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Marine Corps Operations Analysis

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THE ECONOMICS OF MULTIYEAR CONTRACTING

INTRODUCTION

Almost everyone familiar with Defense Department procurement practices believes that the price of defense purchases can be reduced through the increased use of multiyear contracting practices. The theory behind this belief is simple and persuasive: The Defense Department makes a commitment to purchase certain military goods for several years from the same supplier; consequently, the supplier is encouraged to buy larger lots of raw materials and to schedule production more efficiently; the supplier passes these savings onto the government and the Pentagon gets more out of each budget dollar.

Witness after witness confirmed this chain of events at the House Armed Services Committee Hearings on the Defense Industrial Base in the Fall of 1980. This consensus was reflected in Deputy Secretary Carlucci's April 1981 recommendations for improving the weapons acquisition process. The Carlucci recommendations called for increased use of multiyear contracting and cited cost savings of 10 to 20 percent under multiyear procedures. Apparently, Congress was impressed with these arguments. The 1982 Defense Authorization Act removed many of the contested restrictions on multiyear procurement and new multiyear contracts are now being proposed and signed.

The many proponents of multiyear contracting do not believe that new multiyear contracts will be an unmitigated blessing. Multiyear contracting can easily raise the cost of changes in defense plans. If

Congress or DoD cancels a multiyear contract because of funding cuts or because a system has run into trouble, DoD could be liable for a large cancellation fee. It is also possible, under some of the proposed funding methods for multiyear contracting, that Congress will have to appropriate money not only for cancellation charges but also to finish weapons already in production. Congress has faced this unpleasant choice in the past and, as a result, severely limited multiyear contracting in 1972 after huge cancellation fees were paid on some Navy shipbuilding programs.

The current plan for multiyear contracting is supposed to capture the benefits of multiyear procedures while avoiding the pitfalls of the past by carefully selecting programs that are to be multiyear funded. DoD has a list of criteria for the selection of programs for multiyear contracting. Five of the six criteria deal with the inherent predictability of the program, but the first one restricts multiyear to programs that "yield substantial cost avoidance or other benefits when compared to annual contracting methods." Because of the risks inherent in multiyear contracts, the government does not want to use multiyear procedures unless the expected benefits are very high. This paper analyzes the effects of legislative changes sought by DoD on the price of weapons systems. Budgeting and funding practices are also discussed because these practices play an important role in choosing the best type of contract.

There are several important conclusions drawn in the paper. We show that the changes in contracting regulations sought and obtained by

DoD to facilitate multiyear procurement will lower prices only under certain circumstances that may, in fact, not exist. If these conditions do not exist, multiyear contracts could easily raise defense prices.

DoD has been advertising large savings from multiyear contracts. We show that these savings estimates are based on an invalid comparison of conventional and multiyear contracts. We also discuss why the services have an incentive to request multiyear procurement and overstate the savings even when these new contracts do not lower prices: An underestimate of program costs gives the services an opportunity to start more programs within a fixed yearly budget. The services have always had incentives to start new programs whether or not current budget projections allow for execution of the program plans. The services appear to believe, with good reason, that projects are rarely terminated even when they would not have been started if true costs had been known from the outset. In addition, new programs are a foot in the door, a foot that helps establish claims to a bigger share of the defense budget.

Perhaps the most important contribution of the paper is the development of a funding rule that allows reductions in the required funding request only when multiyear contracts actually do save money. With this funding rule there will be little incentive to overstate the savings from multiyear contracts and the services will request multiyear contracts when, and only when, they result in true savings.

BACKGROUND

Normally, DOD cannot obligate money (sign a contract) for programs unless funds are appropriated by Congress. Outlays (cash expenditures) are made for several years after money is obligated. Cash flows to contractors from a single year's appropriation can stretch out over the next ten years. Thus, DoD can sign a contract for production and payment many years into the future. All they have to do is ask Congress for all the money up front.

This practice of appropriating at the start of a program all the money needed to complete it is known as "full funding." Congress requires that contracts be fully funded so that all the costs of the program are completely visible when a program is started. They also believe that future Congresses and administrations should not have to appropriate money to complete projects started by an earlier regime.

Multiyear contracting under the full-funding policy is not unlawful, but it isn't used because it crowds out other programs. Each year the services are given a limit on the total amount of appropriations that they can request from Congress, called total obligational authority (TOA). With this limit, a given program can have a fully funded multiyear contract only at the expense of some other program. The services are not willing to reduce some programs to get fully funded multiyear contracts for others.

There have always been exceptions to the full funding rule. The new multiyear legislation extends these exceptions. Prior to the new multiyear legislation, DoD could sign contracts for unfunded production

years so long as the penalty for cancellation was small. For instance, a contract could be signed for 200 weapons, 40 to be produced in each of the next five years. Forty weapons would be funded by appropriations each year. The contractor would receive a cancellation fee if less than 200 weapons were built. Cancellation fees were limited to $5 million under the old regulations and could be used only to reimburse non-recurring costs. Non-recurring, or fixed costs, are those costs that are independent of the number of units produced. These restrictions were imposed by the Congress in 1972 after huge cancellation fees were paid in two Navy shipbuilding programs that had large cost overruns: the LHA and DD963. These limits were believed to be too restrictive. A $5 million cancellation fee is meaningful in only the smallest procurement projects. In addition, many of the expenses incurred for the efficient production of large quantities, such as economic lot buys, were considered recurring costs and could not be reimbursed under the old rules.

The second exception to full funding under the old rules was made for the advance procurement of long lead-time items. Advance procurement is early payment to a firm for parts of a system. Advance procurement was limited to items in a weapons system that have significantly longer lead times than other components of the system. In addition, advance procurement was allowed only for items that were fully funded in the next year's budget. Thus, in the vast majority of cases, DoD was given advance funding only one year before they would have under strict adherence to the full funding rule.

DoD sought and obtained three changes in the restrictions on multiyear contracting. First, DoD wanted to raise the maximum cancellation ceiling from $5 million to $100 million. Second, they wanted to include some recurring as well as non-recurring costs in the cancellation ceiling. Third, they wanted advance procurement extended to economic lot buys that will be used over the entire length of the contract, which meant a relaxation of both the limit on the types of items eligible for advance funding and the timing of advance funding relative to full funding of completed end items. Basically, DoD was given more authority to sign up for or actually reimburse a contractor for all or part of a weapons program without obtaining full funding for the entire program.

THE EFFECTS OF MULTIYEAR CONTRACTING ON THE PRICE OF MAJOR WEAPONS SYSTEMS

The legislation to increase the use of multiyear contracts was basically legislation to further relax full funding requirements. DoD needed to convince Congress that there are savings from these multiyear contracts to get additional exceptions to the full funding policy. What are the likely savings? To answer this question we need to know the bid price from the contractor under a multiyear contract and under the old rules, known as the annual funding method.

