitions, the in-house government team as well as outside private contractors submit bids to supply a specified good or service. If the in-house team's bid is no more than 10 percent higher than the minimum contractor bid, the in-house team continues to supply the good or service. When the minimum contractor bid is more than 10 percent lower than the in-house team bid, the good or service is outsourced to the winning contractor. The objective of the CA Program is to promote an efficient support structure through competition. Greater efficiency would allow DoD and the services to spend less money for the same level of support and have more money to spend on operational forces. As a result of the CA Program, DoD initiated 4,311 A-76 competitions from 1978 to 1994 and completed 2,195.[1]

In a previous study [2], CNA analysts used data from past DoD A-76 competitions to construct a model of savings and projected the potential savings from additional DoD CA competitions. In this paper, we use an alternative approach for estimating savings from future DoD CA competitions: We estimate two separate bidding equations—one for the in-house team bid and another for the minimum contractor bids—along with an equation for baseline cost. Based on these estimated equations, one could then indirectly project future

1. Of the initiated competitions, 381 were consolidated with other studies, and 76 were broken into smaller studies. We counted these competitions as false starts rather than cancellations. This results in an overall completion rate of 59 percent. These calculations exclude 807 simplified cost comparisons and direct conversions.

savings in the A-76 inventory as the difference between predicted baseline cost and the predicted winning bid.

Using our new approach, we project an annual savings of **$6 billion** (in FY 1996 dollars) if the entire 1995 DoD CA inventory were competed under A-76 rules. This is slightly lower than our previous estimate of $6.2 billion. As before, the savings are highly influenced by the number of billets that a Service declares are commercial. If the other Services had the same percentage as the Navy, which had the largest percentage classified as commercial in the 1995 CA inventory, the savings would roughly double [3]. Thus, a close review of those billets that are not now considered commercial could result in big savings.

We adopt this alternative, more structural, modeling approach for two reasons:

- It allows us to determine whether the source of savings is from low in-house or contractor bids.
- It allows us to simulate the effect of various DoD policy changes on savings.

To summarize the results from simulations of various policy changes:

- Competition is the main source of savings—accounting for 65 percent of total savings.
- Increasing the number of civilian billets in a competition by 1 percent would increase savings by 2 percent.
- Increasing the number of military billets by 1 percent increases savings by 5 percent.
- Constraining the in-house team to bid no more than baseline costs increased savings by 17 percent.
- Changing the in-house bidding advantage—in either direction—would have a small impact on savings.
- Moving to the new OMB overhead rate should reveal increased savings, on the order of 22 percent, and should lead to a decline in the number of in-house wins.

In our simulations of various policy changes, we find that competition—not private sector cost advantages—accounts for most of the savings. In particular, we estimate that the competitive forces alone account for 65 percent of total savings. The remaining 35 percent is due to inherent comparative advantages of the private sector and the increased number of bidders. Even if there is no private sector cost advantage, more bidders would lead to a larger expected savings.[2]

Because many in-house teams were effectively constrained not to bid over their original baseline cost, we examined the effect of relaxing such a constraint. We find that constraining the in-house team to bid no more than its current baseline cost increases savings by 17 percent.

Neither increasing nor decreasing the in-house team's bidding advantage from its present level of 10 percent would have a significant impact on savings. This is because only 7 percent of competitions are affected by the rule and, even for these, the impact on savings is small.

A final policy simulation estimated the effect of the new method of accounting for overhead. The new OMB Circular A-76 requires the in-house team to use an overhead rate of 12 percent. Based on the limited data available, it is estimated that during the 1978-to-1994 period the in-house team used an overhead rate of about 5 percent on average. We applied this new overhead rate to both the baseline cost estimate and the in-house teams bid. We find that savings would increase by about 22 percent and that the percent of in-house wins would decrease from 50 to 42 percent. This increase in savings should not be regarded as a benefit from moving from the 5-percent to the 12-percent overhead rule. Rather, it suggests that the old 5-percent rule masked some of the true savings from A-76 competitions. This argument assumes that:

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2. More bidders lead to more savings because each additional bidder has some probability that its bid will be lower than all previous bids. This effect is separate from the competition effect which also increases with the number of bidders (actual *or* potential bidders).

- Savings were previously underestimated because the overhead portion of baseline costs was underestimated.
- The new overhead rates were more correct than the old overhead rates.

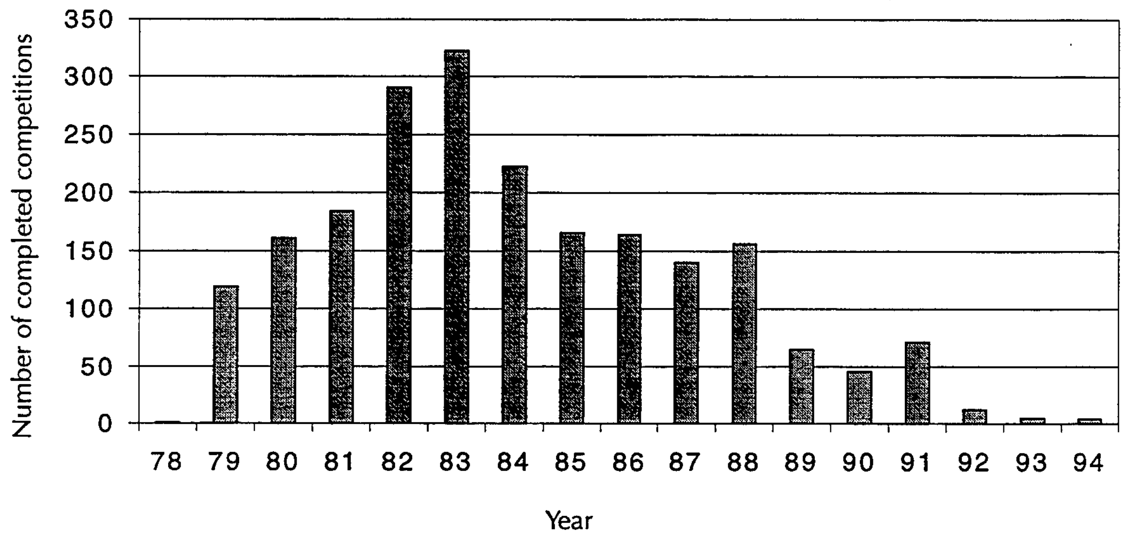
Since the simulations do not account for the fact that bidding strategies may change under different policies, the results from the simulations should be interpreted as approximations of the true impact of these policy changes.

