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FORECASTING SAVINGS FROM REPETITIVE COMPETITION WITH MULTIPLE A--ETC(U)

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FORECASTING SAVINGS FROM REPETITIVE COMPETITION WITH MULTIPLE AWARDS

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ARMY PROCUREMENT RESEARCH OFFICE
U.S. ARMY LOGISTICS MANAGEMENT CENTER
FORT LEE, VIRGINIA 23801

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FORECASTING SAVINGS FROM REPETITIVE COMPETITION WITH MULTIPLE AWARDS.

by

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Nov[redacted]79

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EXECUTIVE SUMMARY

A. BACKGROUND. Previous research has shown that competition usually results in lower unit prices. The literature, however, only addresses the case in which a single winner receives one contract for the total quantity required. The present study generalizes the above work by allowing for the possibility of multiple winners and also the case in which a sequence of competitive awards are made for the same item over a period of several years.

B. STUDY OBJECTIVES. The objectives of this study are to: (i) develop a methodology for estimating the competitive savings where there is a sequence of acquisitions and where multiple awards can be used, (ii) exercise the methodology on a sample of acquisitions, (iii) develop a forecasting methodology for use with future acquisitions, (iv) relate the findings to the question of choosing the optimum number of producers.

C. STUDY APPROACH. A literature review and interviews resulted in a list of suitable ammunition items. A sample of 22 acquisitions was selected and contract data were collected. Data were adjusted to separate the effects of inflation, nonrecurring costs, and contractor learning. The savings attributable to competition were estimated. A sensitivity analysis was done for each acquisition using learning curve slopes of 90, 95 and 100 percent.

D. SUMMARY AND CONCLUSIONS. The sample showed an average competitive savings of 7.1 percent, based on a learning curve slope of 95 percent. The effect of competition varied widely, ranging from a savings of 25 percent to a loss of 30 percent. A discussion is provided on situations where competition may not be advisable. Some have held that in a sole-source acquisition the government receives no benefit from contractor learning, so the data also were analyzed using a flat slope of 100 percent. With this assumption the sample showed an average savings of 10 percent. While range bidding and other competitive techniques give unit price savings of 7 to 10 percent, this savings could be reduced or lost if the production base were reduced to a single contractor.

CHAPTER I

INTRODUCTION

A. <u>BACKGROUND</u>.

Many recent studies (8, 11, 15, 19, 20)[1] have sought to quantify the effect of competition on price. These studies have usually compared the one-time costs of establishing competition (for example, facilities, tooling, and educational awards) with the reduction in unit price resulting from the competition. These studies have found significant savings. For example, Lovett and Norton (11), after carefully separating the effects of nonrecurring costs, learning, and inflation, found an average reduction of 13.7 percent in unit price attributable to competition. The average net savings (considering one-time costs) in that study was 10.8 percent. Using a similar analysis Smith (15) found a net savings of 10.6 percent.

Several terms need to be defined in order to describe the studies above. First, a winner-take-all award refers to a type of acquisition in which one successful bidder receives an award for the Army's total required quantity. This quantity is also called the "buy-out" quantity. Winner-take-all awards can be contrasted to multiple awards, in which several successful bidders receive contracts to produce varying portions of the quantity awarded. If the quantity awarded is not the Army's total required quantity (i.e., if future acquisitions are planned), then the quantity awarded is called the "current requirement."

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[1] Works cited in parentheses are listed in the Reference section.

For many items there are no buy-outs. Instead there is repetitive competition for the current requirement. Often multiple awards are used. Each competitive acquisition makes the bidders fight again for their share of the market, because the quantity awarded depends on the bid price. The studies above address the situation in which a sole-source contract is followed by a winner-take-all buy-out. No previous research has addressed the case of multiple awards or the situation in which a sequence of competitive awards for the same item is made over a period of many years.

The type of competition being studied can be illustrated with ammunition items, the acquisition of which is unique in several ways. Most other weapons systems are purchased within a few years and have quantities in the hundreds, or sometimes in the thousands. Often the production line is shut down after the total requirement has been filled. Ammunition items, on the other hand, are usually purchased over a period of ten years or more and have quantities in the millions. Because ammunition deteriorates with age, or is consumed in training, the production lines are usually not shut down. Even in peacetime, the production base is maintained in a state of readiness, with some lines operating at a minimum rate and other lines in a "layaway" or inactive status. This practice insures that the production base will be able to respond to an emergency. When possible, the Army prefers to have producers in different geographical regions to reduce vulnerability to enemy attack.

In order to maintain a ready industrial base of contractors, and to protect selected technologies which are in danger of disappearing (e.g., the mechanical fuze industry), the Army has established a mobilization base for some items. Under this concept private contractors become members of the mobilization base and agree to respond to any urgent Army requirement. In some cases they agree to keep and maintain government equipment and facilities in their factories. In return the Army often considers for award only members of the mobilization base. Competition for these items is a restricted type of competition.

Another characteristic of competition in the ammunition industry is the frequent use of multiple awards. Usually the larger award goes to the offeror with the lowest price, but other factors are also considered, such as plant capacities and the need to preserve the production base. In summary, competition in the ammunition industry is characterized by long sequences of acquisitions, a restricted pool of producers, frequent use of government-supplied facilities, and frequent use of multiple awards.

Several Army offices are particularly interested in being able to estimate the effects of competition on the price of ammunition items. The Office of the Project Manager for Munitions Production Base Modernization and Expansion (PMMPBME) at Picatinny Arsenal, New Jersey, is responsible for developing, analyzing, and recommending alternatives for facilities to produce munitions. The one-time costs for these facilities can be very large, yet can be offset, at least in part, by the savings in unit price due to competition. An ability to quantify the competitive savings will provide a better basis for choosing between alternative combinations of facilities. While the production base should be large enough to permit a surge capability, it should still be as cost effective as possible. Other factors being considered by the PM are the quantities of munitions required, the number of production facilities, the capacity of each facility, the number of operating shifts, and the depreciation or wearout of the equipment.

The Procurement Directorate at the US Army Armament Materiel Readiness Command (ARRCOM) at Rock Island, Illinois, purchases ammunition. This office must decide whether or not competition for a specific item is feasible, choose whether to have a winner-take-all competition or use multiple awards, and estimate costs for negotiated acquisitions.

Recent guidance from the Office of the Secretary of Defense (OSD) makes it even more important to quantify competitive savings. Traditional policy has been that munitions facilities should be large enough or numerous enough to produce a 180-day Army Authorized Objective (AAO) within a five-year period, with each producer operating one shift, eight hours a day, five days a week. This policy is called the "1-8-5" guidance. The new OSD guidance (3) emphasizes economy. Under this new policy munitions facilities should be of a size to produce a 90-day AAO, less stock on hand, within a four-year period, with each producer operating two shifts, eight hours a day each, five days a week (the "2-8-5" guidance).

The purpose of limiting the size of the production base is to reduce the one-time costs for investment in facilities. A complete tradeoff analysis, however, would also consider the savings in recurring unit price if it were possible to maintain competition over several acquisitions. Using the 1-8-5 guidance the government has held as many as nine competitive acquisitions for the same item over a period of 14 years. Under the 2-8-5 guidance, however, a single contractor would, in many cases, produce the entire current requirement. This contractor, having government equipment in his factory, would be in almost a sole-source position for all the later acquisitions. By using multiple awards, possible with the 1-8-5 guidance, the Army could have effective competition for these later awards.

B. STUDY OBJECTIVES.

The objectives of this study are to:

1. provide a methodology for estimating the price savings of repetitive competition, in a situation where multiple awards are sometimes used,

2. exercise the methodology on a selected sample of acquisitions and provide the resulting data base,

3. develop a forecasting methodology for use with current and future acquisitions, and

4. relate the findings to the larger question of choosing the optimum number of producers.

C. STUDY APPROACH.

In order to accomplish the study objectives the literature on competition and ammunition was reviewed. Then interviews were held at Picatinny Arsenal and at Rock Island to clarify the types of competition used in the acquisition of ammunition. A list was made of items that had been purchased competitively. Price and quantity data and other relevant information were collected from contract files. Other data sources include cost analysis studies and interviews with the contracting officers.

A sample of 22 acquisitions was selected for analysis. The selection was based on the desire to reflect the diversity of ammunition items and to perform a longitudinal analysis of a sequence of acquisitions for the items selected. Before each acquisition there were one or more incumbent contractors already producing the item, and as a result of the acquisition one or more contractors (possibly different ones) received competitive awards.

Data for each contract were adjusted. Nonrecurring costs were subtracted, prices were converted to constant FY 1978 dollars using price indices, and midpoints were calculated to allow further adjustment for learning, as described more fully in the next chapter.

A methodology was developed to estimate the savings in unit price attributable to competition. Finally, factors which could explain these savings were analyzed and a forecasted savings methodology was developed.

D. SCOPE.

This study extends previous research by addressing the effects of competition in acquisitions other than the first. It also addresses multiple awards as well as winner-take-all awards.

Nonrecurring costs (NRC) were collected and are reported in the data base. The forecasted savings methodology, however, estimates only the savings in recurring unit price. A valid estimate for one-time costs, to include NRC and facilitization costs, can be made only when more detailed information is available; i.e., at the time of a specific acquisition. This study does not address in-house costs, such as preparation of solicitations and contract administration.

Other factors must also be considered in any procurement strategy. These include differential wage rates and productivity on a second shift, rapid physical deterioration using two shifts (compared to the deterioration of two facilities using single shifts), the effect of competition on product quality and schedule, and the ultimate scrap value of the equipment. Some factors are not quantifiable, such as the need for a surge capability and the desire for geographic dispersal to reduce vulnerability to attack.

Since others have addressed these areas, this study does not. Instead it seeks to estimate the savings in unit price due to competition in a sequence of acquisitions.

It was necessary to make several assumptions in the analysis. These assumptions relate primarily to how the noncompetitive awards would have been made and to the expected rate of learning. The assumptions will be described as they are made throughout the report.

CHAPTER II

ESTIMATED SAVINGS METHODOLOGY

A. INTRODUCTION.

This chapter describes the types of acquisitions seen within the ammunition industry and the types of items purchased. It describes how the sample of acquisitions was selected and the kinds of data collected. It explains why the effects of competition must be estimated, rather than observed, and it develops a methodology to make this estimate.

B. POPULATION AND SAMPLE.

The target population is defined as all competitive acquisitions for ammunition items which are in the production phase of their life cycle and which are produced by private contractors in contractor-owned plants. An acquisition is considered competitive if any contractor can bid or if bids are restricted to members of the mobilization base. In some acquisitions the government announced that a winner-take-all award would be made, while in others the government stated in advance that at least some members of the mobilization base would receive awards (without specifying which members). Both approaches are competitive. Considered not competitive are options, which are part of the previous contract, and add-ons, in which the government modifies an existing contract to award an additional small quantity to a current producer.