DoD instructions state that multiyear procurement can be used only for fixed price contracts. These are contracts where the bidder quotes a price and is paid that amount, plus perhaps an inflation adjustment, regardless of the actual cost of the project. Under most circumstances, the goverment specifies the production schedule so the only option that

can be exercised to win the contract is the bid price. Each contractor will bid the most he thinks he can get away with and still win the contract. Under competitive conditions, the bid will reflect costs plus the "going" rate of return. The award should go to the most efficient producer. When the award is non-competitive, the final bid will be the result of bargaining between the contractor and the government, the end result depending on the strength of the two parties.

The bid price may be different for the monopolist and the competitive firm, but regardless of market structure, both types of firms will try to maximize profits by minimizing expected project costs. One normal difference between a competitive and a monopolist firm under other circumstances is the quantity produced. These output differences are not relevant here. The firm does not choose the quantity; it is specified by the government. Thus, for both types of firms, the bid price will equal profit plus costs, and both types of contractors will try to minimize expected costs.

To illustrate a contractor's behavior under annual and multiyear contracts, we examine the behavior of a firm that is asked to bid on a system (aircraft, for example) where the number of units is known with certainty for the first year and anticipated quantities are specified for the second year. (The number of years can easily be expanded to more than two and uncertainty can be included in the first year but these extensions unnecessarily complicate the example.) Let X_1 be the number of aircraft built the first year and X_2 be the anticipated aircraft for the second year. The second year program will be executed

with probability π, where π is between zero and one. The implicit probability for the first program year is equal to one.

Again, with a fixed price contract a firm will maximize profits by minimizing total costs. Total costs (TC) are composed of fixed costs (non-recurring costs) and variable costs (recurring). Fixed cost could cover almost any type of input into the production process, such as a labor-saving machine that would be used for all the potential aircraft. Economic lot purchases made at the beginning of the first year are also a fixed cost to the extent that they cannot be resold if the second year of the program is cancelled. The important distinction between fixed cost and variable cost is that variable costs for the second year will only be incurred if the second year is funded while fixed costs are independent of funding in the second year.

Total cost (TC) is a function then, of fixed cost (f) and variable cost (B) or

$$TC = f + BX \qquad (1)$$

where X is the number of units produced.

Firms incur fixed costs in order to lower variable costs. The costs of labor-saving devices are incurred because these machines will lower the variable cost of each future unit produced. The relationship between f and B can be expressed as a derivative or:

$$\frac{dB}{df} < 0$$

The firm will incur fixed costs so long as they lower total costs. This means that any fixed cost item that does not lower variable costs by more than its price will not be purchased. In order to illustrate the choice the firm makes between fixed and variable cost purchases, we will assume a specific relationship between B and f. Let $B = \frac{b}{f}$. (Again, the specifics are not important and can easily be generalized.) This relationship means that variable costs (B) are negatively related to fixed costs. Total costs then for X aircraft are

$$TC = f + \frac{b}{f} X \quad . \tag{3}$$

Expected costs (E(TC)) under a currently allowable (annual) contract would be

$$E(TC) = f + \frac{b}{f} X_1 + \pi \frac{b}{f} X_2 \quad . \tag{4}$$

Where X_1 and X_2 are the number of units to be built in each of the two years.

Firm Behavior Under an Annual Contract

With an annual contract the profit maximizing firm minimizes expected total costs through a choice of f, or

$$\min_{f} E(TC) \rightarrow \frac{dTC}{df} = 0$$

or

$$1 - \frac{bX_1}{f^2} - \frac{\pi bX_2}{f^2} = 0$$

or

$$f^* = \sqrt{b(X_1 + \pi X_2)} \qquad (5)$$

where f^* is the cost-minimizing choice of f. The optimum choice of fixed cost, or f^*, is a function of the number of units and the probability that the program will be continued a second year. The choice of f^* is a positive function of π or

$$\frac{df^*}{d\pi} > 0$$

meaning that more fixed costs will be incurred the more certain the firm is that the second year will be funded. The average cost (AC) of the aircraft is a negative function of π since

$$AC = \frac{TC}{X} \quad \text{or} \quad \frac{TC}{X_1 + \pi X_2}$$

and at the optimum production point, (f^*)

$$AC = \frac{f^*}{X} + \frac{b}{f^*} . \qquad (6)$$

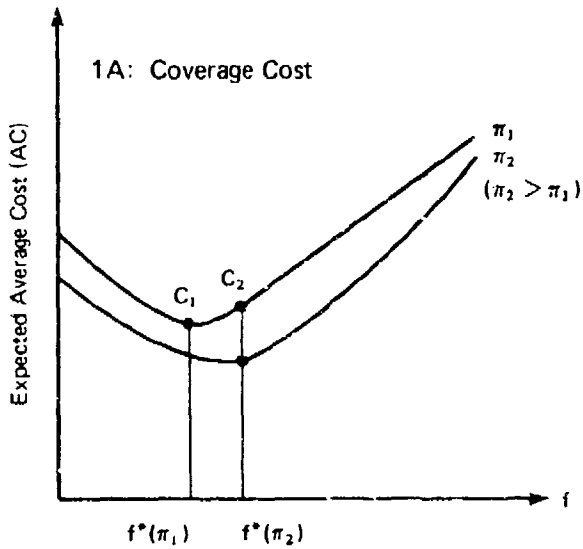
Substituting the expected quantity $X_1 + \pi X_2$ in equation (6) and using equation (5) for f^* shows that

$$\frac{d(AC)}{d\pi} < 0 ,$$

or that average costs of the system decline when π increases.

Figures 1A and 1B show the relationship of average cost (AC) and total cost (TC) to fixed costs (f) and continuation probabilities (π). The figures show expected average cost and total cost as a function of fixed cost for two different continuation probabilities. For each probability there is an f (equal to f^*) that minimizes expected total and average cost. If the firm believes that the probability that the second year will be funded is π_1, it will choose $f^*(\pi_1)$. It will choose $f^*(\pi_2)$, or more fixed cost, if it believes that the probability is higher, say π_2. Note that if the firm believes that the probability is π_2 and it is correct, the expected average cost of the program will be lower than if the firm believes and is correct that the probability is π_1. This is what the derivative $\frac{dAC}{d\pi} < 0$ means.