Background

The A-76 program—past and present

From 1979 to 1994, DoD completed 2,195 A-76 competitions that resulted in recurring annual savings of approximately $1.5 billion.[3] Despite the program's successes, adverse incentives and political pressures effectively ended new competitions. Figure 1 shows the number of competitions by year.

Figure 1. Completed competitions over time



In 1989, installation commanders were given the authority to exempt functions from competitions.[4] Shortly thereafter, the number of new

3. See [2, 4, 5] for more information.

4. The authority expired in 1995. See [6] for more details.

competitions decreased, and the number of cancellations increased.[5] In FY 1992, Congress imposed a one-year moratorium that stopped the program completely. The Air Force was the only service to restart A-76 competitions after the moratorium expired.

The previous success of the A-76 program—and the need to purchase new weapon systems—has led DoD to initiate a new round of A-76 competitions. The Navy plans to compete 80,500 positions between 1996 and 2002. To date, they have announced about 18,000 positions for competition.

Will the savings materialize?

Difficulties in identifying candidates for competition and past failures from other savings initiatives have raised questions for some Navy officials:

- Can the Navy actually find 80,500 positions to compete?
- Will they see the same level of savings that the program generated in the 1980s?

Predicting is always difficult, and DoD has had many initiatives that have fallen short of the fulfilling their promises of savings. However, compared to many DoD savings initiatives, the A-76 program has a long and successful track record. DoD has undergone tremendous change since the end of the Cold War, but there is no evidence that it is more efficient relative to the private sector.[6] There are additional pieces of information that would be good to have, and DoD can do a better job of tracking the A-76 process and resulting savings. We do not have definite answers to either question, but we do have strong historical experience and some recent experience on which to base our conclusions.

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5. We believe that the large number of cancellations was caused by poor incentives for the installations commander. See [7].
6. DoD may have become more efficient relative to itself, but if the private sector has cut its costs even more, larger savings may be possible today.

Can the Navy find 80,500 candidates?

The PR-99 analysis

As part of the PR-99 budgeting process, an Investment Balance Review (IBR)[7] working group identified potential candidates using Navy manpower databases. They excluded a billet from consideration if:

- The function appeared to be inherently governmental.
- Competing the billet would not lead to savings for the Navy.[8]
- There were legislative restrictions on competing the function.

They also took sea-shore rotation and homebasing into account for military billets.

Using this process, the group identified 124,000 potential civilian outsourcing candidates and about 55,000 potential military candidates.[9] The working group concluded that the current plan was aggressive but achievable.

The POM-00 analysis

As part of POM-00 Assessment, an Issue Assessment working group[10] updated the PR-99 analysis with new data and refined rules for excluding billets from consideration. Of roughly 200,000 civilians, 16,000 were already scheduled to be cut between 1998 and 2003. Of the remaining 184,000 civilians, 111,000 were thought to be good potential candidates. The Navy needs to be able to compete about

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7. This group included representatives from N47, N12, N80, N81, N82, CNA, and NAVMAC Civilian Pay Office.

8. For example, many medical billets are paid for by the Office of the Secretary of Defense (OSD).

9. Only 23,000 out of 55,000 military positions can be competed due to sea-shore rotation homebasing policies.

10. This group included representatives from N80, N81, N82, N47, N12, N43, CNA, RDA(I&E), and DONOMIT.

63 percent (70,500) of these 111,000 to meet its goal for civilian candidates.

Using the same process, the group identified 58,000 potential enlisted military candidates out of the roughly 314,000 enlisted billets. An average sea-shore rotation goal of 4:3 reduced the number of candidates to about 13,000 (rather than the 23,000 identified by PR-99). Eliminating all fleet concentration billets further reduced the number of enlisted candidates to about 8,000. Combining these 8,000 with the 2,000 already announced would make the Navy's goal seem possible but very aggressive. However, the following facts suggest that the estimate of 8,000 enlisted candidates is too conservative:[11]

- These numbers do not include any officer billets. (CNA has estimated that there are at least 4,000 officer billets available.)
- Targeting only nonfleet concentration area billets will actually lead to a higher homebasing ratio than exists now. If the 13,000 enlisted candidates are distributed as all other shore billets, then they could all be competed and be neutral to homebasing.
- All A-school instructors were excluded.[12]
- The way sea-shore rotation is measured is questionable.[13]
- Greater use of a sea pay premium would relax the sea-shore constraint. This option would reduce net savings to some extent.
- Competing overseas shore and neutral duty billets will lessen the sea-shore constraint.[14]

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11. See [8] for further information.
12. See [9] for innovative ways of privatizing training.
13. In particular, the current calculation includes some E5s in their fourth and fifth years who are not careerists. Also, any additional at-sea reductions from Smart Ship initiatives are not factored into the calculations. See [10] for additional information.
14. Some overseas shore billets are counted as sea billets in the sea-shore ratio.

- High savings may justify relaxing one or both constraints. (The alternative is to buy fewer ships and planes or to sacrifice readiness.)

CNA's conclusion

The conclusion we draw from both the PR-99 and POM-00 analysis is that there appear to be 80,500 candidates. This is a difficult but achievable goal. We do not imply that this high-level analysis is the best method to identify candidates—that should be done at the claimant or installation level where better information is available. On further inspection, some of the 111,000 civilian and 58,000 military enlisted candidates may prove to be poor candidates, and some of the billets that were excluded may have been good candidates. However, this analysis does provide evidence that the Navy should proceed with its competition plan, and it is a valid basis for allocating competition goals to claimants.

Will the program produce 30-percent savings?

We find no evidence to suggest that savings will be substantially lower. In particular:

- The savings per billet competed had a slight positive trend across the 1980s. (This is evidence against cherry picking, the idea that the competitions yielding the highest savings were performed first. If the Navy had engaged in cherry picking, then savings would have a downward trend.)
- The competitions that were cancelled were comparable to successfully completed competitions. (This suggests that many good candidates remain.)
- Competition was applied unevenly across installations and functions which again suggests that many good candidates are still available. (It is also more evidence against cherry picking.)
- The number of personnel has come down in proportion to the budget. (Increased efficiency would imply a sharper drop in personnel.)
- The Air Force continues to average 34-percent savings.