The term "ammunition" includes bombs, fuzes, projectiles, cartridge cases, warheads, and other items. While the items vary, the acquisitions for these items are similar in several important ways. First, contractors for these systems operate within the same mobilization base environment as described above in Chapter I. Second, all items are in the production phase. They offer low technical risk, as evidenced by the use of fixed-price (firm-fixed-price or fixed-price with escalation) contracts. The risk in many acquisitions is even less, because the contractors have already produced millions of the item.

The main variable of interest in this study is the savings in unit price attributable to competition, after accounting for the effects of non-recurring cost, learning and inflation. This study seeks to quantify the savings due to the government's act of entering the marketplace, as opposed to, say, using add-on contract modifications with the current contractors. Other variables which could explain the main variable savings were also constructed. Examples include the relative size of the acquisition, the competitive pressure (measured in several ways), the number of the acquisition (first, second, etc.) and others. This chapter describes the calculation of the competitive savings variable and the next chapter gives details about the other explanatory variables.

The sample of twenty-two acquisitions was selected to reflect the diversity of the population. Six acquisitions were observed for bombs, four for fuzes, nine for projectiles, and three for cartridge cases. The acquisitions were also selected to illustrate long sequences of purchases for the same item in order to determine whether or not the benefits of competition diminish in later acquisitions.

The sample, like the population, shows some instances of winner-take-all competition and other cases where multiple awards were used. All acquisitions in the sample reflect production contracts. No research and development contracts were analyzed.

No attempt was made to select "successful" competition, i.e., contracts which result in savings; however, in each case government officials had concluded prior to the acquisition that competition was possible. Thus, any findings developed in this study apply only to situations in which competition is possible. As explained in the next chapter, many factors can preclude competition.

C. DATA COLLECTION.

For each system, contract files were searched for prices, quantities, modifications, and othe relevant information. Nonrecurring costs were identified and subtracted. To remove the effects of inflation all costs and prices were converted to constant FY 1978 dollars using inflation multipliers from ARRCOM as shown in Figure 2-1. In some cases data were collected from the Component Cost Record files and the Index Contract Control Card files in the Pricing Office at ARRCOM. For several systems the contract files had to be retrieved from the archives. Interviews were held with contract specialists to determine the contracting situation at the time of each solicitation. Minutes of the Awards Boards gave additional information about the competitive environment. In terms of completeness and accuracy, however, the quality of the resulting data must be called mixed; it ranges from only fair for some systems to good for others. While the data may not be as clean as desired, they are usually all the data available.

FIGURE 2-1

INFLATION MULTIPLIERS TO CONVERT

ORIGINAL YEAR DOLLARS TO FY 78 DOLLARS

FY	MULTIPLIER	FY	MULTIPLIER
60	2.60	70	1.94
61	2.49	71	1.79
62	2.44	72	1.69
63	2.40	73	1.63
64	2.31	74	1.53
65	2.26	75	1.33
66	2.31	76	1.22
67	2.26	7T	1.17
68	2.19	77	1.10
69	2.07	78	1.00

SOURCE: DRSAR-CP, DF dated 8 Sep 78, subject: Inflation Guidance.

D. CALCULATION OF ESTIMATED SAVINGS.

The ideal approach for estimating the effects of competition would be to find a competitively awarded contract and compare it with one that had been awarded without competition. To make the comparison valid, the two contracts should be as similar as possible. In practice, however, if the government's contracting situation were similar in both situations, then both would have been awarded the same way, and no comparison would be possible. For every competitive acquisition it becomes necessary to construct a hypothetical control or point of comparison, to reflect what would have happened if the requirement had been satisfied with no competition.

The literature shows a series of gradually more sophisticated attempts to construct this hypothetical control. Yuspeh in (18) takes as his experimental control the unit price for the most recent sole-source contract. He compares this sole-source price with the price observed after a competitive award and attributes the drop to competition. This approach, however, fails to consider the progress of the sole-source producer along his experience curve and thereby overstates the benefits of competition. Figure 2-2 shows Yuspeh's methodology and Figure 2-3 shows the required adjustment. Yuspeh only considers acquisitions in which a sole-source award is followed by a competitive award.

FIGURE 2-2

YUSPEH'S ESTIMATE FOR COMPETITIVE SAVINGS

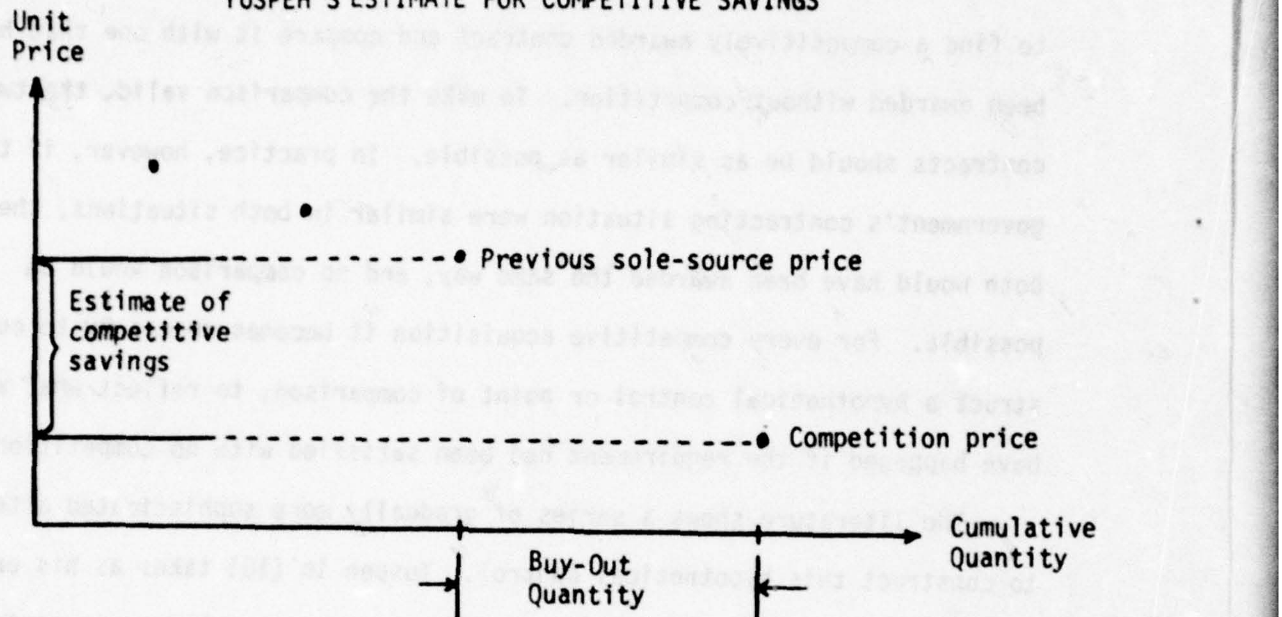
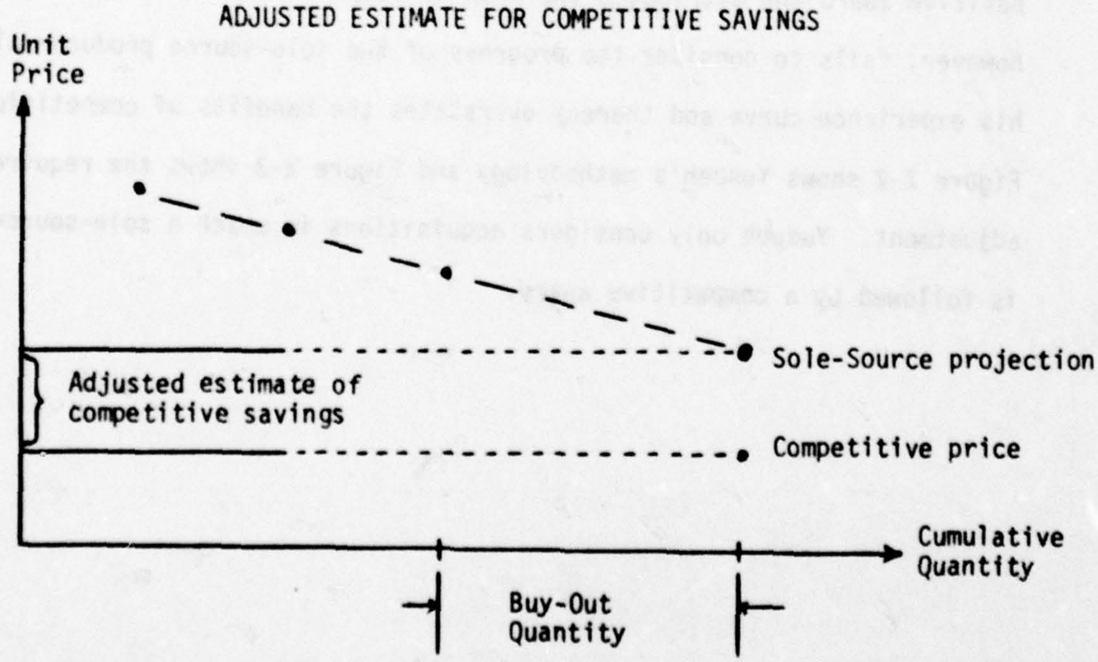


