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Chapter Author: Oliver E. Williamson

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The Economics of Defense Contracting: Incentives and Performance

OLIVER E. WILLIAMSON

UNIVERSITY OF PENNSYLVANIA

My purpose in this paper is to examine current practices and trends in defense contracting with a view to establishing what factors are responsible for the performance results obtained and how improved performance might be secured. In particular, I will emphasize the incentives that are experienced by defense contractors and government contracting agencies in negotiating and executing defense contracts. My analysis of these relations leads me to conclude that neither the manipulation of profit incentives nor the monitoring of contract progress can be expected, in any dependable sense, to yield significant improvements in contract performance as long as the specification of the task remains unchanged. From a contractual point of view at least, the "systems approach" to weapons procurement which has prevailed since 1953 [1] appears to be distinctly suboptimal. Whether this is true when viewed more generally will not be a principal concern of mine here, although this issue will be considered at least tangentially in my concluding remarks.

Investigations of defense contracting ordinarily take the existing procurement strategy and institutional arrangements as given.[2] This is the assumption employed in Sections I–III of this paper where I examine current performance results, the attributes of cost-plus-fixed-fee con-

[1] Carl Kaysen considers 1953 to be the year in which the systems approach came into general use as the preferred strategy in weapons procurement. "Improving the Efficiency of Military Research and Development," in *Public Policy, 1963*, ed. by Carl J. Friedrich and Seymour E. Harris, Cambridge, Mass., 1963, p. 233.

[2] A notable exception is the study by Kaysen, "Improving the Efficiency of Military Research and Development."

tracts, and the effects of incentive-fee arrangements. I continue to assume that institutional arrangements are unchanged but relax the assumption of a fixed procurement strategy in Section IV. There I argue that a much more fundamental way by which to improve defense contracting is to decompose the task into technically separable components. The complimentarities between contractural strategies and research, development, and production strategies are also indicated. The argument is summarized in Section V.

I. Economic Performance in the Defense Industries

Principal among the performance dimensions by which an industry is evaluated are efficiency, equity, stability, and technical progress. Since my concern here is not with technical progress as such but with progress per dollar of expenditure, I take as given that progress is occurring and emphasize instead the efficiency aspect of this performance. Equity is mainly concerned with income distribution objectives. Inasmuch as reasonably tight controls over profits and conspicuous expenditure items (salaries, emoluments, and so on) [3] are typically imposed on defense contractors, I assume that equity performance, in some gross sense at least, is satisfactory. Thus the present study emphasizes the efficiency and stability objectives of performance.

Unsatisfactory efficiency performance has been noted recently by Kaysen [4] and Peck and Scherer [5] and has been indicated by previous investigators as well.[6] Although some of the reasons why efficiency performance has been unsatisfactory have gone undetected, at this point I merely accept the judgment that the efficiency goal requires attention and develop the reasons why this might be so in subsequent sections of the paper.

The stability performance of the defense industries has received less explicit attention, although it has often been observed that the varia-

[3] Frederick M. Scherer, *The Weapons Acquisition Process: Economic Incentives,* Boston, Mass., 1964, p. 205.

[4] Kaysen, "Improving the Efficiency of Military Research and Development," pp. 261–262.

[5] See Merton J. Peck and Frederick M. Scherer, *The Weapons Acquisition Process: An Economic Analysis,* Boston, Mass., 1964, pp. 593–594, and Scherer, *The Weapons Acquisition Process,* pp. 314–315.

[6] For example, John Perry Miller, *Pricing of Military Procurements,* New Haven, Conn., 1949.

bility in sales and employment within individual firms over time has seemed unnecessarily high, considering the over-all stability of expenditures on weapons and space development and procurement. However, the stability statistics on sales and employment have never really been developed. A rough estimate of this performance can be obtained by fitting a least-squares-linear-trend line to the annual sales and employment histories of the principal firms in the aerospace industry and the industry aggregate, as well as for firms of comparable size in four other producers goods industries, over the period 1954–1963. The standard deviation of the residuals was then computed and, dividing by the mean level of activity, my measure of variability is the coefficient of variation of the residuals.[7] The results are reported in the Appendix and are summarized in Table 1.

As is quickly apparent from an inspection of column 2, Table 1, both the sales variability and the employment variability for the principal firms in the aerospace industry were higher than the corresponding variabilities among the principal firms in the four other industries. However, as column 6 reveals, the amount of sales variability for the aerospace industry taken as a whole was also higher than in every industry other than steel, and the amount of employment variability in the aerospace industry was higher than in each of the other industries for which this figure could be obtained. If the level of industry variability is taken as indicative of the level of "natural" variability imposed on the firms in the industry, then firm variability should not be considered excessive unless some correction is made for the amount of industry variability experienced.