Increasing the firm's belief that a program will be funded decreases the expected average cost of a program only if the firm is correct. Figure 1A shows what happens when a firm incorrectly increases it's estimate of π. If the firm is induced to believe that the probability is π_2 when it is, in fact, π_1, the firm will choose $f^*(\pi_2)$ and the average cost would be equal to C_2, higher than the



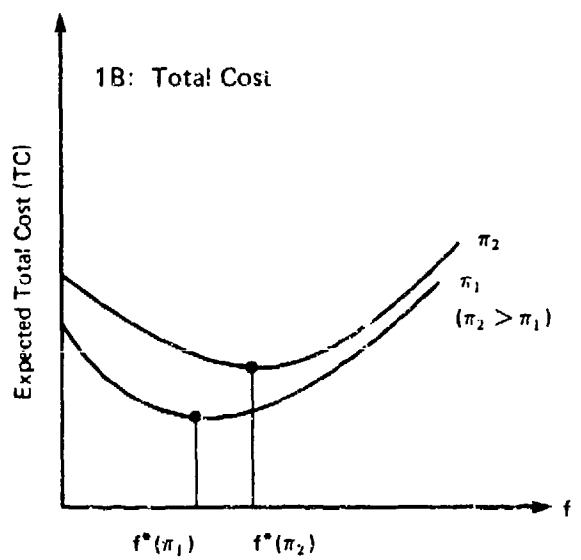


FIG. 1: COST CURVES

anticipated costs with correct expectations (or C_1). In other words, the cost of defense programs can be reduced if we increase the stability of funding by decreasing the number of cancelled programs (increasing π). The cost of defense programs will be increased if the perception of π is increased when the actual π remains unchanged.

Firm Behavior Under a Multiyear Contract

So far, we have described only the behavior of a firm with an annual contract. The main difference between an annual and a multiyear contract is that a multiyear contract reduces the risks of making plans for more than a single year's requirements through either advance procurement or a cancellation clause. Both of these multiyear initiatives reduce the losses due to uncovered fixed costs if a contract is cancelled; and both are a financial commitment to program continuation by the government. Advance procurement payments and cancellation fees both mean that the government will pay for fixed investment whether or not the contract is cancelled. Because of these similarities, advance procurement can be considered a pre-paid cancellation fee. The effects of cancellation fees are examined below. There is, of course, an important difference between advance procurement and a cancellation fee--advance procurement payments are made earlier than cancellation fees. The effect of that difference on a firm's behavior is discussed later in the paper.

Returning to the aircraft example used above, under a multiyear contract, the firm receives a cancellation fee (c) if the second year

program is not funded and only X_1 aircraft are built. The firm will be compensated for some (or most, under the new regulations) of the unamortized fixed cost incurred with the expectation that the second year of the program would be funded. The cancellation fee is proportional to f or

$$c = \alpha f.$$

The magnitude of α depends on the fraction of the program subject to cancellation and the fraction of expenses that are reimbursable under a cancellation clause. The maximum range for α is between zero and the fraction of the original plan that is not executed. In our example, the maximum α would be $\frac{X_2}{X_1 + X_2}$. The cancellation factor α would be equal to the maximum only if all types of expenses were reimburseable. The intent of some of the new multiyear legislation is to increase α by expanding the types of expenditures reimbursable under the cancellation clause.

Under a multiyear contract with a cancellation fee, the expected total costs for the firm are

$$E(TC) = f + \frac{bX_1}{f} + \frac{\pi bX_2}{f} - (1-\pi)\,\alpha f \quad . \tag{7}$$

Again, the firm will maximize profits by minimizing expected costs, which implies that

$$\frac{dE(TC)}{df} = 0 + 1 - \frac{bX_1}{f^2} - \frac{\pi bX_2}{f^2} - (1 - \pi)\alpha = 0 .$$

or

$$f^{**} = \sqrt{\frac{b(X_1 + \pi X_2)}{1 - \alpha(1 - \pi)}} . \qquad (8)$$

Note that f^{**} is greater than f^* if π is less than one. This means that the firm will choose a higher level of fixed costs with a cancellation clause than without one unless the firm is sure that the program will be continued ($\pi = 1$).

Undoubtedly, the belief that a meaningful cancellation clause will raise investment in fixed costs is behind much of the support for raising the cancellation ceiling from $5 million to $100 million. But this increased investment in fixed costs will not lower costs to the government. If the bid price to the government is expected costs plus a profit, the cancellation clause, by inducing the firm to over-invest in fixed equipment, raises the firm's cost and thus the cost to the government.

The relationship between f^* and f^{**} is shown in figure 2. Without a cancellation clause the firm chooses f^* and with a cancellation fee the firm chooses a higher level of f, namely f^{**}. The expected total costs of program are higher with a cancellation fee and, if bids are equal to costs plus a profit, the expected costs to the government are higher with a multiyear contract, holding π constant.

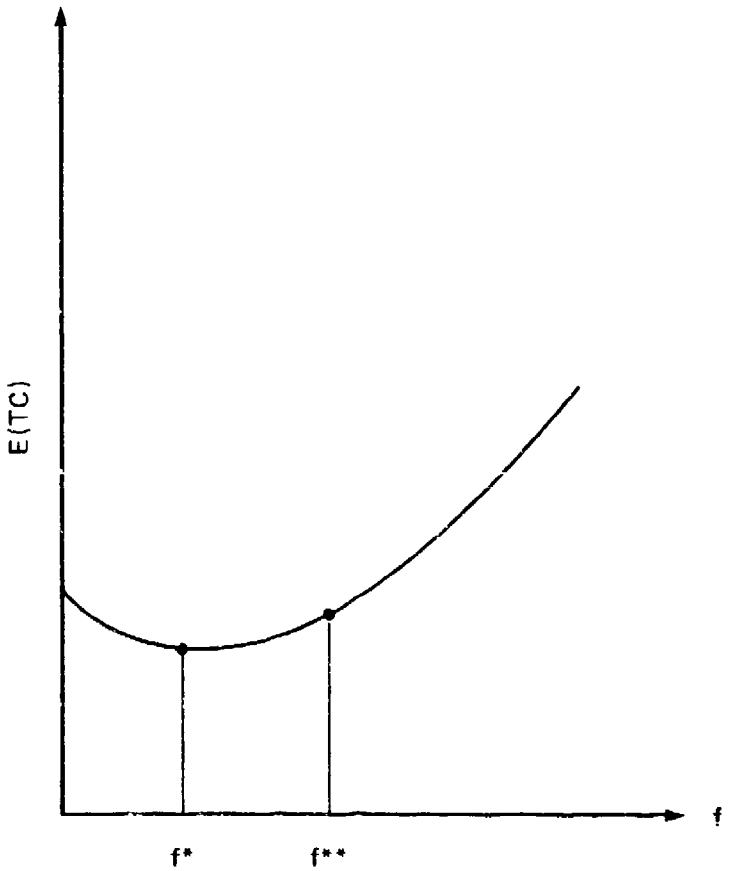


FIG. 2: A FIRM'S CHOICE OF FIXED INVESTMENT WITH AND WITHOUT A CANCELLATION FEE

Where did this surprising result come from? Multiyear contracts are supposed to lower prices, not raise them. In this simple example prices are raised to the government because the firm's investment in fixed capital is subsidized. The source of the subsidy can be seen by comparing the expected total cost function that the firm tries to minimize under each type of contract. Equations (4) and (7) are repeated below in order to make that comparison.