FIGURE 2-3

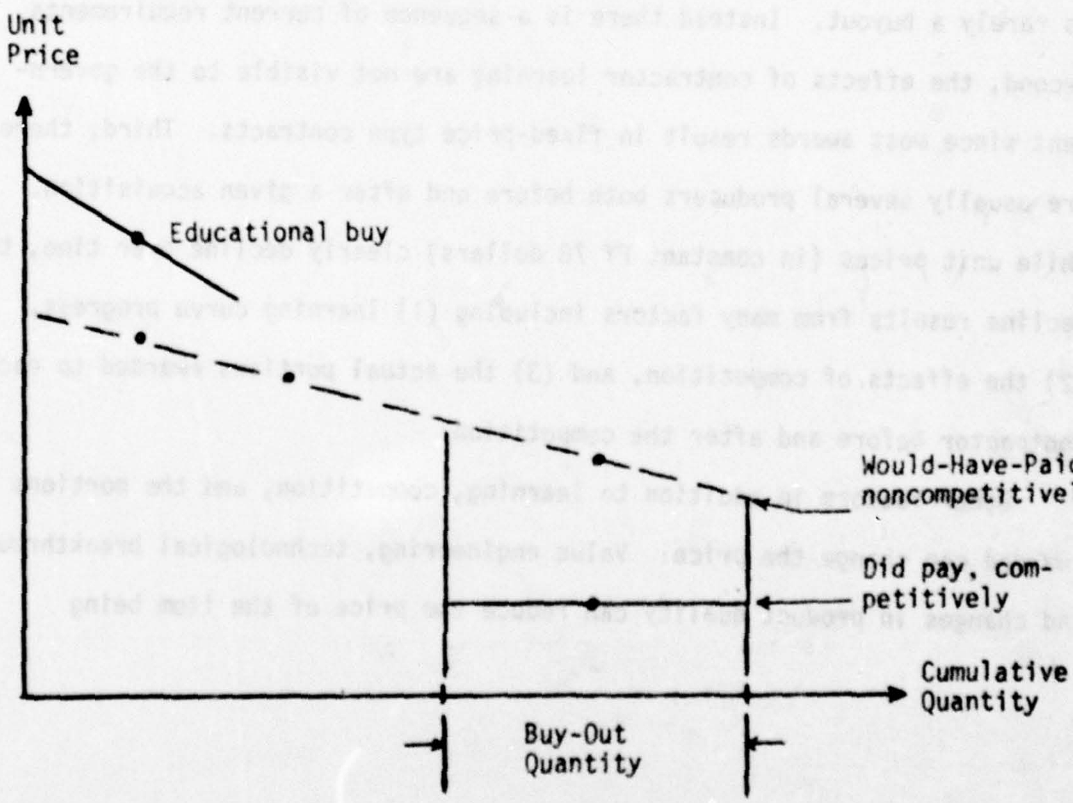
ADJUSTED ESTIMATE FOR COMPETITIVE SAVINGS



Lovett and Norton in (11) develop an improved methodology which takes into account the expected progress of the first producer along his experience curve. Figure 2-4 illustrates the basic methodology. The dotted line reflects what would have happened had there been no competitive pressure--the contractor simply would continue along his experience curve for the quantity of the buyout. The dotted line in this case serves as the experimental control. The actual contract price is shown as a solid line for the same quantity. In figure 2-4 the solid line is shown as horizontal because contracts for the buy-out quantity are usually awarded as fixed-price contracts, and no experience slope is visible to the government. The area between the dotted line (would-have-paid) and the solid line (did pay) is attributed to competition.

FIGURE 2-4

LOVETT-NORTON ESTIMATE FOR COMPETITIVE SAVINGS



In some of the acquisitions studied by Lovett and Norton, the government created a competitive situation by awarding a small quantity to a producer other than the original developer. This small award allowed the second contractor to learn how to produce the item and is called an "educational buy." Once two producers exist a competitive buyout can be held.

Educational buys do not occur for ammunition items, but it may be worthwhile to state Lovett and Norton's findings. They found an average reduction in unit price of 13.7 percent due to competition and a net reduction (considering the one-time costs) of 10.8 percent. Each of their 16 acquisitions consisted of a sole-source award followed by a buyout; that is, the low offeror received a contract to produce the total quantity required.

Several extensions to the Lovett and Norton approach are necessary to address repetitive competition and the use of multiple awards. First, there is rarely a buyout. Instead there is a sequence of current requirements. Second, the effects of contractor learning are not visible to the government since most awards result in fixed-price type contracts. Third, there are usually several producers both before and after a given acquisition. While unit prices (in constant FY 78 dollars) clearly decline over time, this decline results from many factors including (1) learning curve progress, (2) the effects of competition, and (3) the actual portions awarded to each contractor before and after the competition.

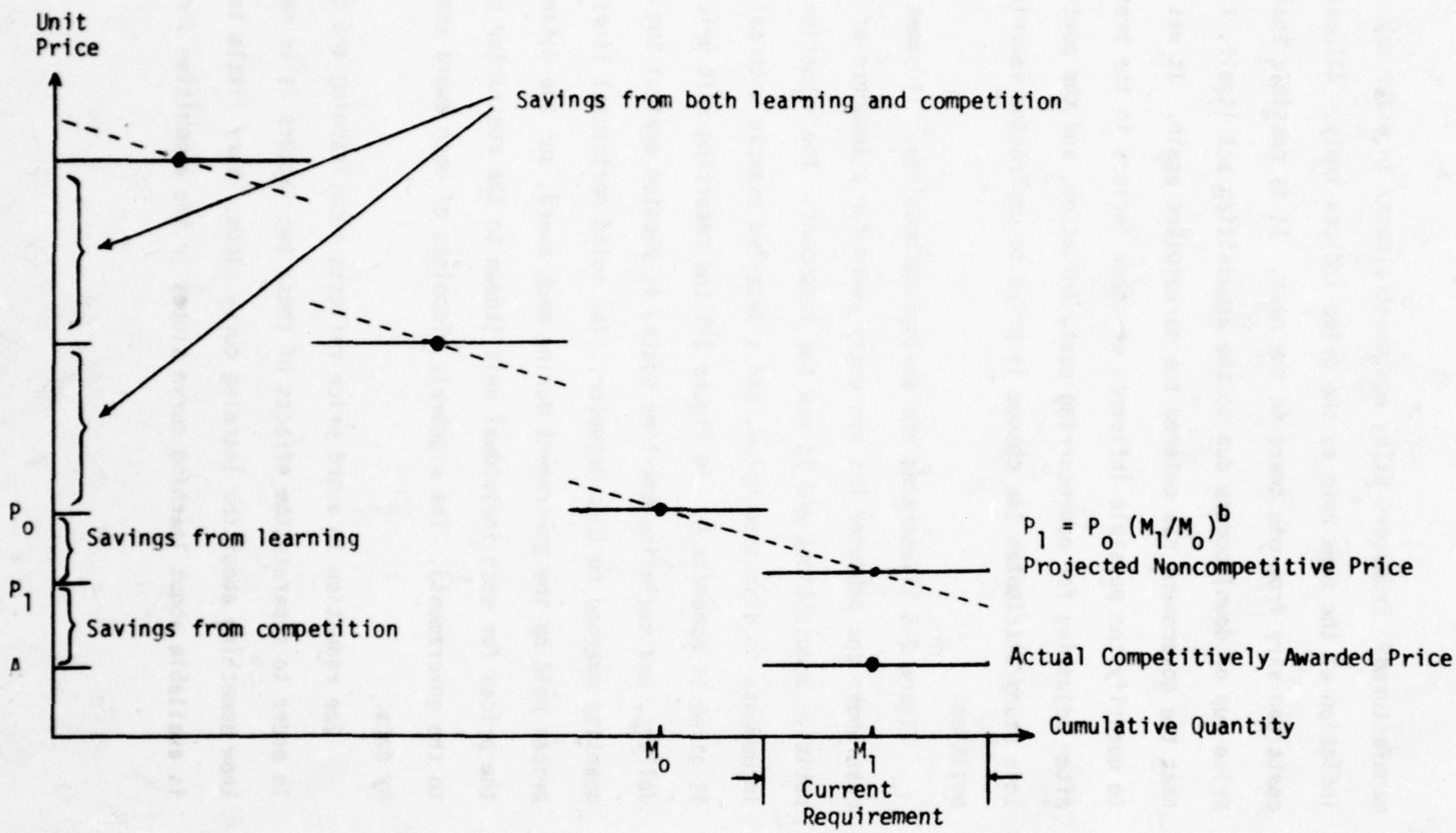
Other factors in addition to learning, competition, and the portions awarded can change the price. Value engineering, technological breakthroughs and changes in product quality can reduce the price of the item being manufactured. Producers using equipment already in place may not experience inflation at the same rate as the price indices imply. Allocation of fixed costs can vary from one award to the next. It is possible that a change in price (up or down) occurs due to the acquisition act itself, i.e., the fact that the government has entered the marketplace again. It was not possible to quantify the possible influence of these factors in the present study. After adjusting for nonrecurring cost, inflation, and the portion awarded, this study attributes the change in price to contractor learning and competition.

Figure 2-5 illustrates the savings methodology. It shows the special case where one producer has won every award for a sequence of three competitive acquisitions and is now the incumbent. The situation of several incumbents is discussed below, and a detailed example with calculations is given at Appendix A. In Figure 2-5 the recurring unit price (in FY 78 dollars, and excluding one-time costs) is plotted against the cumulative quantity awarded to this producer. The solid horizontal lines show the unit prices paid by the government during each award, and the dotted lines show the prices for each individual unit (known to the contractor but not known to the government). The algebraic midpoints of each award are indicated by dots.

The reduction in award price reflects both learning and competition. In order to separate the effects of these two factors it is necessary to know something about the learning curve slope. Very little information is available about learning curve slopes in the ammunition industry, possibly

FIGURE 2-5

ESTIMATED SAVINGS METHODOLOGY



because of the extensive use of fixed-price contracts in which contractor learning is not reported. Government contracting personnel reported that there is very little learning due to the highly automated production techniques and the large quantities involved. Cost analysis personnel have data (7) indicating that slopes range between 90 percent and 95 percent (cases 94.3 percent, projectiles 92.6 percent and fuzes 91.1 percent).

The steeper 90 percent slope attributes a greater portion of the price reduction to the effects of learning. This minimizes the portion of the reduction attributed to competition. The flatter 95 percent slope attributes less of the drop to learning and more to competition. A 100 percent slope would imply no learning at all. In this case the entire drop would be attributed to competition. Several reasons suggest the use of a 95 percent slope in the calculations below. First, the rates reported in (7) reflect actual market conditions; so at least some competitive pressure is reflected. Learning curves are used in this study, however, to calculate what the contractor would do if there were no competitive pressures at all. After several procurements, and after producing several million units, a contractor in a sole-source situation might well tell the government that there was no more learning (i.e., the slope is a flat 100 percent). The government, having always used fixed-price contracts, would be in a poor position to contradict the contractor, but would still insist on some compromise during negotiations. The two parties might agree to calculate costs using a fairly flat rate. The second reason for using the 95 percent slope is that several government personnel stated that the slope becomes flat after several acquisitions. If this is true, then the use of the 95 percent slope will give conservative results; i.e., the competitive savings are really greater than stated. In view of the uncertainty about the slope all calculations are made using the three slopes 90 percent, 95 percent and 100 percent.

Figure 2-5 shows how to calculate the effects of competition for an acquisition in which the single incumbent contractor wins the award. The existence of several incumbents, all candidates to receive a portion of the total award quantity, and the practice of multiple awards make further adjustments necessary.

Multiple awards are often used for noneconomic reasons--to avoid dependence on a single producer who might be vulnerable in time of war, to provide a surge capability in case of urgent requirements, to encourage small or minority businesses, and because of the limited production capacities of potential producers. Multiple awards also make it possible to have competition in future acquisitions.