As is shown in the Appendix, it is possible to devise a measure by which the total amount of firm variability can be corrected for an industry effect. It is necessary, however, to take a complete census of the entire industry in order to make the separation. The cost of doing this would be prohibitive in relation to the needs of the present study. As also shown in the Appendix, however, an approximate correction for the industry effect can nevertheless be obtained. The adjusted estimates

[7] A linear trend is a rough approximation. For the short interval that we are concerned with here, it provided a generally close fit. It is of some interest to note that my correction for trend and analysis of variability is similar to the technique employed by C. E. Ferguson in his study of employment stability in *A Macroeconomic Theory of Workable Competition,* Durham, N.C., 1964, pp. 94–102.

TABLE 1

Variation about Trend, Sales and Employment, Principal Firms and Industry Totals, 1954–1963

(Standard Deviation of Residuals as Percentage of Mean)

Industry	Number of Firms in Sample	Principal Firms				Industry Totals
		Uncorrected		Corrected		
		Average	Standard Deviation	Average	Standard Deviation	
Aerospace	12					
Sales		18.0	6.6	16.0(14.7)[a]	7.4(8.2)[a]	7.5(9.3)[a]
Employment		11.1	3.0	8.3	3.9	7.0
Chemicals	7					
Sales		7.2	4.0	6.1	4.7	3.1
Employment		8.5	6.3	8.1	8.1	1.6
Electrical Equipment	5					
Sales		8.1	3.1	7.2	3.3	3.6
Employment		6.7	2.3	4.0	3.7	5.2
Steel	7					
Sales		10.5	2.3	5.0	4.3	9.1
Employment		7.1	2.1	4.5	3.5	5.5
Aluminum	3					
Sales		6.9	2.0	4.7	2.7	4.9
Employment		6.7	2.1	n.a.	n.a.	n.a.

Source: Appendix.

n.a. Indicates not available.

[a]Industry variability is that of the aircraft industry. The sales variability experienced when all weapons and space development and procurement expenditures are included is shown in parentheses.

are shown in column 4 of Table 1. These corrected stability statistics display substantially the same relations as the unadjusted ones: variability of sales and employment among the principal firms in the aerospace industry is higher than those found in each of the other four industries examined.

It can be argued that variability per se is not necessarily undesirable. It may be that the nature of the task makes high variability a natural result and that it would be very expensive to eliminate it. I return to this issue in Section IV. It is also possible that variability has a therapeutic effect. By confronting the firm with occasional adversity, cost reductions of a fundamental sort might be secured that would not be obtained otherwise.[8] But surely the claims of therapeutic effects require qualification as they apply to the defense industries where the government regards evidence of excess capacity as favorable to contract awards; if adversity is known to be transitory, the incentive to achieve cost corrections is attenuated and the alleged therapeutic effects are correspondingly weaker. Thus, unless task characteristics naturally impose a high level of variability on the firms in the defense industries, so that large systems are necessarily contracted for as units and go through a regular cycle of initiation, rapid growth, peaking, and tailing-off, the high degree of variability observed in the aerospace industry would appear to be without justification. In short, it imposes obvious costs and—task requirements aside—no obvious benefits. This study will therefore proceed as if both efficiency and stability performance in the defense industries leave something to be desired; the question of task requirements is deferred to Section IV.

II. Cost-Plus-Fixed-Fee Contracts

There appear to be three criteria by which defense contracts are awarded: the capability of the contractor, his reputation, and the merits of the proposal. The contractor's capability is measured in terms of his stock of plant and skills. Since previous investment in either equipment or personnel adds to this stock, the prospects that the firm will be awarded contracts in the future can be improved by expenditures of both kinds. Such investments will be further reinforced if evidence of the firm's

[8] For evidence in favor of this proposition see O. E. Williamson, *The Economics of Discretionary Behavior*, Englewood Cliffs, N.J., 1964, Chapter 6.

unused capacity, relative to that of its rivals, weighs favorably in the evaluation of capability.

Capability, which is a measure of the contractor's existing capacity to undertake and complete a task, should be distinguished from his reputation. The latter is concerned with the efficiency and quality of performance of work that the contractor has done previously. Previous cost experience is, of course, an element of reputation; but for a given level of quality, costs in defense work can vary over a wide range and still be considered admissible. Under a systems approach to weapons procurement, technical uncertainties are generally too great and change orders too numerous to assign cost-performance evaluations with confidence. Thus, as I will argue, and as has been observed elsewhere, present practices make it difficult to assign penalties for cost overruns.[9]

The technical merits of the proposal (together with the skill with which it is presented) constitute the third criterion. In contract awards of the magnitude typically involved in the defense industries, much talent and expense go into the preparation and packaging of the proposal, this being the "major instrument of salesmanship in the competition for contracts." [10]

If, as I have suggested, cost performance is difficult to measure, and if, in addition, this efficiency criterion often conflicts with other objectives, a natural displacement of cost performance considerations in favor of other considerations tends frequently to occur. My purpose here is to examine in more detail the incentives and related conditions that have combined to produce this result. I begin with the cost-plus-fixed-fee (CPFF) contract, which (although no longer much used in procuring major systems) has been used often in the past and serves as a convenient starting point for my analysis.