$$\text{Annual} \quad E(TC) = f^* + \frac{b}{f^*}(X_1 + \pi X_2) \tag{4}$$

$$\text{Multiyear} \quad E(TC) = f^{**} + \frac{b}{f^{**}}(X_1 + \pi X_2) - (1 - \pi)\alpha f^{**} \ . \tag{7}$$

With an annual contract the firm trades off the cost of f against the lowering of variable costs $\left(\frac{b}{f}\right)$. Under a multiyear contract the firm has two offsets to a dollar spent on fixed costs: the reduction of variable costs and the expected payment from the government which is $(1 - \pi)\alpha f^{**}$. In a very real sense, the firm does not face the true costs of investment in fixed equipment and consequently makes a socially inefficient decision. The government bears the burden of these wrong choices since the expected costs to the government are higher under a multiyear contract.

Note that the expected costs to the government are the same under both contract types if π is equal to one since, when π is one, the subsidy term goes to zero. Most proponents of multiyear contracting claim that the benefits (compared to the risks) of multiyear contracting

will be high because only programs that have a great deal of funding certainty will be given multiyear contracts. Indeed, when funding is very certain (π is close to one), there is little or no difference between an annual and multiyear contract.

Risk and Contract Prices

The above calculations assume that the firm maximizes expected profits, or equivalently, that the firm is indifferent to risk. A risk neutral firm will be indifferent to a certain profit of $15 million and uncertain outcome with a 50 percent chance of loosing $10 million and a 50 percent chance of a $40 million profit. If firms are risk averse, they will not be indifferent; they will prefer the certain profit of $15 million.

When a contract is cancelled, the major source of loss for a firm is unamortized fixed investment. A firm can cut down on potential loss by reducing fixed investment. A risk-averse firm will choose a lower f, or less investment, than the cost-minimizing level, f*, chosen by a risk-neutral firm. Fixed investment below f* will reduce expected profits, but the firm will make this tradeoff if it is risk averse.

If firms are risk-averse, the government can save money on defense purchases by offering a contract with a cancellation fee. The cancellation fee has two effects: First, it induces the firm to invest more in fixed costs (f). More f could lead to lower costs, but it could also raise them if the firm chooses more than the cost-minimizing level. The second effect of a cancellation fee is to lower the

dispersion of possible outcomes. There are two possible events for our firm--the contract is or is not cancelled. A cancellation fee cuts down on the difference in profits that results from each of these two events. Less dispersion means less uncertainty. If a firm is risk-averse, it will require lower profits when there is less dispersion of possible outcomes, or less uncertainty.

To make money on a multiyear contract, the government must, in essence, sell the firm an insurance policy. The firm pays for that policy in the form of lower profits. Firms cannot be too risk averse, since if they are, they are sacrificing profits to avoid risk and other firms will buy them out and make higher profits. On average, firms are in busines to make profits on risky ventures. We do not expect firms to be offering up a significant amount of their profits to avoid risk, but to the extent that firms are risk averse, multiyear contracting could lower weapons prices. Potential savings due to risk aversion will show up in a valid cost comparison of conventional and multiyear contracts. As we will show later, the current method of calculating savings due to multiyear procurement is not valid. DoD savings estimates cannot be used to support the argument that firms are risk averse.

Note that there is an enormous difference between risk averse behavior and behavior that recognizes risks. The fact that a firm does not behave as if it is sure that a program will be continued does not mean that it is risk averse. Many statements in support of multiyear contracts are really statements that firms consider the risk of contract cancellation when they choose production plans. These statements do not

mean that firms are risk averse; they should not be taken as evidence that multiyear contracts will lower defense prices.

Even if firms are risk averse, there is a serious problem associated with all forms of cancellation contracts. Economists call this problem moral hazard. We have assumed that the firm has no control over the probability that a contract is cancelled. This is not really true. Programs are cancelled not only because of budget cuts but also because of cost overruns and technological problems.* These last two problems are, at least to some extent, controlled by the firm. A cancellation fee acts like an insurance policy. Just as people are less careful about fires--and may even start them--when they have fire insurance, firms may be less diligent about preventing cost overruns and technological problems when they have a contract with a cancellation fee.

If firms are risk averse, and if they do not behave inefficiently when they are protected from loss, then the government can lower the expected cost of weapons system by writing a multiyear contract with a cancellation fee, a contract that shifts risks from the firm to the government. In essence, the government is taking on risk in exchange for lower prices. It is not clear that the government should do this; that issue must be resolved on the basis of how well the government can

* Unexpected cost increases occur even on fixed price contracts because the fixed price must be renegotiated each time the government changes the specifications or the number of items to be procured. In practice, contracts are repriced frequently because of specification and quantity changes and firms are given an opportunity to pass on price increases from other sources.

handle and diversify risk. The lack of widespread risk aversion among firms, however, suggests limited opportunities to make this exchange.

Incorrect Expectations and Contract Prices

There is another case where, in theory, the government can lower the expected costs of weapons systems. If the firm systematically underestimates the probability (π) that the program will be continued, the f it chooses will be too low and the cost for the actual number of expected weapons will not be minimized. In this case, the government can lower expected costs by subsidizing f , inducing the firm to invest more in fixed equipment. This case is illustrated in figure 3.

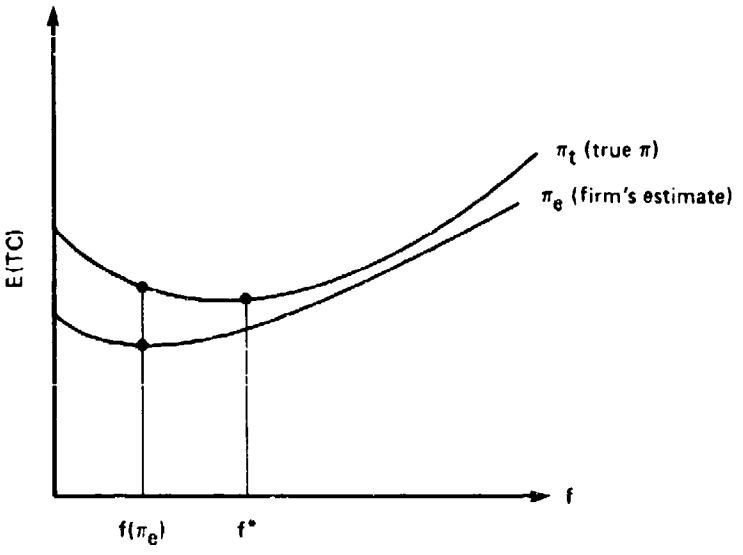


FIG. 3: EXPECTED COSTS AS A FUNCTION OF CANCELLATION EXPECTATIONS

Here the firm believes that the program will be continued with probability π_e, and so chooses fixed investment of $f(\pi_e)$. Expected cost would be lower if the firm chose f^* because the true probability is π_t. With a cancellation fee contingent on fixed expenditures, the government can induce a higher f, perhaps even f^*.