To calculate a projected price for what the government would have paid using multiple noncompetitive add-ons, it is necessary to make some assumptions about how the total new requirement would be split among the incumbents. The assumption usually made in this study is that the awards would be split into the same proportions as are observed in the previous awards. Each incumbent is operating at a different point on his learning curve, so a projected price is calculated for each contractor, based on his assumed portion. The results are combined to give a *composite* projected price for the total acquisition. This projected price reflects the learning achieved by each contractor and estimates what the government would have paid using noncompetitive add-ons. The difference between the projected noncompetitive price and the actual competitive price is attributed to competition.

A numerical example of the calculations described here is given in Appendix A, which also records the detailed system descriptions, the contractor names and contract numbers for each acquisition, and other necessary data. The projected prices, the award prices, the competitive savings, and other variables are recorded in Chapter III where they are used in the forecasted savings methodology.

CHAPTER III

FORECASTED SAVINGS METHODOLOGY

A. INTRODUCTION.

No model can address the entire decision process. In particular, no model based on historical data can predict the facilitization and other one-time costs of a future acquisition, because these costs vary so greatly. For example, as part of the first award for some item the government may have to furnish an entire production line to a contractor. This will be very expensive. In a later acquisition for this same item the line may be in a layaway status, and the one-time costs to activate it will be very low. The present research emphasizes estimating the savings in recurring unit price, leaving the estimate of any one-time costs to be made later by the government analyst who will have a more specific situation together with a list of required facilities for that situation. A tradeoff analysis comparing the one-time costs against the recurring savings in unit price due to competition will then be possible. Section C gives procedures for estimating the savings in unit price, Section D gives a model for estimating the competitive award price, and Section E shows how to make the necessary tradeoff analysis. But first it is necessary to review some of the non-quantifiable considerations that must be addressed in any acquisition.

B. QUALITATIVE CONSIDERATIONS.

Competitive acquisition of military systems is often difficult, if not impossible to achieve. Experience with ammunition items shows that when producers leave the production base, for example, after losing a winner-take-all award, they usually choose not to bid for later awards. These later acquisitions will then have to be awarded noncompetitively. It is sometimes very difficult to find two responsible companies that are able and willing to produce successfully a given item within the constraints of schedule, quality and cost.

Lovett and Norton in (11) develop a list of factors which can influence the competitive environment and offer some techniques to overcome a noncompetitive situation. Figure 3-1 lists these factors, called a "competition screen," since they serve to screen out many situations in which competition is not feasible. Further details relating to the competition screen are given in Lovett and Norton.

FIGURE 3-1

Factors Influencing Competition

1. Prohibitively high initial start-up costs.
2. Lack of a definitive technical data package or a "soft" technical data package.
3. Proprietary data-technology transfer.
4. Congressional interests-budget constraints.
5. Inadequate production quantities.
6. Economic climate.
7. Length of planned production cycle.
8. Critical or scarce materials.
9. Non-conformance to cost accounting standards.
10. Special tooling, test equipment, and unique facilities required.
11. Testing requirements.
12. Government or industry cash flow problems.

Lovett and Norton suggest several approaches to overcome these factors, including government funding of start-up costs, improving the Technical Data Package (TDP), adjusting the delivery schedule in view of producer's plant capacities, using Government Furnished Equipment (GFE) or Government Furnished Materiel (GFM), waiving the requirement to conform to government Cost Accounting Standards, using government technical assistance, providing for progress payments or other financing, using leader-follower acquisitions, and using multi-year awards. The last approach allows participation by companies not able to compete for smaller quantities and is especially valuable when high start-up or facilities costs are involved.

C. FORECASTING THE SAVINGS.

If the system passes the competition screen, or can be made to pass at a reasonable cost, a forecast of the expected savings is needed. This section presents a methodology for making this forecast.

For each of the 22 observations shown in Figure 3-2 the projected price is calculated as described in Chapter II, assuming the use of a noncompetitive award. Figure 3-2 also shows the competitive award price actually achieved. In addition to the above variables, the logarithms of the variables (to the base 10) were also analyzed. The variables SAV90, SAV95, and SAV100 sometimes take negative values, so it is not possible to calculate logarithms for these variables. The definition for each variable is given in Figure 3-3.

FIGURE 3-2(a)

FORECASTED SAVINGS DATA BASE[1]

AMMUNITION ITEM	OBS	NAWD	PROJ90	PROJ95	PROJ100
Bomb, 750 Pound,					
M117	1	1	291.5884	327.3058	365.2288
	2	2	280.9058	287.7090	293.3363
	3	3	241.6833	243.8389	245.9028
	4	4	192.7950	194.1893	195.5216
	5	5	162.3785	163.1251	163.8369
	6	6	151.5261	152.6199	153.6649
Fuze, M223	7	1	.5589	.5866	.6143
	8	2	.4744	.4977	.5210
	9	3	.4820	.5489	.6225
	10	4	.4204	.4402	.4599
Projectile,	11	1	26.5931	27.8086	29.0297
105mm, M489	12	2	30.8433	31.3410	31.8207
	13	3	28.0581	28.7706	29.4830
	14	4	27.2164	27.4355	27.6450
	15	5	22.3795	23.3025	24.2119
	16	6	22.7935	23.2465	23.6904
	17	7	42.4075	44.4542	46.5074
	18	8	42.8253	43.8589	44.8678
	19	9	39.9361	40.2715	40.5922
Case, Ctg, M103,	20	1	.4792	.4968	.5141
Brass	21	2	.4259	.4407	.4555
	22	3	.6045	.6072	.6098

1) See Figure 3-3 for definitions of variables

FIGURE 3-2 (B)

FORECASTED SAVINGS DATA BASE (Continued)

OBS	NBEF	NAFT	SIZE	SIZRAT	PRESS
1	3	3	435,020	1.3534	1.000
2	3	3	333,600	1.0378	1.000
3	3	3	316,000	.9831	1.000
4	3	2	200,000	.6222	1.500
5	2	2	204,000	.6346	1.000
6	2	2	440,000	1.3688	1.000
7	1	1	5,919,050	.1263	1.000
8	1	6	20,000,000	.4268	0.167
9	6	6	154,292,000	3.2924	1.000
10	6	3	7,240,000	.1545	2.000
11	3	1	121,260	.6152	3.000
12	1	2	349,400	1.7726	0.500
13	2	1	237,960	1.2072	2.000
14	1	3	424,026	2.1512	0.333
15	3	1	84,100	.4266	3.000
16	2	1	92,267	.4681	2.000
17	3	1	249,611	1.2663	3.000
18	2	1	100,000	.5073	2.000
19	2	1	115,412	.5855	2.000
20	1	2	30,866,000	1.4885	0.500
21	2	1	20,888,812	1.0074	2.000
22	1	2	10,454,265	.5042	0.500

FIGURE 3-2(c)

FORECASTED SAVINGS DATA BASE (Continued)

OBS	AWARD	SAV90	SAV95	SAV100
1	308.7985	-0.05902	0.05654	0.15451
2	252.7024	0.10040	0.12167	0.13851
3	223.0254	0.07720	0.08536	0.09303
4	167.6975	0.13018	0.13642	0.14231
5	157.8866	0.02766	0.03211	0.03632
6	129.8857	0.14288	0.14896	0.15475
7	.5210	0.06781	0.11183	0.15188
8	.6225	-0.31218	-0.25075	-0.19482
9	.4523	0.06162	0.17599	0.27341
10	.4153	0.01213	0.05657	0.09698
11	33.0330	-0.24216	-0.18787	-0.13790
12	29.4830	0.04410	0.05928	0.07346
13	27.2570	0.02855	0.05261	0.07550
14	23.9825	0.11882	0.12586	0.13248
15	22.5953	-0.00965	0.03035	0.06677
16	20.6550	0.09382	0.11148	0.12813
17	41.1872	0.02878	0.07349	0.11439
18	40.4910	0.05444	0.07662	0.09755
19	35.9200	0.10056	0.10805	0.11510
20	.4555	0.04946	0.08313	0.11399
21	.4210	0.01151	0.04470	0.07574
22	.4250	0.29694	0.30007	0.30305

FIGURE 3-3

VARIABLES AND DEFINITIONS

VARIABLE	DEFINITION
OBS	Observation number.
NAWD	Number of acquisitions observed for this item, including the present one.
PROJ90	Projected price (composite) for this acquisition, assuming the use of noncompetitive awards and a 90 percent slope.[1]
PROJ95	Projected price (composite) for this acquisition, assuming the use of noncompetitive awards and a 95 percent slope.[1]
PROJ100	Projected price (composite) for this acquisition assuming the use of noncompetitive awards and a 100 percent slope (no learning).[1]
NBEF	Number of incumbent contractors before this acquisition.
NAFT	Number of contractors after awards are made.
SIZE	Total quantity awarded in this acquisition.
SIZRAT	Total quantity awarded in this acquisition expressed as a ratio to the average quantity awarded in this sample.
PRESS	Pressure to reduce the number of contractors and equal to NBEF divided by NAFT.
AWARD	Awarded price (composite) for this acquisition.[1]
SAV90	Competitive savings assuming a 90 percent slope for contractor learning. SAV90 = (PROJ90 - AWARD)/PROJ90
SAV95	Competitive savings assuming a 95 percent slope for contractor learning. SAV95 = (PROJ95 - AWARD)/PROJ95
SAV100	Competitive savings assuming a 100 percent slope; i.e., no contractor learning. SAV100 = (PROJ100 - AWARD)/PROJ100

[1]In the case of multiple awards, the word "composite" means that each producer is analyzed individually, and then the results are aggregated to form a composite total, as explained in Chapter II and illustrated in Appendix A.

Figure 3-2(c) shows the effect of competition on unit price. After excluding nonrecurring cost and inflation, and assuming a learning curve slope of 95 percent, the average savings in unit price (compared to the projected price) is 7.1 percent. The results vary from a savings of 30.0 percent in observation 22 to a loss of -25.1 percent in observation 8. The two losses, observations 8 and 11, occurred when the incumbent contractors raised their prices after experiencing difficulty producing the items at the previously awarded price. Details for these and other acquisitions are at Appendix A.

Figure 3-2(c) presents the estimated savings based on three possible slopes. The use of a 95 percent slope, as discussed in Chapter II, implies an average savings of 7.1 percent. A 90 percent slope seems to be too low, based on the data in (7). It is definitely too low for some of the later acquisitions in which, according to mány, there is no further contractor learning. Use of a 90 percent slope implies an average savings of 3.7 percent. A 100 percent slope may be correct, at least for some of the later acquisitions, and implies an average savings of 10.0 percent. The true average savings probably lies between 7.1 percent and 10.0 percent. A conservative rule of thumb would be to estimate competitive savings at 7.1 percent.

Several multiple regression models were considered in order to explain the variation in savings. The criteria used in selecting the best explanatory (independent) variables were that the variables must:

a. have high correlation with savings, the variable to be estimated,

b. have low correlation with other independent variables,

c. be determinable at the time of the acquisition, and not have illogical values or signs for their coefficients.