The overriding justification of CPFF contracts is that of cost uncertainty. A degree of uncertainty pervades all R-and-D work, and early production runs frequently involve product modifications and technique developments that render cost estimation on these items difficult. These conditions are well known and hardly require elaboration here. What I want to call attention to is that it is not merely cost uncertainty, but uncertainty together with large size, that is responsible for the large financial risk associated with defense contracts. Were it possible to pool risks

[9] Scherer, *The Weapons Acquisition Process,* Chapter 4, especially p. 101.
[10] Kaysen, "Improving the Efficiency of Military Research," p. 237.

by distributing the firm's efforts across a variety of projects instead of on only a few, then, by the standard theorems on portfolio selection,[11] the risk of ruin could be reduced significantly. If, however, systems are contracted for as a unit rather than by separable components, the financial risk remains high and contractors have been reluctant to bear it.

It would be possible, of course, through the prospect of large profits, to overcome the firm's aversion to heavy financial risk. But the Services are particularly sensitive to public and congressional criticism when contractors earn large profits,[12] and thus the Services have been unwilling to offset the variance inherent in large weapons programs by increasing the expected return. A natural way out of the dilemma is to adopt a CPFF contract.[13] The risk of ruin is removed so that the con-

[11] For a concise statement of the advantages of diversification, see Jack Hirshleifer, "Investment Approaches Under Uncertainty—Choice—Theoretic Approaches," *Quarterly Journal of Economics,* November 1965, pp. 518–520. Briefly the argument can be summarized by examining the following expression for the variance of a sum:

$$\mathrm{Var}(x_1 + x_2) = \mathrm{Var}(x_1) + \mathrm{Var}(x_2) + 2\,\mathrm{Cov}(x_1, x_2).$$

For convenience, let the variance of x_1 and x_2 be equal and given by σ_1^2. Now $\mathrm{Cov}(x_1, x_2) = \rho\sigma_1\sigma_2 = \rho\sigma_1^2$, where ρ is the coefficient of correlation, so that our variance expression becomes:

$$\mathrm{Var}(x_1 + x_2) = 2(1 + \rho)\sigma_1^2.$$

If only one type of program is undertaken so that $x_1 = x_2$ and $\rho = 1$, we have $\mathrm{Var}(x_1 + x_2) = 4\sigma_1^2$. If two different programs are undertaken that are positively but not perfectly correlated, we have $2\sigma_1^2 < \mathrm{Var}(x_1 + x_2) < 4\sigma_1^2$. If the two programs are independent, $\rho = 0$ and $\mathrm{Var}(x_1 + x_2) = 2\sigma_1^2$. Finally, if the two programs are negatively correlated, $\mathrm{Var}(x_1 + x_2) < 2\sigma_1^2$, becoming zero when $\rho = -1$.

It might be argued that the decision to undertake a single, large program is not properly viewed as selecting an x_1 and x_2 for which ρ is unity. This is correct. The coefficient of correlation between the parts of a single program, however, is probably high by comparison with that which typically prevails between separate (independent?) programs.

For an interesting use of this type of argument as it applies to conglomerate mergers, see M. A. Adelman, "The Antimerger Act, 1950–60," *American Economic Review,* May 1961, pp. 241–242.

[12] Scherer, *The Weapons Acquisition Process,* p. 225; the hostility of Congress to "excess profits" is also noted by Kaysen, "Improving the Efficiency of Military Research," p. 249.

[13] Even if the Services were able to offer a sufficiently high risk premium to induce contractors to accept fixed-price contracts, the CPFF contract might rationally be preferred, considering the government's superior ability to bear risk. See Kenneth J. Arrow, "Economic Welfare and the Allocation of Resources for Invention," in *The Rate and Direction of Inventive Activity,* ed. by Richard R. Nelson, Princeton University Press for National Bureau of Economic Research, 1962, pp. 613–614.

tractor is protected. At the same time, moderate profits—but *no more* than moderate profits—are assured, and the Services are also protected.

Assume for the moment that decomposition of the task into many subtasks is technically feasible at zero or low cost. (This assumption is discussed below in Section IV.) Assume also that whenever uncertainty can be avoided at zero cost it will be. If both these assumptions are correct, why has task decomposition failed to occur? The answer suggested here is that the conventional assumption that uncertainty is undesirable fails to hold for defense contracting. It will be argued that *the Services and the contractors both accept task uncertainty because of the beneficial consequences that each associates with it.*[14]

Fundamental to this argument is the proposition that decision-makers attempt to maintain options in the form of opportunities for *discretion* which permit them to pursue their individual and collective interests. The necessary condition for discretion to exist is that a wide range of behavior can be represented *defensibly*. Defensibility can be secured if, in the nature of the task, a wide range of outcomes are *ex ante* possible. And nonuniqueness will result if the task is defined in such a way as to preserve substantial *uncertainty*. Thus uncertainty becomes desirable for the defensibility and the subsequent opportunities to exercise discretion that it provides.