Although possible, this scenario is not, by any means, likely. There is no evidence that firms consistently underestimate the probability that a program will be continued. In fact, it is much easier to make the case that the government overestimates continuation probabilities. The Five Year Defense Plan (FYDP) consistently predicts higher levels of procurement in the outyears than are actually executed when those years come to pass. This consistent optimism, known as the "bow wave effect" in DOD is due in part to persistent and acknowledged underestimates of inflation in future budget years, and in part to underestimates of the actual costs of weapons systems. The net result of this optimism is that rosy plans cannot be executed within budget constraints, so programs have to be stretched out or cancelled. It is not clear, in any event, that we want to label the government's estimate of π as correct and label other estimates incorrect. We note again that if the government is wrong and firms are right, a multiyear contract will raise the cost of weapons systems.

There is another problem with adopting multiyear contracting on the assumption that firms underestimate the true probability of program continuation. To make money on the scheme, the government has to choose the cancellation fee very carefully in order to lower costs. The wrong

cancellation fee could actually raise costs above those that would result from an annual contract. In the case of our hypothetical aircraft firm, if the true probability is π_t (see figure 3) and the firm believes it is π_e, then the firm can be induced to choose the best f, or f*, if the government sets α so that

$$\frac{1}{1 - \alpha(1 - \pi_t)} = \frac{X_1 + \pi_t X_2}{X_1 + \pi_e X_2} . \qquad (9)$$

The righthand side of equation (9) is the ratio of the correct expectation to the firm's expectation about the number of aircraft. If that ratio is equal to one, ($\pi_e = \pi_t$) , the firm has correct expectations and α should equal zero (no cancellation fee). This is a restatement of our previous result. If the firm has incorrect expectations, α should be set as a function of the distance between the firm's expectations and the true state of affairs. The more pessimistic a firm is, meaning the more it underestimates true probabilities, the higher α should be.

Given the difficulty in determining the firm's perception of π, it is not unlikely that the government would set α too high and actually raise costs with a multiyear contract. This situation is illustrated in figure 4.

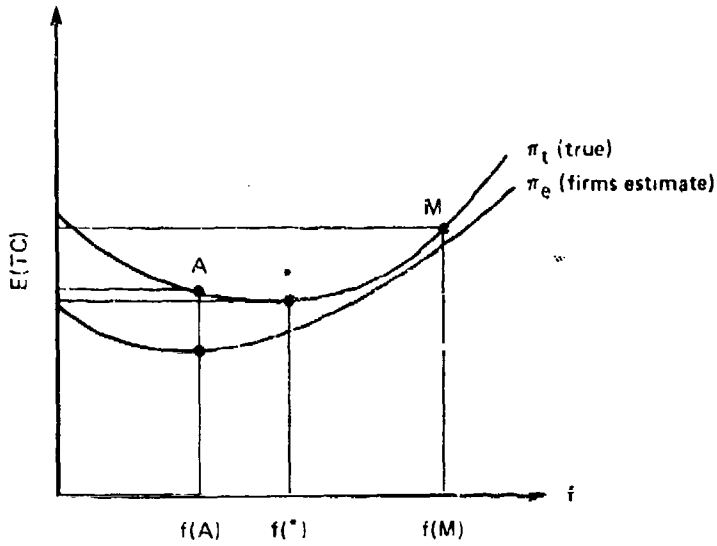


FIG. 4: CANCELLATION FEES AND INCORRECT EXPECTATIONS

The firm believes that π is π_e, while the actual π is higher, equal to π_t. The firm chooses f(A) with an annual contract and the expected total costs are given by point A. When the government offers a multiyear contract with a cancellation fee, the firm chooses f(M) and expected costs are higher than they would have been under an annual contract. In short, the government has to know both the true probability of cancellation and the firm's estimate of this probability and the two have to differ if multiyear contracting is to reduce defense prices. Needless to say, these are stringent conditions.

Instability and Contract Prices

We noted earlier than an increase in the true π does lower the expected costs of weapons systems. If firms correctly perceive that a program is more likely to be funded, they will increase the amount of fixed investment and lower total expected costs. This is undoubtedly what supporters of multiyear contracting have in mind when they say

> "It is the perception of the defense acquisition community that contractors will make substantial investments in defense programs, thus achieving significant cost reductions where the government commits itself to long-term production contracts." (Memorandum from Deputy Undersecretary of Defense (Acquisition Policy) 21 Jul 1980 (enclosure 1)).

The legislative changes obtained by DoD do not, in and of themselves, increase program stability because they do not decrease the probability of program cancellation. Stable programs--programs that are executed on schedule with little chance of cancellation--cost less than unstable programs. But, multiyear contracting does not necessarily increase the stability of a program.

Contracts are cancelled because of (1) technological problems, (2) cost overruns, and (3) explicit budget cuts from Congress, undertaken to achieve some social objective. Multiyear contracts may be used to identify some programs where these risks are believed to be minimal. Thus, they could, under some circumstances, raise the estimate of π for contractors who get multiyear contracts, leading them to produce at

lower costs. With a constant TOA, however, decreasing the probability of some contracts being cancelled must increase the probability of other contracts being cancelled. Consequently, the contractors who have annual contracts will know that they are more at risk and raise their prices. The average price of defense expenditures will not necessarily go down.

It is the third reason that is really the basis for potential gains. Until recently, the Defense budget was a source of many Congressional attempts to either fund social programs or cut the overall budget. A large fraction of government expenditures are "entitlement" programs that do not need to be blessed (appropriated) by Congress each year. These programs, such as Social Security and Unemployment Insurance, live a life of their own, outside the Congressional budget process; they do not need legislation to continue. Multiyear contracting makes the cost of cancellation more visible to Congress, and it may result in a distribution of budget cuts that is more favorable to DOD.

It is clear that DoD wants Congress to perceive the true costs of budget cuts; and program instablity does raise the price of defense. Congress should be aware of the relationships between program instability and prices. They are now being told that prices can be lowered by 10 to 20 percent with multiyear contracts. Large estimates may have a salutary effect on Congress, but DoD must also know the true savings from multiyear contracts if they are to make good decisions about which programs should receive multiyear funding. The risks

associated with multiyear contracts should be compared to correctly calculated savings. While the first part of this paper describes the risks associated with multiyear contracting, the next part of the paper describes how the savings from a multiyear contract should be calculated in order to obtain a valid comparison of the costs and benefits of different types of contracts.