Figure 3-4 gives the independent variables analyzed and the correlation coefficient (R) between each independent variable and the variables to be explained. These independent variables are not statistically strong enough to allow construction of a multiple regression model. Perhaps other variables or a larger sample size will permit construction of a model which can explain the variation in savings among different acquisitions. With the present data base the best predictor of competitive savings is simply the average savings observed, or 7.1 percent.

The fact that NAWD is not correlated with savings, may be however, an important finding. There are several a priori reasons to suspect that the effects of competition diminish after repetitive acquisitions for the same item. The first argument is that as time goes by, the award prices and number of awards become increasingly predictable to all potential contractors. Thus, a very efficient producer; i.e., one able to produce at an unusually low cost, would have little or no pressure to offer the government a correspondingly low price. The second argument is based on considerations of marginal cost. After the first few acquisitions, all producers

FIGURE 3-4

CORRELATION COEFFICIENTS (R)

	SAV95[1)]	AWARD	LAWARD
NAWD	.242	-.106	.311
PROJ95	.115	.998	.757
NBEF	.055	.137	-.022
NAFT	-.162	.109	-.247
SIZE	.159	-.261	-.485
SIZRAT	.258	.026	-.004
PRESS	-.204	-.166	.174
LNAWD	.301	-.102	.288
LPROJ95	.049	.761	.999
LNBEF	.019	.302	.219
LNAFT	-.037	.270	-.131
LSIZE	.072	.386	-.852
LSIZRAT	.182	.216	.267
LPRESS	.042	.009	.261

1) None are significant at the 95 percent level of confidence.

should be at or near their lowest price (perhaps at their marginal cost plus a minimum profit). According to this reasoning, the only future reduction in price to the government would be due to contractor learning.

If either of the above arguments were true, then the coefficient of NAWD, the number of the current acquisition, would be negative. Since the coefficient is not negative, the competitive savings do not diminish for later acquisitions. Figure 3-2 also illustrates this finding. The two largest savings were for the third fuze acquisition (17.6 percent) and the last cartridge case acquisition (30.0 percent). Since the achieved savings varies so widely and the sample size is only 22, the conclusion about repetitive savings must be regarded as tentative.

D. FORECASTING THE AWARD PRICE.

The criteria above were also used in developing models to forecast the competitive award price. Two different model forms giving similar results are presented. The variable PROJ95 and its logarithm form LPROJ95 are the only ones strong enough to be used in the models, which are:

Model 1

$$AWARD = .908 * PROJ95$$

$$R^2 = .997$$

Model 2

$$AWARD = 0.9243 * PROJ95^{0.99966}$$

$$R^2 = .998$$

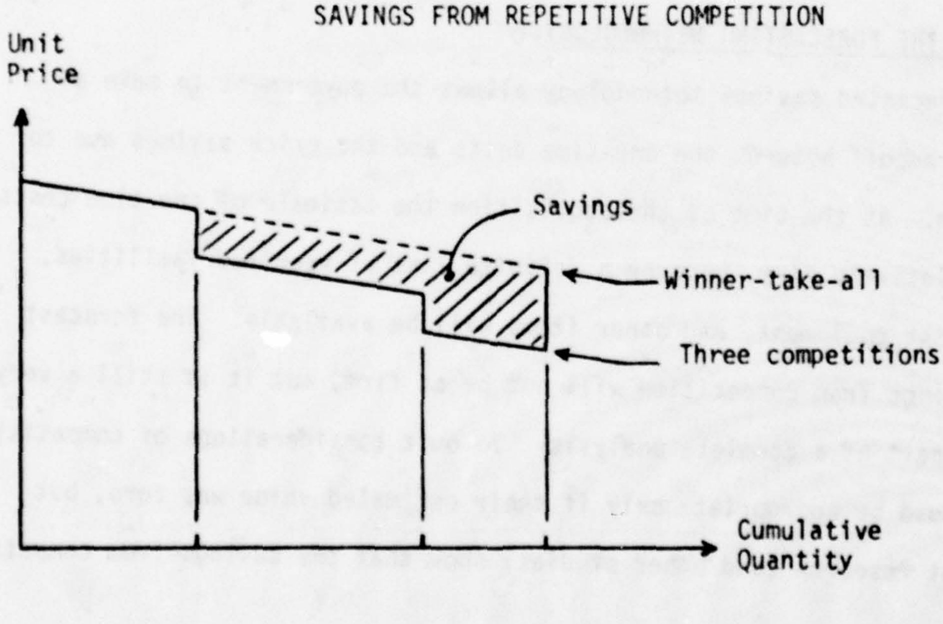
The two models appear to be very strong in terms of their coefficients of determination (R^2), however, this is mainly due to the high correlation between the projected price (assuming learning) and the award price (based on learning and competition). The regression models give more weight to the expensive items in the data base, since their residuals are larger. The average of all observed savings (7.1 percent) gives equal weight to all 22 observations and is recommended for use in making a tradeoff analysis.

E. USE OF THE FORECASTING METHODOLOGY.

The forecasted savings methodology allows the government to make an economic tradeoff between the one-time costs and the price savings due to competition. At the time of the acquisition the estimate of one-time costs will be relatively firm, because a definite list of required facilities, tooling, test equipment, and other items will be available. The forecast of the savings from competition will not be as firm, but it is still a very necessary part of a complete analysis. To omit considerations of competitive savings would be appropriate only if their estimated value was zero, but the present research (and other studies) show that the savings from competition are significant. As in any tradeoff analysis involving time, all price data must be expressed in terms of a common base year. Since the one-time costs occur early and the recurring savings occur later over a period of many years, it is reasonable to use discounting. This section describes the procedure to use for a single acquisition. In order to consider repetitive acquisitions, a scenario must be developed describing the proposed number of facilities, their costs, and the number of acquisitions. Figure 3-5 illustrates how the cumulative savings would be calculated. Details of the forecasted savings methodology for one acquisition follow.

FIGURE 3-5

SAVINGS FROM REPETITIVE COMPETITION



STEP 1. Obtain the input data necessary to use the forecasting methodology.

a. Obtain the total quantity required for DOD and Foreign Military Sales.

b. Obtain the best estimate of each present producer's learning curve slope, the cumulative quantity produced, and a price for a recent production lot (or alternatively a recent year). All prices should be adjusted to reflect only recurring unit costs plus profit. Nonrecurring or start-up costs should be excluded from this part of the analysis.

STEP 2. Construct the projected price for a noncompetitive acquisition.

a. Divide the total quantity required into portions for each noncompetitive award, considering plant capacities and recent awards. Several alternative breakouts will be possible, depending on the number of facilities which are available or which can be made available at a cost. Each alternative breakout should be analyzed separately.

b. Calculate algebraic lot mid-points for each proposed producer. Mid-points are required for the producer's last production lot (or year) and for his proposed award.

c. Calculate the projected unit price for each noncompetitive award using the formula:

$$P_1 = P_o * (M_1/M_o)**b$$

where,

P_1 = The projected unit price for the noncompetitive award.

P_o = The unit price for the last production lot (or year).

M_1 = The algebraic lot mid-point for the proposed noncompetitive award.

M_o = The algebraic lot mid-point for the last production lot (or year).

b = The natural logarithm of the learning curve slope divided by the natural logarithm of 2.

d. Calculate the total recurring price for each producer and add the results to give a total price for the entire procurement (not including one-time costs).

STEP 3. Forecast the total savings from competition.

a. Take 7.1 percent of the projected unit price times the quantity required for this acquisition.

b. Identify any opportunities for cost avoidance -- lengthy and expensive negotiations, Should-Cost studies, detailed audits of producer's records, avoidance of justification required for noncompetitive procurements.

c. Add the savings in recurring unit price (Step 3a) to any savings from cost avoidance (Step 3b) to give the total savings from competition.

STEP 4. Forecast the total costs of competition.

a. Identify facilitization costs, additional tooling costs and other materiel-related costs.

b. Identify any additional costs due to program stretch out, premiums due to underutilization of facilities or uneconomic production rates.

c. The sum of Steps 4a and 4b is the forecasted cost of competition.

STEP 5. Forecast the net effect of competition.

a. Subtract the one-time cost in Step 4c from the competitive savings in Step 3c. The result is the net savings.

b. Compute the expected savings percentage by dividing the savings in Step 5a by the total projected price in Step 2d.

CHAPTER IV

FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

A. FINDINGS.

Competition tends to reduce unit price, even when the use of multiple awards is announced to the bidders in advance. In the 22 acquisitions analyzed the average competitive savings achieved after accounting for nonrecurring costs, inflation, and contractor learning was 7.1 percent, assuming a 95 percent slope for learning. The exact amount of contractor learning is difficult to determine for ammunition items because of the extensive use of fixed-price contracts which do not record the learning. The use of a 90 percent slope implies an average competitive savings of 3.7 percent, and the use of a 100 percent slope (i.e., no contractor learning) implies an average savings of 10.0 percent.

The competitive savings achieved in later acquisitions seems to be approximately the same as the savings achieved in the first few acquisitions for the same item. The present data do not show whether this repeated savings is due to continued improvements in contractor efficiency, a decline in product quality, or the economic effects of competition. Although the 22 acquisitions in this study show repeated savings, this finding should be considered tentative.

It is possible that increased award quantities and increased competitive pressure will result in greater savings, but the present data do not allow this question to be answered definitively. A larger sample, better learning curve data, and perhaps other explanatory variables should be developed.

B. CONCLUSIONS.

The estimated savings methodology developed in this report can be used to estimate the savings attributable to competition in a historical acquisition. Some assumptions have to be made about how a noncompetitive award would have been made, but this is not an insurmountable problem.

The forecasted savings methodology developed can be used to predict the competitive savings for a future acquisition. A useful rule of thumb is that the competition reduces the unit price by 7.1 percent.

The costs of facilities, tooling, test equipment and other one-time costs are best estimated by using specific information available at the time of the acquisition. Then a tradeoff analysis can be made comparing the forecasted competitive savings in unit price to the costs. A section of this report gives step-by-step instructions for performing this analysis.

Factors other than economic ones can be very important in determing the optimum number of producers. Specifically, the need for a surge capability and the desire to avoid dependence on a single contractor should be considered.

C. RECOMMENDATIONS.

It is recommended:

1. that future proposals for alternative combinations of facilities

include an estimate for the effects of competition;

2. that a rule of thumb of 7.1 percent be used as the estimate for competitive savings in unit price, when multiple awards are planned;

3. that qualitative considerations, as discussed in this report, be considered before deciding whether or not to compete or to use multiple awards;

4. that when repetitive competition is planned, the cumulative savings be estimated and presented to decision makers;

5. that further research be done to identify variables that can better predict competitive savings.