But uncertainty ordinarily produces negative consequences also; risk aversion serves to limit the appetite for uncertainty. However the special institutional arrangements which exist between the Services and their contractors permit contractual adaptations that suppress (and, in the given limit, substantially eliminate) these risk conditions. From the standpoint of both the contractors and the Services, the CPFF contract represents a particularly successful adaptation to risk.

The existence of uncertainty has the advantage to the contractor that it is difficult to assess efficiency-reputation effects with any degree of confidence, while the cost-reimbursable features of the CPFF contract make it attractive to increase current expenditures on items that yield

[14] The emphasis throughout is on task uncertainty. It should be recognized, however, that there are other types of uncertainties that are associated with defense work. Among these is "program" uncertainty, which arises over the possibility that a program will be canceled. Unlike task uncertainty, program uncertainty has, from the standpoint of the contractor, no beneficial consequences associated with it and hence contractors display the usual aversion to uncertainty of this kind.

satisfaction. That is, not only will current expenditures be reimbursed, but the inability to assess cost-effectiveness means that future contract evaluations will be substantially unaffected by any overrun costs that are incurred. Hence the contractor has the incentive to expand those expenditures that improve his future capability, particularly investment in plant and personnel. There is likewise an incentive to relax any burdensome on-the-job pressures designed to achieve operating cost economies, for, under a CPFF contract, in terms of forgone profits, the cost of relaxing pressure is effectively zero. The argument is simply an application of the principle that when the relative price of commodity is reduced, more of the commodity will ordinarily be consumed. Similarly, when the penalty for relaxing an effort which yields individual disutility is reduced, less effort of this sort will be forthcoming.

The difficulty of assessing cost-performance reputation effects, and therefore the difficulty of assigning penalties, deserves further discussion. These difficulties arise from the variety of factors that, in principle, can contribute to large cost overruns on contracts that involve uncertainty and extend over a period of years. Typically these factors have two characteristics: their existence is easy to establish qualitatively but difficult to estimate quantitatively. Price and wage changes are among the factors making for uncertainty, as also are changes in technology that may give rise to revised systems requirements of indeterminate cost. But even if neither of these types of changes occurred, the very existence of substantial cost uncertainties at the inception of the task may be invoked as the reason for the overrun. As long as cost overruns, for whatever reason, can be made "defensible," penalties for previous cost excesses will be difficult to assign.

As indicated above, cost-reimbursement type contracts in which overrun penalties are weak or lacking will produce two effects: there are incentives to expand those expenditures that improve the contractor's future capability and to relax any burdensome on-the-job pressures designed to achieve operating cost economies. Of these effects, the one that I wish to emphasize is the tendency to expand "investment" type expenses and thereby improve capabilities. These effects are investigated in more detail in Section III. Very briefly, I argue that wherever the prospects of future contract awards are enhanced by currently expanding technical staff and by acquiring technical experience, present staff expenditures will be increased accordingly. More precisely, a firm will

employ additional personnel up to the point at which the discounted value of current and expected *future* benefits is equal to its *current* marginal cost.[15] Under CPFF contracts current marginal cost is zero. The government reimburses the whole of these expenses and the contractor bears none of the cost. Although this is actually an overstatement, for cost constraints are sometimes invoked and some types of expenses may be disallowed, staff may be expanded enormously, with a tendency to favor in-house R and D rather than to contract the work out. In support of this, Scherer observes that there is a tendency to hoard

> . . . engineers, technicians, skilled production workers, and administrative personnel not required on current contracts but useful for winning and executing future contracts. . . . Performing work "in house" which could be done more efficiently by specialist vendors is another means . . . of building up new capabilities for future business. Engaging in technical tasks and buying equipment essentially unrelated to an ongoing development effort also enhances an organization's ability to compete in new fields for profitable future contracts.[16]

The fact that this expansion of staff and in-house capability provides the contractor with the type of advantages described is evidenced by the high frequency with which the Services use differences in capability (prior investment in the stock of plant and skills) as grounds for justifying negotiation rather than competitive bidding in awarding procurement contracts. As Hall and Johnson have observed, negotiations of this type tend to produce a "locked-in" effect, where the award of the contract is no longer an issue but only its terms. They go on to note that in 1964 the Air Force used capability-related differences to justify the award by negotiation rather than competitive bidding of 52 per cent of its new contract obligations for components procurements and 95 per cent of its new contract procurements of complete weapons systems.[17]

Consider now the reasons why uncertainty and the institutional circumstances which surround it may also be valued by the Services.[18] The

[15] This assumes that there is no continuing employment commitment for staff and that severance costs are negligible. These are rough but probably close approximations.