- Three recently completed Navy competitions all resulted in savings of at least 30 percent.[15]

The savings are possible but not guaranteed

The savings are possible, but achieving them requires considerable effort and leadership. Leaders need to use every opportunity to state what must be done and why it must be done. There are many disincentives in the system that lead people to resist if they sense that their leaders do not fully support competition and outsourcing. The following actions would increase the chances of success:[16]

- *Increase the involvement and commitment of leaders at all levels.*
- *Fully fund studies.* The current $2,000 per FTE does not appear adequate to cover all costs.
- *Improve incentives.* Letting claimants keep a fraction of savings for a limited time would be an important incentive.
- *Do not penalize aggressive claimants.* Budget cuts should be based on a claimant's potential to compete billets rather than actual efforts. Otherwise, claimants who are aggressive in pursuing competition will be penalized.
- *Focus on larger competitions.* Thirty-seven percent of competitions with ten or fewer positions had zero savings.
- *Improve and expand tracking.* A substantial amount of useful information was collected during the 1980s; however, a lot of valuable information was not collected or was unusable. For example, we need more information on study costs, reasons for cancellation, workload, number of bidders, and recompetitions. There should also be a better database of candidates. Good tracking could also lessen the probability of a competition falling behind or being cancelled.

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15. These competitions were fuel services at Guam, telecommunications in Stockton, and family services in San Diego.

16. Additional ideas and more specific suggestions will be incorporated into a forthcoming paper on improving the Navy's competition process. Also, see [7].

Descriptive statistics

Previously completed A-76 competitions

Table 1 provides descriptive statistics for completed A-76 competitions. Of the 2,195 completed competitions, we examined 2,069.[17]

Weighted averages are presented by military service, size, and function type. The first column is the number of competitions in each group. The Navy and Air Force completed the most competitions. The breakdown by size shows that most competitions were small. Interestingly, an A-76 competition was not required for competitions of ten or fewer civilian positions, but the full A-76 process was often used to justify even these outsourcing decisions. The last breakdown is by function, and it shows that Installation Services and Other Non-manufacturing were the most commonly competed.

The second column shows the percentage won in house. About half of all competitions were won in-house. The third, fourth, and fifth columns provide information on the billets (military and civilian positions) associated with each competition. These competitions in total represented about 77,000 positions of which about 78 percent were civilian.

The last four columns provide information on the savings associated with each competition. About 40 percent of the competitions were for fewer than 10 billets, but these competitions accounted for only 5 percent of total savings. Of the completed competitions, 439, or 21 percent, yielded no savings. This suggests that some tasks may be efficiently undertaken by the in-house team without exposure to competitive private markets. Or, it could mean that these competitions

17. Of the 126 competitions not used in the analysis, 119 were missing vital data, 4 were outliers, 2 were unusual cases (unique functions), and 1 contained an apparent typographical error.

were structured in a way that made it difficult for the private sector to find efficiencies. For example, a small competition involving five billets and a performance work statement (PSW) that specifies procedures rather than products could make it difficult for the private sector to bid effectively. In these cases, the Navy can bundle small functions together and write a more flexible PSW.

Table 1. Descriptive statistics for completed A-76 competitions[a]

	Number of competitions	Percent won in-house	Billets: Total	Billets: Per task	Billets: Percent military	Annual savings (1996 dollars): Total (in millions)	Annual savings: Per billet (in thousands)	Annual savings: Per task (in thousands)	Percent with no savings
By service branch									
DoD Agencies	50	42.0	1,034	21	0.5	13	13.0	270	16
Army	445	50.1	23,588	53	14.1	432	18.3	970	21
Air Force	732	37.7	26,080	36	32.9	560	21.5	765	14
Marines	39	53.8	1,264	32	12.4	23	18.5	600	26
Navy	803	56.8	25,391	32	19.0	412	16.2	513	28
By size (number of billets)									
1-10	833	57.1	4,626	6	10.7	72	15.6	87	36
11-50	915	41.4	21,081	23	11.1	377	17.9	412	13
51-100	174	46.0	12,086	70	13.6	189	15.7	1,088	8
101-150	52	50.0	6,115	118	17.8	121	19.8	2,330	4
151-200	32	50.0	5,605	175	12.9	99	17.7	3,108	9
More than 200	63	31.7	27,844	442	38.1	581	20.9	9,229	2
By function type									
Installation Services	647	52.6	26,806	41	9.4	504	18.8	779	24
Social Services	230	19.1	4,198	18	12.6	68	16.2	296	14
Health Services	27	74.1	436	16	17.9	4	8.2	133	41
Intermediate Maintenance	159	40.9	15,575	98	45.7	285	18.3	1,791	23
Depot Maintenance	6	100.0	86	14	0.0	1	11.7	168	50
Real Property Maintenance	312	44.9	10,493	34	8.5	208	19.8	666	17
Research Support	12	25.0	984	82	76.2	68	69.1	5,670	8
Training	8	50.0	1,232	154	91.9	21	17.4	2,678	0
Data Processing	94	56.4	2,150	23	14.3	23	10.6	243	33
Other Nonmanufacturing	574	56.1	15,397	27	23.1	259	16.8	451	20
Total	**2,069**	**48.2**	**77,357**	**37**	**21.8**	**1,440**	**18.6**	**696**	**21**