CALCULATING SAVINGS FROM A MULTIYEAR CONTRACT

Table 1 shows DoD's recommended procedure for calculating and presenting savings due to multiyear contract methods.* This exhibit was presented at the Defense Appropriations Hearings for 1982 by Richard DeLauer, Undersecretary of Defense for Research and Engineering. The numbers are fictional but they illustrate how DoD wants the savings calculated, given the different funding requests required under multiyear and annual contracts.

Table 1 shows the yearly (net) budget requests and the cumulative (total) request for a weapons system with annual and multiyear funding. The proposed savings (the last line) is calculated by subtracting the cumulative budget request each year under the two funding/contract schemes. According to DoD's method of calculating savings, the savings from multiyear contracting would be the percentage difference in the total budget request or (4600-3700)/4600 = 20 percent.

* Memorandum from the Deputy Secretary of Defense (May 1, 1981); Subject: Policy Memorandum on Multiyear Procurement, Exhibit No. 2: Estimated Savings from Multiyear Procurement.

TABLE 1
ESTIMATED SAVINGS FOR MULTIYEAR PROCUREMENT
(Millions of Dollars)

	Quantity/amount						
	FY 1983	FY 1984	FY 1985	FY 1986	FY 1987	FY 1988	Total
Annual proposal							
End item	---	40/900	40/950	40/950	40/920	40/880	200/4,600
Less advance funding	---	-220	-300	-280	-260	-250	-1,310
Net request	---	680	650	670	660	630	3,290
Advance funding							
For 1984	220						220
For 1985		300					300
For 1986			280				280
For 1987				260			260
For 1988					250		250
Total budget request	220	980	930	930	910	630	4,600
Multiyear proposal							
End item	---	40/900	40/800	40/750	40/650	40/600	200/3,700
Less advance funding	---	-220	-480	-480	-400	-400	-1,980
Net request	---	680	320	270	250	200	1,720
Advance funding	510	620	400	350	100	---	1,980
For 1984	220	---	---	---	---	---	
For 1985	180	300	---	---	---	---	
For 1986	70	210	200	---	---	---	
For 1987	40	60	150	150	---	---	
For 1988	---	50	50	200	100	---	
Total budget request	510	1,300	720	620	350	200	3,700
Proposed savings	-290	-320	210	310	560	430	900

Suppose that table 1 is based on accurate bids from contractors. Is the savings due to multiyear contracting initiatives really 20 percent? Since the production rate of procurement items is the same under both types of contracts, any savings must come from differences in funding or contracting.

There are two major differences between the two funding proposals in table 1; these differences reflect the legislative changes that DoD is seeking as a part of their multiyear initiatives. The first difference between the two proposals is that the firm gets money sooner under the multiyear proposal; multiyear contracts make the firm eligible for more advance funding than do annual contracts. The second difference between the annual and multiyear contract is that the firm may be eligible for a cancellation fee if the contract is cancelled before 200 units are completed.

These two differences--early funding and cancellation fees--are not costless to the government. The DoD savings calculation treats them as if they are. In essence, a 20 percent savings would be a correct calculation only if the government should be loaning money at a zero rate of interest and only if there were absolutely no possibility of program cancellation. Neither of these conditions holds. The true savings from a program can only be calculated if the time value of money and the probability of cancellation are taken into account.

Time Value of Money

Companies will bid lower if they know they will receive payments earlier in the contract period because they can use the money either to reduce borrowing or to make other profitable investments. This does not mean, however, that the savings to the government from advance procurement is equal to the reduction in bid price. The government can also reduce its borrowing or make profitable investments. This opportunity cost of the money must be taken into account. If it is not, wrong decisions will be made. Suppose that a contractor lowers his price because of advance procurement to an extent that would imply a 5 percent rate of return on government funds. At current interest rates, the real price of this program has gone up. The opportunity cost of this money is considerably in excess of 5 percent. The government could take the money and reduce the national debt or give it back to the taxpayer who must pay rates in excess of 15 percent for mortgages.

The process of comparing two streams of money with different time dimensions is called a present value calculation. The present value calculation uses a process where future dollars are "discounted" relative to present dollars because we value less (or discount) receipts of money that are delayed. The appropriate discount rate is the going rate of return for money invested for the same amount of time.

This process of discounting makes a delayed payment to a contractor look preferable to a current payment, and that is the way it should be. Thus, the first adjustment that must be made to the figures in table 1 to calculate the true savings from multiyear contracting is to

calculate the present value of the expected outlay stream under the multiyear and annual proposal. To do this, we need more information than is available in table 1. Table 1 gives only required requests for obligational authority, not outlays; as we noted before, money will not necessarily be spent when it is obligated. We now turn to an example which permits these calculations.

The first candidate for multiyear funding under the new initiatives was the F-16 airframe. The Air Force began the multiyear program in FY 1982. The F-16 program appears to meet most of the stability requirements for multiyear funding: contractor costs and performance are known from experience and at least some future production seems relatively certain, especially in view of foreign military sales. The program is not without risk, however, since the Air Force plans to upgrade the radar, avionics, and other components. If these upgrades are not possible at the specified prices, the contract is in trouble.

The Air Force has estimated the savings from a 4-year, 1982-85 multiyear contract of 120 F-16's per year at $350 million or about 10 percent. This savings estimate is based on the expected outlay (expenditure) figures given in table 2.

TABLE 2

F-16 PROGRAM OUTLAYS
(Millions of Dollars)

	1981	1982	1983	1984	1985	1986	1987
Annual	12	227	566	811	870	708	140
Cumulative	12	240	806	1,617	2,488	3,196	3,336
Multiyear	92	434	508	635	655	547	114
Cumulative	92	506	1,034	1,669	2,324	2,871	2,985

Source: Memorandum from the Assistant Secretary of the Air Force (Financial Management) (14 July, 1981); Subject F-16 Multiyear Procurement.

The Air Force has followed the DoD recommended method for calculating savings but, in doing so, they have overstated savings. Table 3 shows our calculation of the present, discounted value of outlays under the two types of contracts. The present value is calculated as

$$PV = \sum_{t} \frac{O_t}{(1 + r)^t}$$

where O_t is the dollar amount of outlays in the t^{th} year (82 = the first year) and r is the interest rate (either 10 or 15 percent).

TABLE 3

PRESENT DISCOUNTED VALUE OF OUTLAYS
GIVEN IN TABLE 2

	Annual	Multiyear
10 percent	$2408.3	$2234.8
15 percent	2080.5	1966.8

The Air Force (in a 14 July memo from the Assistant Secretary for Financial Management) has argued that the present value is not the appropriate calculation for computing savings. They use the following example to make their case: Suppose the government has to make a choice between the outlay streams given by the first two columns of numbers in table 4. The Air Force argues that

> "The government would appropriate $600 in either case, whether fully--or incrementally--funded. Although a present value analysis would lead one to choose the first alternative and immediately invest $401 into an interest bearing account to finance the outlays, the government does not do business this way. Assuming the alternative selected would be financed by borrowing (as opposed to raising taxes) and that interest rates are known with certainty, the second alternative would be preferred because of its $2 interest avoidance."