[16] Scherer, *The Weapons Acquisition Process*, p. 183.

[17] George R. Hall and Robert E. Johnson, *A Review of Air Force Procurement, 1962–1964*, RM-4500-PR, The RAND Corporation, May 1965, pp. 83–93.

[18] Kaysen observes that the CPFF contract has been used "because it is necessary, not because the Services have desired it. On the contrary, both the tradition and the statutory framework of government procurement within which

principal reason why task uncertainty is likely to be valued by the Services is the ready defensibility that it provides. Task uncertainty frees not only the contractor but also the Services from critical efficiency reviews. Unable to ascertain efficiency performance in any fundamental sense, congressional attention is shifted to an examination of profits and conspicuous-expenditure items. But CPFF assures that no windfall profits will be realized and hence criticism from this quarter is also forestalled. Assuming that tight controls are exercised over salaries, advertising, travel, entertainment, and so forth (and the evidence suggests that these are in fact closely scrutinized),[19] the Services together with their contract-negotiating and administrating officials are unlikely to be found vulnerable.

Since, as Enthoven and Rowan have pungently observed "the Services are concerned primarily with the defense of the United States and not with saving the taxpayers' money," [20] the Services may not only feel secure in approving costs of a technical nature (both operating and "investment" types) which, given task uncertainty, require expertise to evaluate, but they may actively support such expenditures. Put somewhat differently, there is a natural tendency in most organizations to regard the opportunity cost of money in other uses as rather low; and the development of a broad capability by each contractor enhances, from the Services' point of view, the defense posture of the country.

A final if indirect reason why the Services may value (or at least accept) uncertainty, arises from the positive relationship between program size and uncertainty. Large programs tend to be both more uncertain and more "glamorous" (for example, the "man on the moon program"), and because of this glamour it may be easier to obtain public support for them. Moreover, they secure a commitment which, while subject to stretch-out or modification, is infrequently canceled outright.[21]

the Services operate emphasize competitive bidding on a fixed price basis" ("Improving the Efficiency of Military Research," p. 243). Surely Kaysen is correct in diagnosing the need for the change and the natural reluctance of the Services to make the shift. But one should guard against concluding that once the shift was made that the Services found the CPFF arrangement undesirable and that a preference for fixed price contracts remains. Learning to live with CPFF may not have been so painful after all.

[19] Scherer, *The Weapons Acquisition Process,* p. 205.

[20] Alain Enthoven and Harry S. Rowen, "Defense Planning and Organization," in *Public Finances: Needs, Sources, and Utilization,* ed. by James M. Buchanan, Princeton, N.J., 1961, p. 381.

[21] Scherer, *The Weapons Acquisition System,* pp. 320–321.

For these reasons, as well as for the reasons of providing defensibility and enhancing capability, uncertainty has practical advantages for the Services. Since both contracting parties benefit from it, it is scarcely surprising that efforts to reduce uncertainty by partitioning the task rather than following a unified-systems-approach have not been favored.

III. Incentive Fee Contracts

To the extent that cost uncertainty has *net* advantages from the point of view of both the contractor and the Service negotiators, it is only reasonable to assume that both display some preference for it. Earlier treatments of defense contracting have ignored these advantages and thus, in my view, have provided incomplete explanations for the overrun conditions observed in the weapons acquisition process. Likewise, the failure to distinguish between operating and investment expenditures has frequently obscured the analysis of overrun tendencies. Nevertheless, it has long been recognized that overruns have been excessive and that incentives for cost control have been weak under the CPFF form of contracting. As a remedy for this condition, incentive-fee contracts have been employed. These contracts permit the contractor to retain some of the cost savings when an underrun is experienced and require him to bear part of the cost burden when target costs are overrun. Incentive payments are also occasionally tied to technical performance and delivery time, but I will focus on the cost-incentive problem.

The Defense Department has recently attempted to shift away from CPFF contracts to those with profit-incentive features. Between 1961 and 1965, CPFF contracts as a percentage of total contract awards were reduced from 38 per cent to 9.5 per cent. The Secretary of Defense reports that, "At a minimum, our analyses indicate that 10 cents is saved for each dollar shifted from CPFF to other forms of contracts." [22] Among

[22] Memorandum from the Secretary of Defense to the President, *Department of Defense Cost Reduction Program—Second Annual Progress Report,* July 7, 1964, p. 8. The estimated 10 per cent savings is incredibly stable. In fiscal 1963, $4.3 billion in contracts were converted from CPFF with estimated savings of $ .436 billion. In 1964 the corresponding figures were $6.2 billion and $ .616 billion, while for 1965 they were $6.6 billion and $ .658 billion. *Department of Defense Cost Reduction Program—Third Annual Progress Report,* July 14, 1965, p. 39.

the factors that are said to be responsible for these savings are: (1) more detailed precontract planning, (2) fewer and smaller cost overruns, and (3) improved weapon system performance. Unfortunately the detailed basis for the estimated savings of 10 cents per dollar shifted out of the CPFF form is not provided. Lacking such support these claims appear to be highly conjectural and, for reasons that I will develop shortly, may be entirely specious.