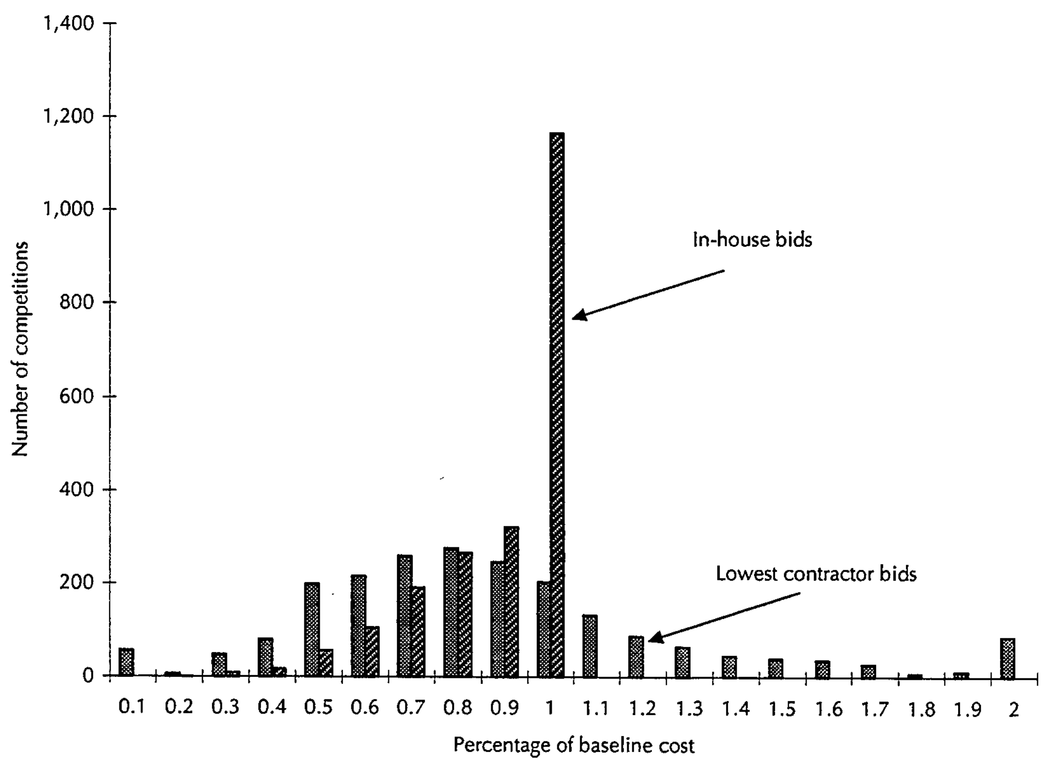
a: Savings are measured in thousands of FY 1996 dollars on an annual basis.

For 68 of the competitions with zero savings, however, the private contractors submitted a bid lower than the baseline cost, but were prevented from winning by the in-house team's 10-percent bidding advantage. If we only include competitions with no bids below the base cost, the percent with zero savings drops 18 percent.

Comparison of bids

Figure 2 shows the distribution of bids relative to the original cost for the in-house team and the lowest contractor bid. Along the horizontal axis in figure 2, a "1" means that the bid is equal to the baseline cost. A number less than 1 means that the bid is lower than baseline cost. A number greater than 1 means that the bid is greater than baseline cost. The "2" on the horizontal axis is "2 or more" times the baseline cost.

Figure 2. Distribution of bids relative to original cost



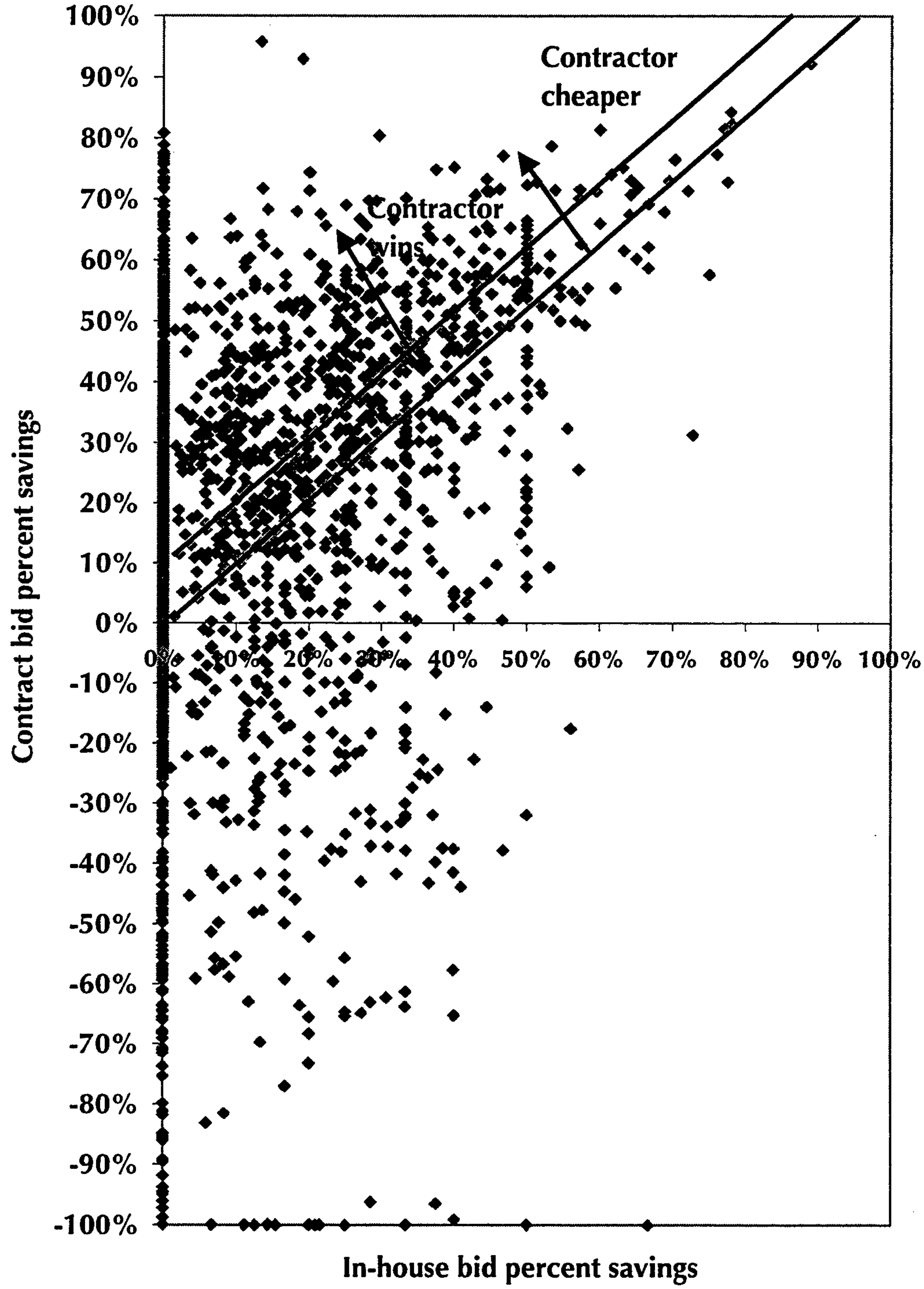
The fact that there are no in-house bids above the original cost is dictated by the rules of the A-76 process. This probably explains why many of the in-house bids are equal to the original cost of performing the task. On the other hand, the mode for the lowest contractor bid is at 80 percent of the original cost, and many bids are below that. (In figure 2 note that the "2" on the horizontal axis is "2 or more.")