TABLE 4

AIR FORCE EXAMPLE

	Alt. #1 outlays	Alt. #2 outlays	P.V. alt. #1 10 %	P.V. alt. #2 10%	Interest rate on public debt	Alt. #1 interest	Alt. #2 interest
FY N	$100	$250	$ 91	$227	10%	$ 9 (sic)	$25
FY N+1	200	200	165	165	11	22	22
FY N+2	300	150	225	133	12	36	18
Total	$600	$600	$481	$505		$67	$65

Think of alternatives #1 and #2 as two debt repayment schedules. No one would choose alternative #2 over #1; neither should the government. The Air Force has made the wrong calculation because they computed the interest cost for only one year, ignoring which year the money is "borrowed." Interest must be paid for 3 years on FYN dollars and two years on FYN + 1 dollars. When these adjustments are made, it is clear that alternative #2 has higher interest costs and is less attractive than alternative #1.

Other things equal, the government should never choose an outlay stream like #2 over #1. The best choice is the one with the lowest present value. When the present value of the outlay streams for the F-16 are computed, the two streams are quite close at 15 percent, certainly not an unreasonable discount rate. OMB policy stipulates that 10 percent discount rate be used on deflated dollars. Thus the

appropriate discount rate for undeflated dollars like those in table 2 is 10 percent plus the inflation rate.

Probability of Cancellation

The second problem with the 10 percent savings estimate for the F-16 multiyear contract is that there is no estimate for the probability that the program is cancelled. If the expected costs of cancellation are not included in the savings estimate, incorrect choices will be made between annual and multiyear contracts. To illustrate why cancellation probabilities must be included in the savings estimate, we return to the simple two-period example of an aircraft firm. Table 5 shows the bid and expected cost to the government under an annual and a multiyear contract.

The firm will offer a lower bid under a multiyear contract than under annual contract because it expects to get a cancellation fee of αf^{**} with probability $(1 - \pi)$. Suppose the firm is right that the probability of continuation is π, and they are not risk averse. We have shown that, under these circumstances, there is no savings to the government due to switching to a multiyear contract. In fact, the costs could be higher because the firm chooses f^{**} instead of f^{*}. The true cost to the government under a multiyear contract is the bid price plus $(1 - \pi)(\alpha f^{**})$, where αf^{**} is the cancellation fee. If the government does not include the expected cancellation payment in cost estimates, the wrong decision could easily result.

TABLE 5

BIDS AND COSTS UNDER
ANNUAL AND MULTIYEAR CONTRACTS

Annual contract	Multiyear contract
Bid = profits (P) + costs	
$P + [f^* + \frac{b}{f^*}(X_1 + \pi X_2)]$	$P + [f^{**} + \frac{b}{f^{**}}(X_1 + \pi X_2) - (1 - \pi)\alpha f^{**}]$
Expected cost to the government:	
Same as bid or $P + f^* + \frac{b}{f^*}(X_1 + \pi X_2)$	Bid plus expected cancellation fee or $P + f^{**} + \frac{b}{f^{**}}(X_1 + \pi X_2)$

MULTIYEAR CONTRACTS AND FULL FUNDING

The biggest controversy surrounding multiyear contracting is funding. DoD wants multiyear contracts fully-funded. The current DoD policy stipulates that the services must use part of their TOA allotment for funding advance procurement as well as providing money for completed end items. Cancellation ceilings are not funded.

When the services request funding under an annual contract program they must request enough TOA for completing the items in each year of the contract. To fund a program with an annual contract to build 40 aircraft a year for five years, the Air Force must request enough TOA to complete 40 aircraft in each of the program years. The TOA appropriated

the first year may be spent over many years, but no future Congress will have to come up with more money to get 40 aircraft if the program is cancelled after the first year.

The Chief of the Air Force Systems Command, General Robert T. Marsh, believes that requiring TOA for advance procurement will kill multiyear efforts.

> "If we asked for $280 million over and above the F-16 buy for something like spares in multiyear procurement, that can crowd the Air Force and Defense Department budget over a long period, and then no multiyear procurement will succeed. It will get crowded out under the tremendous pressures each year as the budget POMs [program objective memorandums] go to bed."

General Marsh believes that money for spare parts should come from the TOA that is not spent during the initial program year.

> "If you're buying $100 million worth of aircraft, you actually pay about $6 million the first year, $40 million the second, $25 million the third, and it tails off after that. So, you would have idle money to take care of an economical lot buy at the outset without increasing total obligational authority. That way, there would be no pressure on the current POM from multiyear procurement." (Aviation Week and Space Technology, Sept 21, 1981).

How should multiyear contracts be funded? To ensure the correct choice of contracts, two criteria should be satisfied. First, budget

request should accurately reflect the savings from multiyear contracts. The services should not be asked to sacrifice programs to get some programs multiyear funded if, in fact, these multiyear programs generate true savings. Conversely, the services should be allowed new program growth only to the extent of the true savings achieved through multiyear programming. If program cost estimates are artificially lowered because of inflated savings estimates, the services will crowd more programs into a given TOA allowance. This will decrease the executability of the budget, more programs will need to be cancelled, and contractors will raise their prices due to decreased program stability.

To get truly lower defense prices, DoD has to correctly increase contractors estimates of continuation probabilities. Continuation probabilities are a function of the amount of money appropriated per program start. Starting more programs without more TOA will decrease continuation probabilities and increase program turbulence. If multiyear contracts are funded in a way that increases programs by more than the savings due to multiyear contracts, instability will increase and so will defense prices.

These criteria imply that if the Air Force wants to go from an annual to a multiyear contract for 40 aircraft per year for 5 years, the Air Force should request TOA in the first year for all the following:

1. Bid to complete 40 aircraft
2. All the advance funding to be awarded that year

3. The cancellation fee times an accurate estimate of the probability that the contract will be cancelled at the end of the year.*

We have already shown that even though a contractor will lower his bid with a cancellation clause, the true cost to the government is the bid plus the expected cancellation payment, or (3) in the above list. If the only difference between the multiyear contract and the annual contract is a cancellation fee, savings would be measured by the difference between the required TOA under an annual contract and TOA required to fund (1) plus (3) under a multiyear contract. If there are savings from a multiyear contract, the services will be able to sign up for more programs under this proposed funding scheme.