The fact that there are subtle problems in interpreting the effects of incentive contracts has been widely recognized—by the Department of Defense,[23] as well as by numerous economists who have been concerned with the weapons acquisition process. The present analysis reaffirms this view. Indeed, I conclude that the behavioral assumptions required in order to establish, *a priori,* the direction of the effect of profit incentives on cost performance are quite implausible, and a very sophisticated statistical analysis would be required to determine the magnitude of the effect.

1. BARGAINING BEHAVIOR

The principal difficulty in evaluating the effect of incentive contracts on cost performance rests on the negotiation of target costs. If negotiated target costs are identical under both types of contract, and if the technical characteristics of the tasks to be performed are similar, the observation that target costs tend to be overrun using CPFF contracts but underrun when a positive sharing rate is employed clearly suggests that costs are more carefully controlled by the firm under profit-incentive contracts. But the assumption that estimated target costs are unchanged is very much open to question.

It is generally accepted that the contractor is inclined to underestimate full costs when CPFF contracts are used, in order to improve his prospects for winning the contract. And the Services may, at least tacitly, encourage such underestimation to gain budgetary support for the program, while later agreeing to additional fees on overrun costs.[24] A substantial identity of interest between the contracting parties exists in these circumstances. When contracts are shifted to an incentive-fee basis, how-

[23] Department of Defense, *Incentive Contracting Guide,* 1963, especially pp. 5–23 and 52–54.

[24] Scherer, *The Weapons Acquisition Process,* pp. 27, 131, 157.

ever, a penalty for overruns is operative. Here, I would expect that either the attitude of the contractor toward the bargain would harden or that a tacit understanding that task uncertainty will be resolved in the contractor's favor through change orders and contract amendments would exist (or both). Let us examine the shift in bargaining posture first.

Although an underestimation bias exists when CPFF contracts are in force, an overestimation bias may operate when incentive-fee contracts are used; for the greater the differential between negotiated target costs and true expected costs, the larger the potential profit return to the contractor. Thus, if we let π be expected profit, π_T be negotiated target fee,[25] C_T be negotiated target cost, C be expected cost, and α be the sharing rate, we have $\pi = \pi_T + \alpha(C_T - C)$. Under CPFF contracts, α is zero and hence the last term vanishes. When a positive sharing rate is selected, however, the cost difference between negotiated and expected cost necessarily affects profits; and to assume that bargaining behavior is unaffected by this change in circumstances is unwarranted.

It is possible, of course, that any toughening of the attitude on the part of the contractor would be offset by a corresponding toughening in the attitude of the bargaining agent for the government. Indeed, it has been argued that the government, as almost the sole purchaser, has an enormous advantage in its dealings with defense contractors. Moore observes, however, that the government has been either unable or unwilling to realize this monopsonistic bargaining advantage, and suggests that one reason is that it "lacks the skills and resources to make the necessary technical and cost evaluations of contractors' proposals, but instead must rely on information supplied by the firm." [26] Although it is unquestionably true that the government suffers from an information disadvantage, this is normally the case for the buyer in most buyer-seller relationships. Why should the government be decisively less skillful in its representation for this reason? Indeed, it could be asked, Why should an information disadvantage prove to be a bargaining disadvantage at all? As Schelling has argued (and experimental evidence does not controvert, the bargainer with complete information is apt to take a

[25] In practice, negotiated target profit is an increasing function of the sharing rate, α.

[26] Frederick T. Moore, *Military Procurement and Contracting: An Economic Analysis*, The RAND Corporation, RM-2948-PR, June 1962, p. 54.

more "reasonable" position than his counterpart whose incomplete information inclines him to bargain "tough." [27]

Among the conditions frequently cited as evidence of the bargaining disadvantage of the Services are scarcity of eligible contractors, importance of maintaining each source of supply, nonstandard character of the product, smallness of lot sizes, and so on; but parallels could probably be found among firms bargaining among themselves in the private sector—and the information disadvantage of the customer does not appear to have such overriding consequences.[28] Thus there must be special disadvantages that the government's bargaining agents experience in negotiating contracts with the private sector. Political considerations aside, I would suggest that there are two: asymmetry in rewards, and disparity of status between bargainers.