That the in-house team is bidding at less than the original cost can be attributed to the increase in competitive pressures. However, the lower mean for contractor bids cannot simply be attributed to greater inherent efficiency of private versus in-house provision. This is because the private bids in figure 2 are for the lowest and not the average bids received. In a sense, we have a distribution of potential private and in-house bids where we receive a number of private bids, select the lowest, and then compare it to the in-house bid. Even if the contractor and in-house bids come from the same distribution, the lowest contractor bid will, on average, be lower than the one in-house bid.

Figure 3 shows a scatter plot for each competition of the savings relative to the baseline costs for the lowest contractor bid compared to the in-house bid. Again, the in-house savings cannot be negative due to the rules of A-76 competitions. We have truncated the savings from lowest contractor bids at -100 percent. Each dot represents a pair of bids for the same competition. Thus, they can be compared to see which bid gave greater savings and which bid won. (Recall that the winning bid need not provide the greatest savings of the two since the lowest contractor bid must be at least 10 percent less than the in-house team's bid to win.)

Note the wide dispersion of the data. This indicates that the two bids were often quite different and, thus, even if one bid would result in savings, the other bid would not. Any points along the vertical axis above zero are places where there were no savings from the in-house bid, but the lowest contractor bid did produce savings. For all points below the horizontal axis and to the right of the vertical axis, the in-house bid produced savings, but the lowest contractor bid did not. All points between the two dark lines are cases where the contractor bid was cheaper, but the in-house team won because of its 10-percent bidding advantage.

Figure 3. Bid comparison scatter plot



The 1995 DoD CA Inventory

The 1995 DoD CA Inventory is a list of candidates from which future competitions can be drawn. Table 2 lists descriptive statistics for this inventory. Later, we project savings from competing the entire inventory.

Overall, the inventory is very similar to those functions already competed. However, there are some differences:

- The average function is smaller.
- DoD agencies are more prevalent.
- Some functions have had only a very small percentage of billets competed (Health Services, Depot Maintenance, Research Support, and Training).
- The inventory is 37-percent military compared to the 22 percent of previous competitions.

Table 2. Descriptive statistics for the 1995 DoD CA Inventory

		Billets		
	Number of tasks	Total	Per task	Percent military
By service branch				
DoD Agencies	1,280	52,824	41.3	4.0
Army	3,712	96,277	25.9	27.9
Air Force	3,873	49,089	12.7	55.5
Marines	523	19,082	36.5	56.0
Navy	3,941	162,778	41.3	45.6
By size (number of billets)				
1-10	7,897	31,198	4.0	29.8
11-50	3,896	90,947	23.3	34.7
51-100	923	64,560	69.9	38.3
101-150	265	32,544	122.8	38.9
151-200	113	19,378	171.5	59.8
More than 200	235	141,423	601.8	36.4

Table 2. Descriptive statistics for the 1995 DoD CA Inventory (continued)

	Number of tasks	Billets		
		Total	Per task	Percent military
By function type				
Installation Services	3,619	90,950	25.1	30.9
Social Services	2,020	26,774	13.3	13.9
Health Services	1,369	64,852	47.4	63.3
Intermediate Maintenance	1,069	35,334	33.1	73.5
Depot Maintenance	139	43,869	315.6	1.7
Real Property Maintenance	917	18,367	20.0	8.2
Research Support	242	8,748	36.1	27.2
Training	618	24,253	39.2	81.0
Data Processing	706	14,505	20.5	14.7
Other Nonmanufacturing	2,630	52,398	19.9	30.5
Total	13,329	380,050	28.5	37.2

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 detail.

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 1-percent increase in the number of civilian billets in a competition leads to a 2-percent increase in savings.
- A 1-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

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

where Δ 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 Δ, 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 R separate draws of u_j, an estimate of savings for a completed A-76 competition for function i is

$$S_i = \frac{1}{R}\sum_{j=1}^{R} S_{ij} \qquad (8)$$

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

$$S_{tot} = \sum_{i=1}^{N} S_i \ . \qquad (9)$$

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 1995 DoD CA Inventory[a]

	Service branch					
Function type	Army	DoD Agencies	Air Force	Marines	Navy	Total
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 10-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-76 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.

Appendix A: Theoretical bidding model

In this section, we present a formal model of privatization competitions. The government requires the performances of certain functions, indexed by *i*. At the onset, in stage 0, function *i* is performed by an in-house team, labeled *I*. Let Y_{1i} denote the baseline cost of function *i*. Baseline cost is therefore the cost to the government of having the function performed during this initial stage. Baseline cost is determined by the following:

$$Y_{1i} = Y_1 (X_i, X_I, \Lambda_0, u_{1i}) , \qquad (10)$$

where X_i is a vector of variables relating to the scale and complexity of function *i*, X_I is a vector of variables relating to *I*'s inherent technological efficiency, Λ_0 is a vector of variables relating to the stringency of the government's monitoring and control of *I*'s costs, and u_{1i} is an unobservable error term. To illustrate the role of Λ_0 in equation (1), holding all other variables constant, baseline cost may be relatively high if the government exerts little control over *I*'s cost and relatively low if *I* under an optimal incentive contract along the lines proposed in [11]. In practice, variables X_I and Λ_0 may be unobservable and therefore folded into the error term for estimation purposes. Assuming this is so, and defining a log-linear relationship between the dependent and independent variables, the specification of (1) becomes (2)

$$\ell n (Y_{1i}) = X_i\beta_1 + u_{1i}. \qquad (11)$$

In the next stage of the model, the government conducts a privatization competition such as the A-76 competition. In the privatization competition, the in-house team and a number of private contractors bid for the right to be the sole provider of function *i* for the government. Let $\{P_j\}$ be the set of private contractors that are potential bidders. This set includes actual participants in the privatization competition as well as those who elect not to participate, effectively submitting infinite bids. The players submit secret bids simultaneously. A private contractor's bid is the price at which it agrees to perform the function; the in-house team's bid is the cost at which it agrees to perform the function. We assume all players know their own cost of performing the function. Thus, the privatization competition is a private-values procurement auction.