Advance funding is essentially a prepaid cancellation fee, paid with probability one. With advance funding, a firm is fully compensated for allowable items, no matter how many years of the program are executed. Again, the firm will bid lower because of the advance procurement payments. If there are savings from advance payments, then the funding rule suggested above will require less TOA over the funding cycle. The services will reap the benefits of these savings because they will be able to get more programs within their TOA limits.

Advance procurement and cancellation fees are essentially the same, except the firm gets the money earlier with advance procurement. Under our suggested funding rule the services will have to ask for more TOA

* To be exact, the expected cancellation fee should be discounted by one year because it is paid at the end of the year, while advance procurement funds are paid at the beginning.

earlier in a program and less later if they choose advance procurement as a substitute for cancellation fees. Thus, the services are less likely to choose advance procurement because it crowds out other programs. This is a good outcome of the rule because it forces the services to recognize the opportunity costs of money.

In short, the funding rules suggested above will ensure that the services adopt multiyear contracts when, and only when, these contracts lower the price of defense purchases.

ADDITIONAL CONSIDERATIONS

There are some issues that always arise in discussions of multiyear contracting that we have not yet addressed.

Supplies and Services

The preceding analysis has focused on the acquisition of major weapons systems where the decision is whether to produce the system, not who should produce the system. Once a major weapons system has entered the production stage, it is not usually transferred to another producer because the start up costs to a new producer would be prohibitive.

There are, however, other procurement items where the issue is not whether the items should be produced but who should produce them. These are standardized items with a fairly predictable demand, like fuel, copying equipment, or janitorial services. For these items, multiyear procurement can result in savings, so long as the multiyear contract is awarded competitively for a fixed price. The major risk to the

government from optimally awarded multiyear contracts in these cases is that the government is locked into a long-term contract with the producer who is currently most efficient and thus cannot accept bids from new producers who come into the market later. These new producers could have lower prices if they have developed a more efficient production process.

Annual contracts allow for frequent changes to the most efficient producer; a new producer with a better idea can enter the competition quickly. The drawback of annual contracts is that they result in higher bids because producers know they may not win the contract in subsequent years. Multiyear contracts can be designed to optimally balance the costs and benefits of annual contracts.

Suppose, for instance, that the cheapest current producer can produce requirements for one year at $50 per item or two year's worth at $46 per item. He knows that a new producer will enter the market next year and be able to produce at $44. Without a two-year guarantee, the current producer will bid $50 because he knows he will be underbid the second year. The best strategy for the government is to buy for two years from the first producer at $46, and purchase from the third year the second, new producer. Multiyear contracts make these kinds of savings possible.

Many of the savings estimates that are cited in testimonials to multiyear contracting are for supplies and services. It is dangerous to abstract from these savings estimates to savings for major procurement programs. Again, the distinguishing feature between the two areas is

whether a cancelled contract means the end of the program or whether it means the program will be transferred to another producer. Is the government trying to decide who should produce (or whether to produce) the item in a second or subsequent year of the program?

The savings from multiyear contracts for supplies and services are usually calculated by comparing bids from a single contractor for contracts of different lengths. The bid for an annual contract is compared to the bid for a multiyear contract. This is not the true savings from multiyear contracting. The true savings is the lowest bid from all contractors in each year under an annual contract compared to the lowest bid for a multiyear contract. This correct method will produce a lower savings estimate than the normally used method because it allows for lower bids from competing contractors in subsequent years of an annual contract. In our example above, the normal method of calculating savings would be to compare the single year bid from the first contractor ($50) to his multiyear bid ($46). The true savings is not $4 per item, however. The true savings is the difference between the lowest bid for annual contract from all contractors in all years (50, 44, 44; average = 46) and the best price from a multiyear contract $46, 46, 44; average = 45.33). The true savings is $.67 per item.

This lower, more accurate estimate of the savings is nearly impossible to obtain at the start of the program. It could, however, be useful for calculating savings after similar programs with different contracts have been completed. These ex-post savings estimates should be used to predict savings from future multiyear contracts. Savings

calculated the normal way are misleading and will overestimate the true savings from multiyear contracts.

Mobilization and the Industrial Base

One reason why multiyear contracts have received so much support is of the belief that these contracts will improve the industrial base and the ability of that base to mobilize in the event of war. We have shown that multiyear contracts with cancellation fees tied to investment in fixed costs will increase investment. This investment may increase mobilization capability, but it may not be the most cost effective way of achieving mobilization goals. There is no guarantee that multiyear contracting will direct investment where it is most effective for mobilization. Other programs for achieving these goals, such as stockpiling and contingency contracts, need to be evaluated as well if multiyear contracting is to be justified on mobilization grounds.

SUMMARY, CONCLUSIONS, AND IMPLICATIONS

Multiyear Contracts and Defense Prices

Multiyear contracts will lower defense prices only if one of the following conditions prevails:

1. All bidders on a contract are risk averse.
2. All bidders underestimate the true probability that the contract will be continued in subsequent years.
3. Congress cancels fewer programs for non-defense, social objectives because of multiyear contracts.

There is little evidence that any of these conditions exist, especially to the extent that would yield the 10 to 20 percent savings predicted by proponents of multiyear contracts. Moreover, these conditions are necessary, not sufficient; if they exist, the benefits must be weighed against the inefficiencies, risks, and funding problems inherent in multiyear contrating. If they do not exist, multiyear contracting will raise defense prices.

The conclusions above apply only to major procurement programs, where the decision is whether to continue the program in subsequent years. Multiyear contracts may be valuable under a wider range of circumstances for standardized procurement items for which there is a long term, predictable demand. Savings due to multiyear contracts from these programs should not be used to predict savings for major weapons programs.

Calculating the Savings From Multiyear Contracts

Naturally, the best way to find out if there is saving from multiyear contracts is to compare costs to the government under multiyear and annual contracts. The true costs to the government include both the opportunity costs of money and expected cancellation costs. Since neither of these costs is included in current estimates of savings from multiyear contracts, multiyear savings are overstated.

Overly optimistic savings calculations cause two problems. First, they lead to the wrong choice of contract. Second, they increase the

probability of program cancellation and delay because all the funds necessary to complete a project are not included in the budget.

Defense costs increase with program instability. Program instability is caused by program cancellation and delay. If multiyear contracts increase program instablity they will increase, not decrease defense prices.

Funding And Multiyear Contracts

The following funding rule will ensure that multiyear contracts are chosen when and only when they yield true savings to the government: TOA should be allocated for a multiyear contract to cover (1) funds to complete items contracted for in the current year, (2) fully funded advance payments, (3) funds to pay the expected cancellation fee at the end of the year, namely, the cancellation fee times an accurate estimate of the probability of cancellation.

Under this rule, the true savings estimate will be reflected in differences between the TOA requirements for annual and multiyear contracts. Consequently, the services will request multiyear contracts only when they require less TOA and hence, yield true savings.

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