Consider first the asymmetry of rewards. I take the objective of the Service negotiator to be the "responsible" placement of contracts—by which I mean placement of contracts with organizations that have the competence to successfully complete the task and under terms that protect against gouging. The objective of the contractor's negotiator is to secure contracts which provide opportunities for discretion while simultaneously promising an adequate rate of return and protection against devastating losses. As indicated above, the joint interests of both parties under a CPFF contract lead frequently to an underestimation bias. The Services prefer such a result if it is easier to secure budgetary support when program costs are underestimated, and cost underestimation provides them with greater discretionary control over the execution of the

[27] T. C. Schelling, "Bargaining, Communication, and Limited War," *Journal of Conflict Resolution,* 1957, pp. 19–36. In experimental sessions, differences in bargaining outcomes have been obtained in the direction predicted by Schelling, but not significantly so (see Sidney Siegel and L. E. Fouraker, *Bargaining and Group Decision Making,* New York, 1960). Although the experimental bargaining situations that they investigated do not obviously generalize to the circumstances that we are concerned with, neither should we want to dismiss out of hand the possibility that incomplete information may have advantages. Probably the most important difference to be noted between the Siegel-Fouraker experiments and defense contract bargaining is that the bargainer with full information in the experiments was unable to communicate the details of his knowledge to the other party, whereas this is not the case for defense contracting. An interesting bargaining experiment is obviously suggested: How is the bargaining outcome affected when communication between parties is unrestricted and one party has complete while the other only partial information?

[28] This is not to say that such parallels are common, but only that they exist and can be successively adapted to within the private sector.

contract. (This latter point has, so far as I can determine, gone undetected in previous studies of defense contracting. It may, however, be a principal factor in explaining underestimation bias, and it introduces a certain subtle kind of rationality into such behavior. From the standpoint of control, an underestimation bias may well be desirable.) The contractor is apt to yield to these preferences, particularly if plant idleness is threatened otherwise and the prospects for securing amendments which recover the normal rate of return on overruns are favorable.

Given an incentive-fee contract, however, the contractor's position becomes much more vulnerable, and this is evident to both parties to the bargain. Despite the fact that implicit "understandings" that cost overruns will be covered by contract amendments may exist, these are quite unenforceable and given the caprices of politics, the contractor is unwilling to accept the same low target cost figure that he would with a CPFF contract. By mutual consent, therefore, an increase in target costs over the CPFF figure naturally results when incentive fees are introduced. If indeed this description of bargaining behavior is at all representative of true preferences and attitudes in defense contracting, clearly the notion of "arms-length" bargaining is quite inappropriate to an understanding of this phenomenon.

Status differentials may also influence the outcome of the negotiations.[29] Thus, I would suggest that where such differentials exist, the low-status bargainer tends to defer to the high-status bargainer and is inclined to adopt a less vigorous bargaining posture. Exceptions are possible of course, but on the average I would expect such attitudes to prevail. In the present circumstances it would appear that inferior status is generally imputed to the civil servant relative to his counterpart in private industry. Moreover, for the civil servant, taking a tough bargaining posture may well expose him to contempt rather than enhance his professional recognition. The structural advantage (monopsony power) that the government's bargaining agents possess indeed makes it difficult for them to adopt a tough bargaining stance. To do so is to invite the charge of an arbitrary exercise of power that is attributable neither to negotiating skills nor superior performance in a prior period, but is merely the result of structural leverage. As with most professionals, the status of the Service negotiators depends jointly on the evaluations of their em-

[29] Kaysen, "Improving the Efficiency of Military Research," p. 261.

ployer and of the profession with which they identify. If the Service's rewards for tough bargaining are weak, a tendency to make concessions in order to obtain professional favor seems likely. A more conciliatory bargaining stance may seem an appropriate way to secure such favor.[30]

Thus, I suggest that the importance of imperfect knowledge of the character (and hence cost) of the product is not so much that imperfect knowledge leaves the government's negotiators at a bargaining disadvantage, but that it permits nonobjective considerations to influence bargaining behavior. Where knowledge of the product and costs is complete, the appropriate target cost is fully specified. Where this is not true, however, a range of outcomes is possible so that the individual and collective objectives of the parties and the differences in bargaining posture can affect the negotiations. When CPFF contracts are used, the joint preferences of the parties tend to bias the negotiated target cost downward. However, an adjustment upward can be expected to occur when strong profit-incentive features are employed. Such upward adjustments may be quite desirable from the viewpoint of the Office of the Secretary of Defense, as long at least as realized costs do not increase significantly as a result (a possibility which my analysis makes clear but which the OSD appears to ignore). It provides the OSD with somewhat better planning data and tends to weaken the interest identities between the Services and their contractors.[31]

2. THE SHARING RATE AND INVESTMENT EXPENSE

I consider now the effects of increasing the sharing rate on "investment" expenses. Assuming that the firm is operated as a profit-maximizer, an increase in negotiated target costs encourages additional expenditures on investment expense while an increase in the sharing rate makes it less attractive to incur current-period expenses that yield future-

[30] These propositions would appear to be testable in laboratory bargaining investigations. In support of this general position we note Scherer's observation that, "Service officials deliberately refrained from pressing for development cost reductions because they wanted to maintain amicable contractor relations, anticipation that a friendly contractor would turn in a quicker and better development job." *The Weapons Acquisition Process,* p. 33. I would suggest that amicable relations are valued by the contracting officers and technical personnel of the Services whether or not they lead to these performance results. Indeed, if there is a correlation between attitude of the Services and performance results, I would predict it is the opposite of that suggested above.