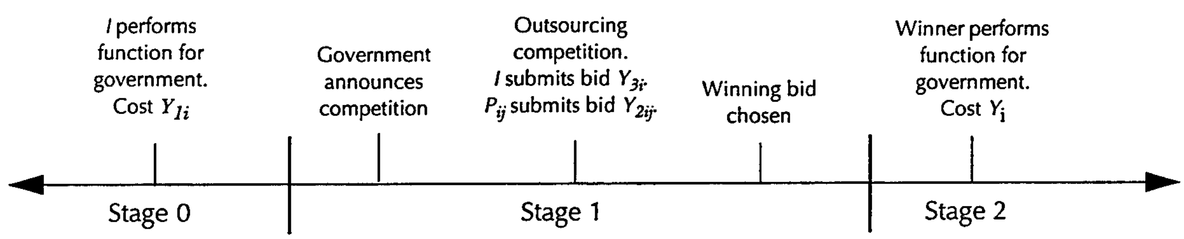
Let Y_{3i} be *I*'s bid. Let Y_{2i} be the lowest of the outside contractor's bids. That is, $Y_{2i} = min\{Y_{2ij} \mid j = 1, 2, \ldots N_i\}$, where Y_{2ij} is the bid of contractor P_j. The government selects the winning bid Y_i according to prespecified rules. A simple rule would be to select the lowest bid. We will allow the government to use a more complicated selection rule, possibly providing an incumbency advantage to the in-house team:

$$\begin{aligned} Y_i &= Y_3 \text{ if } Y_{3i} \leq (1+\Delta)\, Y_{2i} \\ &= Y_{2i} \text{ if } Y_{3i} > (1+\Delta)\, Y_{2i} \end{aligned} \qquad (12)$$

According to equation (12), *I* wins the competition as long as its bid is less than a scaled-up version of the private contractor's bid. For the A-76 competitions considered in this study, the scaling factor, Δ, was 10 percent. Of course, if $\Delta = 0$, then equation (12) simply selects the lowest bid.

In the last stage of the game, the winning bidder performs the task for the government according to the terms of its bid. A schematic diagram of the timing of the game is provided in figure 4.

Figure 4. Timing of model



Private contractor's bids

Private contractor P_j is assumed to choose its bid Y_{2ij} to maximize its expected profit, defined as the payment from the government minus the cost of performing the task. An increase in its bid has two effects: the positive effect of increasing the revenue it obtains if it wins the outsourcing competition and the negative effect of decreasing the probability if it wins the competition. Formally, let $\Psi(X_i, X_j, \nu_j)$ denote P_j's cost of performing the task. This cost depends on several variables. As before, X_i is a vector of task-specific variables relating to the scale and complexity of the task that would increase the cost of performing. X_j is a vector of contractor-specific variables that would increase the cost of performing the task. X_i and X_j are assumed to be observable to all players. Similar to X_j, ν_j is a vector of variables relating to P_j's cost of performing the task, the difference being that ν_j is assumed to be unobservable to all players except P_j. Let f_j be the density function and F_j be the distribution function associated with ν_j. Assume these functions are common to all players. Normalizing its profit conditional on losing the outsourcing competition to zero, we can express P_j's optimization problem as

$$Y_{2ij} = \operatorname{argmax}_{C \in \Re^+} \{[C - \Psi(X_i, X_j, \nu_j)]\Pr[C < min(\{Y_{2ik}\}_{k \neq j}, [1/(1+\Delta)\, Y_{3i})]\}. \tag{13}$$

From equation (4), we can derive the following reduced-form expression for P_j's equilibrium bid:

$$Y_{2ij} = Y_{2j}\left(X_i, X_j, \{X_k\}_{k \neq j}, X_I, \Delta, \Lambda_0, \nu_j\right). \tag{14}$$

It is clear that Y_{2ij} will depend on X_i, X_j, and ν_j since these variables directly affect P_j's cost of performing the task. The other variables affect Y_{2ij} indirectly by affecting the best-response functions of the other players. Just as X_j affects P_j's bid, a vector of variables increasing P_k's cost of performing the task, denoted by X_k, affects P_k's bid. Similarly, a vector of variables increasing I's cost of performing the task, denoted by X_I, affects I's bid. An increase in any of the variables in $\{X_k | k \neq j\}$ or X_I will tend to cause P_j's rivals to bid less aggressively, and this will have the indirect effect of causing P_j to bid less aggressively.

Of course, this indirect effect can only occur if $\{X_k | k \neq j\}$ and X_I are observable to P_j, as we have assumed. Similarly, an increase in X_i will affect a rival's best-response functions and thus will have an indirect effect, as well as a direct effect, on P_j's equilibrium bid. As will be discussed in more detail in the next subsection, increases in Δ and Λ_O may have an indirect effect on P_j's bid by causing I to bid less aggressively.[19]

In view of equation (14), the minimum of the private contractors' bids can be written

$$Y_{2i} = Y_2\left(X_i, \{X_j | j = 1,\ldots, N_i\}, X_I, \Delta, \Lambda_0, \{v_j | j = 1,\ldots, N_i\} \right) . \qquad (15)$$

In practice, we may not observe variables $\{X_j | j = 1,\ldots N_i\}$, X_I or Λ_0. Recognizing this fact, letting the relationship between the independent and dependent variables be linear, and collecting the unobservable error terms together as u_{2i}, equation (15) becomes (16) as shown below

$$Y_{2i} = X_i\beta_2 + u_{2i}. \qquad (16)$$

Note that another difference between equations (15) and (16) is the exclusion of a Δ term. Δ has been excluded from equation (16) because, in practice, the rules of the privatization competitions held Δ constant across function *i*. It is important to remember that the coefficients β_2 are conditioned on Δ. Changes in Δ will cause changes in β_2. However, it may be possible to predict the direction of the effect of Δ on β_2 , so policy simulations involving changes in Δ will still be useful.

In-house team's bid

I's decision problem is similar to the private contractor's described above. One difference is that the private contractors are for-profit

19. The comparative-statics results given in this paragraph are conjectures meant to build intuition regarding the reduced-form bid in (12). In general, it is not possible to sign the partials unless strong assumptions are placed on the distribution of the unobservable terms ν_i and ν_I.

firms, while I is a nonprofit unit of government. We will address this first issue by supposing the cost-reduction provides I with disutility, rather than a reduction in revenues as with the private contractors. Another important difference is that at the privatization stage, I has already demonstrated it can provide the task at a cost Y_{1i} in stage 0. The government can reduce the ultimate cost of obtaining the task by constraining I's bid to lie below Y_{1i}. We will address this issue by treating I's desired bid as a latent variable that may differ because of the government's constraint from I's actual bid.