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APPENDIX A

ANALYSIS OF INDIVIDUAL ACQUISITIONS

1. BOMB, 750 POUND, M117.

The 750 pound general purpose bomb, M117 series, is designed to produce maximum blast, fragmentation and deep mining effect. It was used extensively in the Southeast Asia conflict. From 1965 to 1972 three producers, A. O. Smith, Letourneau, and A.M.F. manufactured 5,260,995 bombs for a total cost of $1,170,674,052 (FY 1978 dollars). A total of six acquisitions were analyzed, as recorded below in Figure A-2.

In the late 1950s the bomb metal parts production capabilities had been greatly reduced. In the mid 1960s the increased requirements resulting from the Southeast Asia conflict made it necessary to increase the production capability. The three contractors named above responded to a solicitation and were awarded facility contracts to establish bomb metal parts lines at Waco, Texas (A. O. Smith), Longview, Texas (Letourneau), and Long Island, New York (A.M.F.).

From 1965 to 1969 range bidding techniques were used with these contractors. The contract unit price was negotiated, with the low bidder receiving the larger quantity. The option clause often was used to respond to frequently changing requirements and also to provide continuity in the production lines.

There was no danger to the contractors of failing to receive an award during this period, yet the quantity awarded depended on the offered price. The three procurements of this period, then, illustrate the effects of a multiple award type of competition rather than winner-take-all type.

Figure A-1 illustrates the calculations used to estimate the effects of competition on unit price. The calculations are made as follows.

STEP 1. For each candidate for a noncompetitive add-on or sole-source award collect data for the most recent production lot (or alternatively, the most recent year). Adjust the unit price to exclude any nonrecurring cost and express the result in constant dollars of a selected base year (FY 1978 was used for this data). Calculate an algebraic lot midpoint for this lot (or year). If the cumulative quantity is very large, the arithmetic midpoint is a close approximation to the algebraic midpoint.

STEP 2. Make an assumption about how any new requirement would have been broken out to the candidate producers. This breakout must be consistent with plant capacities and with the way the government has made awards in the past. In the case of the 750 pound bomb, the government did not award the total requirement to the lowest offeror, but rather awarded an approximately equal share to each member of the production base. In Figure A-1 the assumed breakout for a noncompetitive award is one-third to each candidate. The assumption usually made in this study is that a noncompetitive breakout would have been made according to the proportions observed for the currently producing contractors.

FIGURE A-1

ESTIMATED SAVINGS METHODOLOGY[1)]

	A.O. SMITH	A.M.F.	LETOURNEAU	COMPOSITE
First Unit	1	1	1	
Last Unit	59,000	64,721	59,000	
Midpoint (M_o)	29,500	32,361	29,500	
Unit Price, P_o	405.6700	287.7432	402.5060	
Assumed Breakout for Noncompetitive Procurement	.333	.334	.333	
Total Requirement				435,020
Award Quantity	145,006	145,007	145,007	435,020
Midpoint (M_1)	131,503	137,224	131,504	
Projected Noncompetitive Unit Price, P_1 2)	363.1938	258.5692	360.3609	327.3058
Actual Competitive Unit Price	286.4400	337.2600	302.6100	
Actual Breakout for Competitive Procurement	.333	.334	.333	
Actual Award Price for Total 3)				308.7985
Percent Savings in unit price				5.65%

1) All prices are in FY 1978 dollars. Prices exclude nonrecurring costs.

2) $P_1 = P_o * (M_1/M_o)**b$

3) A composite price based on the quantities actually awarded and the prices.

STEP 3. Divide the total quantity required for this acquisition into quantities to be awarded to each producer, using the proportions from Step 2. Calculate lot midpoints for the new awards.

STEP 4. Calculate a projected noncompetitive unit price for each contractor using the formula,

$$P_1 = P_o *(M_1/M_o)**b$$

where,

P_1 = The projected unit price for the noncompetitive award.

P_o = The unit price for the last production lot (or year).

M_1 = The lot midpoint for the proposed noncompetitive award.

M_o = The lot midpoint for the last production lot (or year).

b = The natural logarithm of the learning curve slope divided by the natural logarithm of 2.

STEP 5. Calculate a composite unit price for the total acquisition by forming a weighted average of the projected prices for each producer. Use as weights the proportions from Step 2.

STEP 6. Record the actual unit prices paid, adjusted to exclude any nonrecurring costs, and expressed in constant dollars of the selected base year. Often a different set of contractors wins the competitive awards, or the proportions are different. Record the actual winning contractors and the proportion of the total award each one actually receives.

STEP 7. Calculate a composite unit price for the total acquisition by using a weighted average of the actual award prices for each winning producer. Use as weights the actual proportions awarded. In Figure A-1 the actual award was split into three equal portions.

STEP 8. Calculate the savings in recurring unit price using the formula,

$$S = (P - A)/P$$

where,

- S = The savings in recurring unit price attributable to competition, expressed as a fraction.
- P = The projected unit price (composite) for a noncompetitive acquisition.
- A = The actual unit price (composite) observed for the competitive acquisition.

The first competitive acquisition of the 750 pound bomb achieved a savings of 5.6 percent. This represents the difference in unit price between a projected noncompetitive price and an actually observed competitive price. The effects of nonrecurring costs and inflation have been removed.

For the first few acquisitions the estimate of savings is very sensitive to the assumption about the learning curve slope. For the present procurement, an assumed slope of 95 percent implies an estimated savings of 5.6 percent, while an assumed slope of 90 percent implies an estimated loss of -5.9 percent. All procurements were analyzed using slopes of 90 percent, 95 percent, and 100 percent (see Figure 3-2(c) in Chapter III). For later acquisitions the estimate of savings is much less sensitive to the assumption about the slope.

For the remainder of the acquisitions analyzed in this study the calculations were made as stated above, and the results are recorded in Figure 3-2(c). The only additional detail that will be recorded here is the list of contractors considered candidates for a noncompetitive award (the incumbents), their current contract numbers, and the assumption made about how a noncompetitive award would have been made. For the acquisitions for the 750 pound bomb the information is in Figure A-2. Sometimes more than one award is made under the same contract number. To identify which award is meant, a number in parentheses appears after the contractor's name in Figure A-2. In Figure A-2 the portions are based on the portions in effect for the previous acquisitions.

In 1970 the requirement for 750 pound bombs declined, and a competition was held to determine which producer would be put into a layaway, or inactive status. A. O. Smith lost this competition. A.M.F. and Letourneau had previously been the high cost producers, charging $215.28 and $193.44 respectively (FY 78 dollars). Assuming a 95 percent slope they would have charged $214.18 and $192.17, respectively, for a noncompetitive award.

FIGURE A-2

ACQUISITIONS FOR THE 750 POUND BOMB

OBSERVATION	CONTRACTOR	CONTRACT NUMBER	PORTION
1	A. O. Smith	AMC-482(A)	.333
	A.M.F.	AMC-509(A)	.334
	Letourneau	AMC-476(A)	.333
2	A. O. Smith (4)	AMC-857(A)	.333
	A.M.F. (3)	AMC-877(A)	.334
	Letourneau (2)	AMC-854(A)	.333
3	A. O. Smith (4)	68-C-0078	.357
	A.M.F. (3)	68-C-0161	.292
	Letourneau (3)	68-C-0030	.351
4	A. O. Smith	69-C-0398	.563
	A.M.F. (3)	69-C-0035	.234
	Letourneau (3)	69-C-0044	.203
5	A.M.F. (2)	70-C-0279	.400
	Letourneau	70-C-0411	.600
6	A.M.F. (2)	71-C-0011	.353
	Letourneau	71-C-0368	.647

The actual prices offered were $167.67 and $167.71. That part of the drop not due to learning is attributed to the intense competition. Observation four refers to this acquisition.

In 1971 both A.M.F. and Letourneau were awarded contracts. Letourneau as the low bidder received the larger award. Resumption of intensive bombing in 1972 resulted in an increased requirement for the M117 bomb. The government decided to reactivate the A. O. Smith facility, which had been laid away, but A. O. Smith declined to operate the plant, and so Letourneau operated this Waco, Texas plant in addition to its Longview, Texas plant. These acquisitions are observations five and six in Figure A-2.

2. FUZE, M223.

The M223 General Purpose Grenade Fuze is a mechanical time fuze having nine parts. It is used in both the M42 and the M46 grenades which make up the cargo of the 8-inch M509 projectile and the 155mm M483 projectile. When the projectiles eject the grenades, a tape stiffener acting as an airfoil turns a screw, arming each grenade. The M223 detonates the grenade upon impact. During the years 1973 through 1978, 198,653,646 fuzes were bought for a total price of $94,691,036 (FY 78 dollars).

The M223 fuze can be manufactured either by automated assembly, or by large volume hand assembly. It requires stamping and die casting expertise. The fuze was developed by AVCO and Honeywell in the mid 1960s

FIGURE A-3

ACQUISITIONS FOR THE M223 FUZE

OBSERVATION	CONTRACTOR	CONTRACT NUMBER	PORTION
7	Dayron (3)	73-C-0211	1.00
8	Honeywell (2)	74-C-0008	1.00
9	Dayron (1)	76-C-0074	.125
	Honeywell	76-C-0073	.125
	Etowah	76-C-0089	.250
	E. Walters	76-C-0090	.250
	REDM	76-C-0091	.125
	AVCO	76-C-0072	.125
10	Dayron (2)	76-C-0074	.325
	Honeywell	77-C-0182	.010
	Etowah	76-C-0075	.216
	E. Walters	77-C-0073	.325
	REDM	77-C-0076	.108
	AVCO	77-C-0183	.016

and a winner-take-all competition for the first production was won by AVCO. In 1973 the government awarded Dayron a competitive contract, and in 1974 Honeywell won the competition. The earliest acquisition for which data are available is the one in which Dayron, as the incumbent, was displaced by Honeywell. Observation 7 in Figure A-3 refers to this acquisition, which achieved an estimated savings of 11.2 percent.

In 1976 the requirement for fuzes increased greatly, and the government decided to increase the number of producers to six. Three contractors which had never before produced the item (E. Walters, Etowah and REDM) joined the three experienced contractors (AVCO, Dayron and Honeywell) for a total award of 20,000,000 fuzes. Observation 8 refers to this acquisition. Before this acquisition, Honeywell was producing the fuzes for a unit price of $0.512 (FY 78 dollars) and the projected price was $0.4977. After the acquisition the weighted average price for all six producers was $0.6225, giving an estimated loss of 25.1 percent.