Let Y^*_{5i} be the solution to the following optimization problem for I:

$$Y^*_{3i} = \operatorname{argmax}_{C \in \Re^+} \{ U(C, X_i, X_I, \nu_I) \Pr[C < (1+\Delta) Y_{2i}] \} , \tag{17}$$

where X_I and ν_I are to I as X_j and ν_j are to P_j. To account for the fact that I is a nonprofit unit, instead of the profit term appearing in (4), a term measuring I's surplus from performing the task, denoted by $U(C, X_i, X_I, \nu_I)$, appears in (17). We assume $\partial U / \partial C > 0$. That is, we assume I's utility is lower for a lower cost target. There are many potential sources of this disutility: effort, the disutility of cost-cutting measures such as firing employees, and so forth. As a reduced form, Y^*_{3i} can be written

$$Y^*_{3i} = Y^*_3 (X_i, X_I, \{X_j | j=1, \ldots N_i\} \Delta, \Lambda_O, \nu_I) . \tag{18}$$

It is clear from (12) that Y^*_{3i} should depend on Δ, the bidding advantage given to I by the government. An increase in Δ will tend to make I bid less aggressively. It may be less clear why Y^*_{3i} should depend on Λ_O. This is due to an indirect effect. Though Y^*_{3i} may not depend directly on Λ_O, as will be formalized below, its realized bid, Y_{3i}, may. The private contractors form their bids $\{ Y_{2ij} | j = 1, \ldots N_i \}$ based on their expectations of Y_{3i}, and Y^*_{3i} in turn depends on I's expectations of $\{ Y_{2ij} | j = 1, \ldots N_i \}$. This indirect effect will only arise if Λ_O is observable to the private contractors. Similar reasoning can be offered that, in addition to its direct effect on Y^*_{3i}, X_i may exert an indirect effect on Y^*_{3i} as well.

By analogy to the derivation of (16) from (15), we can express (18) in a form that can be implemented as

$$Y^*_{3i} = X_i\beta_3 + u_{3i} \quad . \tag{19}$$

The government's constraint that *I*'s realized bid cannot exceed baseline cost implies

$$Y_{3i} = min(Y_{1i}, Y^*_{3i}) \quad . \tag{20}$$

To interpret (20), Y^*_{3i} can be thought of as a latent variable measuring *I*'s desired bid. If Y^*_{3i} is less than Y_{1i}, Y^*_{3i} is the realized bid. If Y^*_{3i} exceeds Y_{1i}, the latent variable is not observed, and Y_{1i} is the observed or realized bid.

Cost savings from competition

In this section, we derive an expression for the expected cost savings due to outsourcing. The discussion will be based on reduced-form equations (11), (16), and (19). Some simplifying notation will prove useful. Let $u_i = (u_{1i}, u_{2i}, u_{3i})$ be the vector of error terms and *f* be its associated density. Define U_i to be a set of realizations of u_i, U_{Ii} to be the subset of u_i such that *I* wins the outsourcing competition, and U_{Pi} the subset of u_i such that a private contractor wins. That is,

$$U_{Ii} = \{u_i \in U_i | Y_{3i} \leq (1+\Delta) Y_{2i}\}$$

$$U_{Pi} = \{u_i \in U_i | Y_{3i} > (1+\Delta) Y_{2i}\} \ .$$

The expected cost savings from the competition equals

$$\int_{U_i} Y_{1i} f(u_i)\, du_i - \int_{U_{Pi}} Y_{2i} f(u_i)\, du_i - \int_{U_{Ii}} Y_{3i} f(u_i)\, du_i \quad . \tag{21}$$

Note that equation (21) is a highly nonlinear function of the errors. In general, there exists no easily attainable closed-form solution for this expectation. This justifies the use of the simulation methodology for predicting savings discussed in the text.

Appendix B: Estimating the bidding and baseline cost equations

Consider the three equation models given by

$$\ell n\,(Y_{1i}) = X_i\beta_1 + u_{1i} \tag{22}$$

$$\ell n\,(Y_{2i}) = X_i\beta_2 + u_{2i} \tag{23}$$

$$\ell n\,(Y^*_{3i}) = X_i\beta_3 + u_{3i}\ , \tag{24}$$

where

$$Y_{3i} = \min\,(Y^*_{3i}, Y_{1i})\ . \tag{24a}$$

Equation (23) can be estimated consistently with ordinary least squares. Equations (22) and (24) can be estimated consistently with a maximum likelihood (ML) procedure.

To estimate equations (22) and (24), assume the vector of error terms $u_i = (u_{1i}, u_{2i}, u_{3i})$ is distributed Normally with zero mean and covariance matrix Σ given by

$$\Sigma = \begin{pmatrix} \sigma_1^2 & \sigma_{12} & \sigma_{13} \\ \sigma_{12} & \sigma_2^2 & \sigma_{23} \\ \sigma_{13} & \sigma_{23} & \sigma_3^2 \end{pmatrix}.$$

Defining $\rho_{ij} = \dfrac{\sigma_{ij}}{\sigma_i\sigma_j}$, the likelihood function for the joint estimation of equations (22) and (24) is given by

$$L = \Pi\{i|Y^*_{3i} < Y_{1i}\}\, Pr(u_{1i})\, Pr(u_{3i}|u_{1i})\, \Pi\{i|Y^*_{3i} \geq Y_{1i}\}\, Pr(u_{1i})\, Pr(Y^*_{3i} \geq Y_{1i}|u_{1i})$$

(25)

where $Pr(u_{1i})$, $Pr(u_{3i}|u_{1i})$, and $Pr(Y^*_{3i} \geq Y_{1i}|u_{1i})$ are given by

$$Pr(u_1) = \frac{1}{\sqrt{2\pi\sigma_1}} \exp\left[-\frac{1}{2}\left(\frac{u_{1i}}{\sigma_2}\right)^2\right] = \frac{1}{\sigma_1}\phi(u_{1i}) \quad . \qquad (26)$$

$$Pr(u_{3i}|u_{1i}) = \frac{1}{\sqrt{2\pi\sigma_3^2(1-\rho_{13}^2)}} \exp\left[-\frac{1}{2\sigma_3^2(1-\rho_{13}^2)}\left(u_{3i} - \frac{\rho_{13}\sigma_3}{\sigma_1} u_{1i}\right)^2\right]$$

$$= \frac{1}{\sigma_3\sqrt{1-\rho_{13}^2}}\,\phi\left(u_{3i} - \frac{\frac{\rho_{13}\sigma_3}{\sigma_1} u_{1i}}{\sigma_3\sqrt{1-\rho_{13}^2}}\right) \qquad (27)$$

$$Pr(Y^*_{3i} \geq Y_{1i}|u_{1i}) = Pr(X_i\beta_3 + u_{3i} \geq Y_{1i}|u_{1i})$$

$$= Pr(u_{3i} \geq Y_{1i} - X_i\beta_3|u_{1i})$$

$$= 1 - \Phi\left(u_{3i} - \frac{\frac{\rho_{13}\sigma_3}{\sigma_1} u_{1i}}{\sigma_3\sqrt{1-\rho_{13}^2}}\right) \quad , \qquad (28)$$

where

ϕ = Standard normal probability density function

Φ = Standard normal cumulative distribution function.

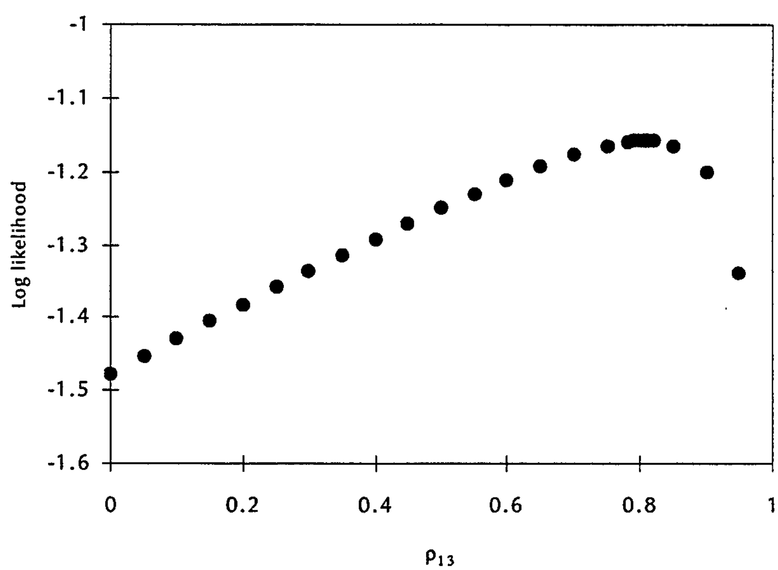
Substituting $Pr(u_{1i})$, $Pr(u_{3i}|u_{1i})$, and $Pr(Y_{3i}{}^* \geq Y_{1i}|u_{1i})$ in equation (4) gives

$$L = \prod_{\{i \mid Y^*_{3i} < y_{1i}\}} \left(\frac{1}{\sigma_1}\phi\,(Y_{1i} - X_i\beta_1)\right) \left[\frac{1}{\sigma_3\sqrt{1-\rho^2}}\,\phi\left(\frac{Y_{3i} - X_i\beta_3 - \frac{\rho_{13}\sigma_3}{\sigma_1}(Y_{1i} - X_i\beta_1)}{\sigma_3\sqrt{1-\rho_{13}^2}}\right)\right]$$

$$\times \prod_{\{i \mid Y^*_{3i} \geq Y_{1i}\}} \left(\frac{1}{\sigma_1}\phi\,(Y_{1i} - X_i\beta_1)\right) \left[1 - \Phi\left(\frac{Y_{3i} - X_i\beta_3 - \frac{\rho_{13}\sigma_3}{\sigma_1}(Y_{1i} - X_i\beta_1)}{\sigma_3\sqrt{1-\rho_{13}^2}}\right)\right] . \quad (29)$$

Olsen in [12] has shown that likelihood functions such as equation (29) have a unique maximum conditional on ρ. Also, Nawata in [13] has shown that the likelihood function conditional on ρ gives reliable estimates. For this reason, we maximize equation (29) for a given $\hat{\rho}_{13}$ and then search over the interval $-0.99 \leq \hat{\rho}_{13} \leq 0.99$ for the final ML estimates. A plot of the maximum likelihood value as a function of $\hat{\rho}_{13}$ is given in figure 5.

Figure 5. Grid search over ρ_{13}



Note that all the elements of Σ can be easily estimated except σ_{23}. Estimates of ρ_{13}, σ_1^2, and σ_3^2 are obtained by the ML procedure which can be used to also compute σ_{13}. An estimate of σ_2^2 is obtained from OLS, and an estimate of ρ_{12} can be obtained from within the sample residuals of equations (22) and (23). An estimate of ρ_{23} can be obtained with stochastic simulation of predicted savings from

$$Y_{1i} = \exp(X_i\beta_1 + u_{1i}) \tag{30}$$

$$Y_{2i} = \exp(X_i\beta_2 + u_{2i}) \tag{31}$$

$$Y_{3i} = min[\exp((X_i\beta_3 + u_{3i}), Y_{1i})] \tag{32}$$

$$\begin{aligned} S_i &= Y_{1i} - Y_{3i} \text{ if } Y_{3i} \leq (1+\Delta)\, Y_{2i} \\ &= Y_{1i} - Y_{2i} \text{ if } Y_{3i} > (1+\Delta)\, Y_{2i} \quad . \end{aligned} \tag{33}$$

Let u_j be the j^{th} draw from a normal distribution with covariance matrix Σ, where the estimate of ρ_{23} is set at -0.99. Substituting u_j and the parameter estimates into equations (30)–(33) yields the j^{th} draw of savings for the i^{th} function in the A-76 completed competitions, denoted by S_{ij}. If this process is repeated *R* times with *R* separate draws of u_j, an estimate of savings for a completed A-76 competition for funciton *i* is

$$S_i = \frac{1}{R}\sum_{j=1}^{R} S_{ij} \quad . \tag{34}$$

This process can be repeated for each of the N functions in the completed A-76 competitions. Total predicted savings for the N completed A-76 competitions is given by

$$S_{tot} = \sum_{i=1}^{N} S_i \quad . \tag{35}$$

To obtain an estimate of ρ_{23}, repeat the stochastic simulation of equations (30) to (35) in 0.01 step increments for all values of $\hat{\rho}_{23}$ in the interval -0.99 to 0.99. The value of $\hat{\rho}_{23}$ that gives predicted savings from equation (35) equal to observed savings in the completed A-76 competitions is the estimate of ρ_{23}.

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