Discussions with government contracting personnel reveal the reason for this price increase. The experienced contractors, AVCO, Dayron and Honeywell had lost money on their previous contracts, and they now bid at a more realistic level. Their bids were, respectively, $1.1519, $1.0420 and $0.8007. The new contractors, E. Walters, Etowah, and REDM bid very low, and ultimately los money at their bid prices of $0.3788, $0.4094, and $0.4087. The after-award price of $0.6225 seems high, because the projected price of $0.4977 was unrealistically low. Nevertheless, the government actually paid these prices, and observation 8 is included in the data base in this study.

In 1977 a very large requirement was satisfied using range bidding. The larger multi-year awards went to E. Walters, Etowah, REDM, and Dayron based on their low price, and smaller, minimum sustaining awards went to AVCO and Honeywell. This was the largest total award observed for the M223 and resulted in a competitive savings of 17.6 percent compared to the projected price. In 1978 another competition was held. Observations 9 and 10 refer to these acquisitions.

3. PROJECTILE, M489.

The M489 projectile is a 105mm tracer used for target practice. It is used with the 105mm cartridge (M490) and is similar in appearance and ballistic performance to the M456 series combat round. The projectile consists of a steel body, an aluminum stand-off spike, and an aluminum fin and boom assembly with a tracer cavity. The Army is the largest user, but the Marine Corps and Foreign Military Sales also have large requirements. During the years 1965 through 1979, 6,006,685 units were bought for a total price of $219,167,633 (1978 dollars).

The observed sequence of nine competitive acquisitions for the M489 illustrates the finding that the competitive savings in later acquisitions

FIGURE A-4

ACQUISITIONS FOR THE M489 PROJECTILE

OBSERVATION	CONTRACTOR	CONTRACT NUMBER	PORTION
11	Norris (2)	AMC-286(A)	.500
	Hesse	AMC-346(A)	.500
	Weatherhead	AMC-524(A)	
12	Kennedy (3)	68-C-0109	1.00
13	Kennedy	69-C-0257	.772
	Whittaker	69-C-0410	.228
14	Kennedy (5)	70-C-0037	1.00
15	Kennedy (2)	71-C-0201	.333
	Morewell	71-C-0093	.333
	Epic	71-C-0006	.334
16	Kennedy (4)	72-C-0162	.400
	Moreweld	73-C-0006	.600
17	Norris (1)	75-C-0024	.400
	Kennedy (4)	74-C-0023	.200
	Chamberlain (1)	75-C-0023	.400
18	Chamberlain (3)	75-C-0023	.600
	Norris (1)	75-C-0024	.400
19	Norris (1)	77-C-0123	.600
	Chamberlain	77-C-0066	.400

are approximately the same as the savings in earlier acquisitions. The eighth and ninth acquisitions, as shown in Figure A-4, show competitive savings of 7.7 percent and 10.8 percent respectively.

The first competitive buy is observation 11 in Figure A-4. In 1965 Norris, Hesse and Weatherhead were producing the M489 for unit prices of $28.5212, $29.5382, and $30.9620, respectively. In order to exercise the estimated savings methodology, it is assumed that a noncompetitive award would have been divided equally between the two low cost producers, Norris and Hesse. The projected unit prices are $27.4198 and $25.7664.

Kennedy Van Saun won the award for $33.033, giving a loss of -18.8 percent according to the estimated savings methodology. This is similar to the second fuze acquisition (observation 8) which also showed an estimated loss. In both situations the incumbent producers were experiencing production problems and had offered what, in retrospect, was an unrealistically low price. In both cases the final award price seems high because it is being compared to a projected price that is unrealistically low. Nevertheless, the government did pay these prices, and the observation is kept in the data base.

Kennedy was the principle producer during the mid 1960s and early 1970s. In 1974 Kennedy withdrew from the production base. Government sources state that the withdrawal was motivated by Kennedy's desire to devote more resources to their more profitable commercial lines. The requirements for 1975 and beyond were competitively negotiated and split awards were made to Norris or Chamberlain, or both. Observations 12 through 19 refer to these acquisitions.

4. CARTRIDGE CASE, M103, BRASS.

The M103 cartridge case is produced from brass blanks using a drawing and machining process. It is a NATO standard center fire 20mm case and is used with many cartridges, including the M55A2-TP, M53-API, M56A3-HEI, M221-TP-T, M242-HEI-T, and the M246-HEIT-SD. During the years 1970 through 1978, 165,304,103 cartridge cases were bought for a total price of $83,980,123 (FY 78 dollars).

Three competitive acquisitions were observed, as shown in Figure A-5. In 1971 Amron was the only privately-owned producer of M103 brass cartridge cases. A competition was held, resulting in awards to Amron and National Eastern. Observation 20 refers to this acquisition. In 1973 another acquisition was held. Only one of the two incumbents, Amron, received a contract. Observation 21 refers to this acquisition.

For several years Amron was the only private producer of M103 brass cartridge cases, although a Government-owned Contractor-operated (GOCO) facility at Lake City Army Ammunition Plant produced some cases. In 1978 the government solicited Amron and National Eastern, using a range bidding

FIGURE A-5

ACQUISITIONS FOR THE M103 BRASS CARTRIDGE CASE

OBSERVATION	CONTRACTOR	CONTRACT NUMBER	PORTION
20	Amron	71-C-0423	1.00
21	Amron	72-C-0476	.693
	National Eastern	72-C-0515	.307
22	Amron	77-C-0116 (1)	1.00

technique. National Eastern won the award based on price. A few days after losing, however, Amron offered a much reduced option price on one of their current contracts. The government chose to exercise this option. Observation 22 refers to this observation. The savings are calculated on the basis of two awards, National Eastern and Amron, for an estimated savings of 30 percent (assuming a 95 percent learning curve slope). If the savings were calculated using only the competitive winner, National Eastern, the estimated savings would have been 31 percent.

This last acquisition illustrates the effects of competition on a contractor who had enjoyed a 100 percent share of the market for many years. In 1978 Amron was producing under their eighth government contract for this item. They had received awards totaling 142,640,841 cases, and the price (in FY 78 dollars) had risen to $0.6098. Considering the effects of learning only, they would have offered $0.6045 and $0.6072 (based on slopes of 90 percent and 95 percent, respectively). After losing the competition, Amron engineers reviewed their procedures and costs and found they were able to offer the government a price of $0.4393.

APPENDIX B

CONTRACT COST DATA

FIGURE B-1

CONTRACT DATA, 750 POUND BOMB

A. M. F.

CONTRACT NUMBER	FISCAL YEAR	QUANTITY	CUMULATIVE QUANTITY	UNIT PRICE	NONREC COSTS	ADJ UNIT PRICE,$78
AMC-509(A)	65	64721	64721	127.3200	0.	287.7432
AMC-877(A)	66	145007	209728	146.0000	0.	337.2600
AMC-877(A)	67	43752	253480	150.5100	0.	340.1526
AMC-877(A)	67	109598	363078	144.6000	0.	326.7960
68-C-0161	68	97500	460578	130.5500	0.	285.9045
68-C-0161	68	77664	538242	127.7500	0.	279.7725
68-C-0161	68	96836	635078	127.7500	0.	279.7725
69-C-0035	69	74000	709078	116.8500	0.	241.8795
69-C-0035	69	189000	898078	114.3200	0.	236.6424
69-C-0035	69	88000	986078	104.0000	0.	215.2800
70-C-0036	70	80000	1066078	86.4300	0.	167.6742
70-C-0279	70	59600	1125678	94.1600	0.	182.6704
70-C-0279	70	14100	1139778	94.1600	0.	182.6704
71-C-0011	71	72000	1211778	95.9300	0.	171.7147
71-C-0011	71	60000	1271778	97.0200	0.	173.6658
72-C-0054	72	420000	1691778	76.9900	0.	130.1131
72-C-0054	72	46752	1738530	82.0000	0.	138.5800

A. O. SMITH

CONTRACT NUMBER	FISCAL YEAR	QUANTITY	CUMULATIVE QUANTITY	UNIT PRICE	NONREC COSTS	ADJ UNIT PRICE,$78
AMC-482(A)	65	59000	59000	179.5000	0.	405.6700
AMC-857(A)	66	145006	204006	124.0000	0.	286.4400
AMC-857(A)	67	126794	330800	127.5000	0.	288.1500
AMC-857(A)	67	38199	368999	126.7700	0.	286.5002
AMC-857(A)	67	11801	380800	125.7400	0.	284.1724
AMC-857(A)	68	119100	499900	116.4900	0.	255.1131
AMC-857(A)	68	46100	546000	114.9500	0.	251.7405
68-C-0078	68	146244	692244	112.9100	0.	247.2729
68-C-0078	68	150000	842244	110.8000	0.	242.6520
68-C-0078	69	14756	857000	113.0400	0.	233.9928
68-C-0078	69	85130	942130	110.2000	0.	228.1140
69-C-0102	69	178000	1120130	106.5600	0.	220.5792
69-C-0102	69	116000	1236130	106.5600	0.	220.5792
69-C-0398	69	180000	1416130	90.8500	0.	188.0595

FIGURE B-1 (Continued)

LETOURNEAU

CONTRACT NUMBER	FISCAL YEAR	QUANTITY	CUMULATIVE QUANTITY	UNIT PRICE	NONREC COSTS	ADJ UNIT PRICE,$78
AMC-476(A)	65	59000	59000	178.1000	0.	402.5060
AMC-854(A)	66	145007	204007	131.0000	0.	302.6100
AMC-854(A)	67	179552	383559	119.0000	0.	268.9400
68-C-0030	68	117000	500559	115.5900	0.	253.1421
68-C-0030	68	189000	689559	109.4100	0.	239.6079
68-C-0030	68	18000	707559	107.6800	0.	235.8192
69-C-0044	69	64000	771559	100.5200	0.	208.0764
69-C-0044	69	179000	950559	98.3600	0.	203.6052
69-C-0044	69	151140	1101699	93.4500	0.	193.4415
70-C-0035	70	120000	1221699	86.4500	0.	167.7130
70-C-0278	70	76400	1298099	82.7600	0.	160.5544
70-C-0411	70	80000	1378099	77.9800	0.	151.2812
71-C-0010	71	132000	1510099	83.9900	0.	150.3421
71-C-0010	71	20000	1530099	83.0000	0.	148.5700
71-C-0010	71	30000	1560099	78.5000	0.	140.5150
71-C-0150	71	52000	1612099	80.3000	0.	143.7370
71-C-0150	71	52000	1664099	80.3000	0.	143.7370
71-C-0254	71	36236	1700335	81.2500	0.	145.4375
71-C-0368	71	74000	1774335	79.7500	0.	142.7525
72-C-0213	72	20000	1794335	74.0000	0.	125.0600
72-C-0213	72	58000	1852335	76.9000	0.	129.9610
72-C-0213	72	156000	2008335	85.0000	0.	143.6500
72-C-0213	73	20000	2028335	85.0000	0.	138.5500
72-C-0330	72	78000	2106335	147.0000	0.	248.4300

FIGURE B-2

CONTRACT DATA, FUZE, M223

CONTRACT NUMBER	FISCAL YEAR	QUANTITY	CUMULATIVE QUANTITY	UNIT PRICE	NONREC COSTS	ADJ UNIT PRICE,$78
DAYRON						
73-C-0211	73	3420100	3420100	.4471	0.	.7288
73-C-0211	73	134250	3554350	.3769	0.	.6143
73-C-0211	73	1575800	5130150	.3769	0.	.6143
76-C-0074	76	2500000	7630150	.8990	112200.	1.0420
77-C-0074	77	50085000	57715150	.3587	0.	.3946
76-C-0074	77	3393200	61108350	.3800	0.	.4180
HONEYWELL						
74-C-0018	74	5919050	5919050	.3405	0.	.5210
74-C-0018	74	685000	6604050	.3405	0.	.5210
76-C-0007	76	825000	7429050	.6564	0.	.8008
76-C-0073	76	2500000	9929050	.6563	0.	.8007
77-C-0182	77	1565000	11494050	.6500	0.	.7150
78-C-0118	78	1600000	13094050	.5310	0.	.5310
ETOWAH						
76-C-0089	76	5000000	5000000	.3500	72000.	.4094
76-C-0075	76	33390000	38390000	.4520	0.	.5514
78-C-0117	78	4043608	42433608	.3150	0.	.3150
78-C-0117	78	200000	42633608	.3150	0.	.3150
78-C-0117	78	965638	43599246	.3150	0.	.3150
E. WALTERS						
76-C-0090	76	5000000	5000000	.3799	347050.	.3788
77-C-0073	77	50085000	55085000	.3850	1086556.	.3996
REDM						
76-C-0091	76	2500000	2500000	.3950	150000.	.4087
77-C-0076	77	16695000	19195000	.4850	0.	.5335

FIGURE B-2 (Continued)

AVCO

CONTRACT NUMBER	FISCAL YEAR	QUANTITY	CUMULATIVE QUANTITY	UNIT PRICE	NONREC COSTS	ADJ UNIT PRICE,$78
76-C-0072	76	2500000	2500000	.9922	120000.	1.1519
77-C-0183	77	2472000	4972000	.5840	0.	.6424
78-C-0119	78	1600000	6572000	.5527	0.	.5527

FIGURE B-3

CONTRACT DATA, PROJECTILE, M489

CONTRACT NUMBER	FISCAL YEAR	QUANTITY	CUMULATIVE QUANTITY	UNIT PRICE	NONREC COSTS	ADJ UNIT PRICE, $78
WEATHERHEAD						
AMC-524(A)	65	70000	70000	13.7000	0.	30.9620
NORRIS						
AMC-286(A)	65	114400	114400	12.6200	0.	28.5212
AMC-286(A)	65	10000	124400	12.6200	0.	28.5212
75-C-0024	75	280000	404400	36.1800	0.	48.1194
75-C-0024	77	100000	504400	36.8100	0.	40.4910
75-C-0024	77	10722	515122	36.1800	0.	39.7980
77-C-0062	77	188950	704072	37.2600	0.	40.9860
77-C-0123	77	110231	814303	34.7900	0.	38.2690
77-C-0123	78	5180	819483	34.7900	0.	34.7900
78-C-0142	78	115412	934895	35.9200	0.	35.9200
78-C-0142	78	33630	968525	36.2000	0.	36.2000
HESSE						
AMC-346(A)	65	132800	132800	13.0700	0.	29.5382
KENNEDY						
AMC-580(A)	66	121260	121260	14.3000	0.	33.0330
AMC-580(A)	66	121260	242520	13.7000	0.	31.6470
AMC-580(A)	66	17520	260040	13.8000	0.	31.8780
AMC-580(A)	67	12100	272140	14.1800	0.	32.0468
67-C-0061	67	166000	438140	14.3200	0.	32.3632
67-C-0061	67	80440	518580	14.3200	0.	32.3632
67-C-0061	67	54300	572880	14.3200	0.	32.3632
68-C-0109	68	317000	889880	14.6000	0.	31.9740
68-C-0109	68	104000	993880	14.7500	0.	32.3025
68-C-109	68	134000	1127880	14.5300	0.	31.8207
68-C-0109	69	179500	1307380	14.2300	0.	29.4561
69-C-0257	69	269800	1577180	14.3000	0.	29.6010
70-C-0037	70	237960	1815140	14.0500	0.	27.2570

FIGURE B-3 (Continued)

CONTRACT NUMBER	FISCAL YEAR	QUANTITY	CUMULATIVE QUANTITY	UNIT PRICE	NONREC COSTS	ADJ UNIT PRICE,$78
70-C-0037	70	16400	1831540	13.7800	0.	26.7332
70-C-0037	70	30800	1862340	13.7800	0.	26.7332
70-C-0037	70	97200	1959540	14.2500	0.	27.6450
70-C-0037	70	360	1959900	14.2500	0.	27.6450
71-C-0201	71	72000	2031900	13.8400	0.	24.7736
71-C-0201	71	126000	2157900	13.8400	0.	24.7736
72-C-0002	72	84100	2242000	13.3700	0.	22.5953
72-C-0002	72	210350	2452350	13.3700	0.	22.5953
72-C-0162	72	417400	2869750	13.2100	0.	22.3249
72-C-0162	73	12300	2882050	13.2100	0.	21.5323
72-C-0162	73	23700	2905750	14.7100	0.	23.9773
72-C-0162	73	80000	2985750	15.8000	0.	25.7540
74-C-0023	74	47800	3033550	20.8600	0.	31.9158
74-C-0023	74	47200	3080750	19.1400	0.	29.2842
74-C-0023	74	92267	3173017	13.5000	0.	20.6560
74-C-0023	75	150000	3323017	24.0000	0.	31.9200
WHITTAKER						
69-C-0410	69	79600	79600	14.0500	0.	29.0835
MOREWELD						
71-C-0093	71	141676	141676	13.6900	0.	24.5051
73-C-0006	73	226400	368076	13.6900	0.	22.3147
EPIC						
71-C-0286	71	210350	210350	13.0500	0.	23.3595
CHAMBERLAIN						
75-C-0023	75	280000	280000	39.2400	0.	52.1892
75-C-0023	76	249611	529611	33.7600	0.	41.1872
75-C-0023	76	192974	722585	35.0000	0.	42.7000
77-C-0066	77	120823	843408	40.0700	0.	44.0770

FIGURE B-4

CONTRACT DATA, CARTRIDGE CASE, M103, BRASS

AMRON

CONTRACT NUMBER	FISCAL YEAR	QUANTITY	CUMULATIVE QUANTITY	UNIT PRICE	NONREC COSTS	ADJ UNIT PRICE,$78
70-C-0495	70	36000000	36000000	.3093	0.	.6000
71-C-0423	71	28000000	64000000	.2872	0.	.5141
72-C-0476	72	21392000	85392000	.2698	0.	.4560
73-C-0337	73	20888812	106280812	.2583	0.	.4210
73-C-0337	74	6461469	112742281	.2683	0.	.4105
75-C-0401	75	3500000	116242281	.4200	0.	.5586
75-C-0401	75	35000000	119742281	.4200	0.	.5653
75-C-0401	75	2733997	122476278	.4250	0.	.5142
75-C-0401	76	1834224	124310502	.4215	0.	.5856
76-C-0094	76	2000000	126310502	.4800	0.	.5440
76-C-0160	77	7690339	134000841	.4650	0.	.5366
76-C-0160	77	2592000	136592841	.4876	0.	.6098
77-C-0116	77	6048000	142640841	.5680	82457.	.4393
77-C-0116	78	3473905	146114746	.4393	0.	.4445
77-C-0116	78	540000	146654746	.4445	0.	

NATIONAL EASTERN

CONTRACT NUMBER	FISCAL YEAR	QUANTITY	CUMULATIVE QUANTITY	UNIT PRICE	NONREC COSTS	ADJ UNIT PRICE,$78
72-C-0515	72	9474177	9474177	.2688	0.	.4543
78-C-0137	78	6980360	16454537	.4179	0.	.4179
78-C-0137	78	2194820	18649357	.4388	0.	.4388

STUDY TEAM COMPOSITION

The study team consisted of the following individuals:

Richard C. Brannon, Project Leader, is a statistician with the US Army Procurement Research Office (APRO), Fort Lee, Virginia. He has an M.S. in mathematics from Southern Illinois University, Carbondale, Illinois (1967), and a B.A. in mathematics and statistics from the University of Missouri, Columbia, Missouri. Before coming to APRO, Mr. Brannon was an Operations Research Analyst with the Comptroller of the Army, Washington, DC. Mr. Brannon has worked as a cost analyst and as a computer system analyst, and has taught Calculus, Analytic Geometry and Algebra at the college level.

Richard P. Burns is a Contract Specialist and Procuring Contracting Officer at the US Army Armament Materiel Readiness Command (ARRCOM), Rock Island, Illinois. He has an M.S. in contract and procurement management from the Florida Institute of Technology, Melbourne, Florida (1974), and a B.S. in business administration from Lewis University, Lockport, Illinois (1962). He has been a Certified Professional Contracts Manager since 1976. Mr. Burns was assigned temporarily to APRO as part of his development in the Materiel Acquisition and Readiness Executive Development (MARED) program. In addition to his assignment at ARRCOM, Mr. Burns is an adjunct professor of Contract Management in the graduate program of a local university.

John I. Neely is an Industrial Engineer at APRO. He earned his M.S.I.E. from Purdue (1942) and has a B.S. in education from Indiana University (1938). Mr. Neely has been licensed as an Industrial Engineer in several states. Prior to coming to APRO Mr. Neely was an Industrial Engineer with the Defense Logistics Agency, and taught I.E. for US Navy in the Far East. He received the civilian "E" Award from President Roosevelt for R&D at Eli Lilly and Company.

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13. ABSTRACT

BACKGROUND. Previous research has shown that competition usually results in lower unit prices. The literature, however, only addresses the case in which a single winner receives one contract for the total quantity required. The present study generalizes the above work by allowing for the possibility of multiple winners and also the case in which a sequence of competitive awards are made for the same item over a period of several years.

APPROACH. A sample of 22 acquisitions was selected and contract cost data was collected. Data were adjusted to separate the effects of inflation, nonrecurring costs, and contractor learning. The savings attributable to competition were estimated. A sensitivity analysis was performed using learning curve slopes of 90, 95 and 100 percent.

SUMMARY. The sample showed an average competitive savings of 7.1 percent, based on a slope of 95 percent. The effect of competition varied widely, and in some situations competition may not be advisable. The advantages of competition could be lost if the production base were reduced to a single contractor.

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