[31] I am indebted to M. J. Peck for calling my attention to this possibility.

period benefits. But an increased sharing rate designed to discourage expenditures on internal technical and administrative expenses may be partly (or even wholly) offset by an increase in the target cost, as discussed above.

These relations can be investigated somewhat more formally with the following model. Designating the participation rate (or "sharing" rate) in overruns and underruns as α, the negotiated target profit as π_T, the negotiated target cost as C_T, and actual cost as C_A, actual profit is given by

$$\pi_A = \pi_T + \alpha(C_T - C_A), \tag{1}$$

where all the terms refer to current-period results. My objective is to elaborate the model and extend it to include multiperiod effects.

First we look at the components of current-period cost. These are of two types: current-period operating costs, C_1, that are mainly of a direct-cost nature, and current-period "investments" in staff expenditures, S_1, that both contribute to current performance and provide the firm with a future-period capability and tend to be of an indirect-cost nature. Neglecting overrun penalties (reputation effects), these latter expenditures improve the contractor's eligibility for future-period awards.

Target profit can be broken down into target revenue less target cost. Letting ρ be the target rate of return over target cost, and assuming that

$$\rho = \rho(\alpha); \frac{\delta\rho}{\delta\alpha} > 0, \frac{\delta^2 o}{\delta\alpha^2} < 0 \tag{2}$$

we have target revenue given by

$$R_T = [1 + \rho(\alpha)]C_T. \tag{3}$$

Actual revenue is given by

$$R_A = R_T + (1 - \alpha)(C_A - C_T) \tag{4}$$

so that expected actual current period profits, as given by (1), can be expressed as

$$\pi_A = R_A - C_A = \rho(\alpha)C_T + \alpha(C_T - C_1 - S_1). \tag{1'}$$

The analysis can be shifted into a two-period context (the generalization to a multiperiod analysis being a simple extension of the two-period model) by letting R_2, C_2, and S_2 be revenue, direct cost, and staff expenditure respectively in period 2 and by denoting the discount factor by

V, where $V = 1/(1 + r)$ and r is the discount rate. Since future-period awards are a function of current-period capability and reputation for cost control R_2 is expressed as

$$R_2 = R_2(S_1, Z_1, \ldots) \tag{5}$$

$$\frac{\delta R_2}{\delta S_1} > 0, \frac{\delta^2 R_2}{\delta S_1^2} < 0 \quad \text{"capability" effect}$$

$$\frac{\delta R_2}{\delta Z_1} < 0, \frac{\delta^2 R_2}{\delta Z_1^2} < 0 \quad \text{"reputation" effect}$$

where Z_1 is the excess of cost over the allowable overrun in period 1 and is defined as

$$Z_1 = C_1 + S_1 - (1 + \gamma)C_T$$

where γ is the overrun allowance.[32]

The objective of the firm is assumed to be the maximization of discounted profits subject to the constraint that the "yield" of C_1 and S_1, given by $f(C_1, S_1)$, where $\delta f/\delta C_1 > 0$, $\delta f/\delta S_1 > 0$, satisfies the performance specifications $\bar{P}_1$. Formulating the problem as a Lagrangian we have:

$$\max L(C_1, S_1, \lambda) = \rho(\alpha)C_T + \alpha(C_T - C_1 - S_1) + (R_2 - C_2 - S_2)V + \lambda[f(C_1, S_1) - \bar{P}_1] \tag{6}$$

From the first order condition for a maximum we obtain the following marginal rate of technical substitution relation:

$$-\frac{dS_1}{dC_1} = \frac{\dfrac{\delta f}{\delta C_1}}{\dfrac{\delta f}{\delta S_1}} = \frac{-\alpha + \dfrac{\delta R_2}{\delta Z_1} V}{-\alpha + \left(\dfrac{\delta R_2}{\delta S_1} + \dfrac{\delta R_2}{\delta Z_1}\right) V} \tag{7}$$

This is shown graphically in Figure 1.

The system is constrained to operate along $\bar{P}_1$. Current costs will be minimized by operating at the point where the 45 degree line is tangent to the locus $\bar{P}_1$, namely at E. Since the absolute value of the numerator exceeds that of the denominator in equation (7), however, the firm will operate at a position on the locus above E. It will, in other words, favor staff expense due to the capability advantage this furnishes in period 2.

[32] I assume that R_2 is separable, so that $\delta^2 R_2/\delta S_1 \delta Z_1 = 0$, and that γ is an increasing function of the cost variance.

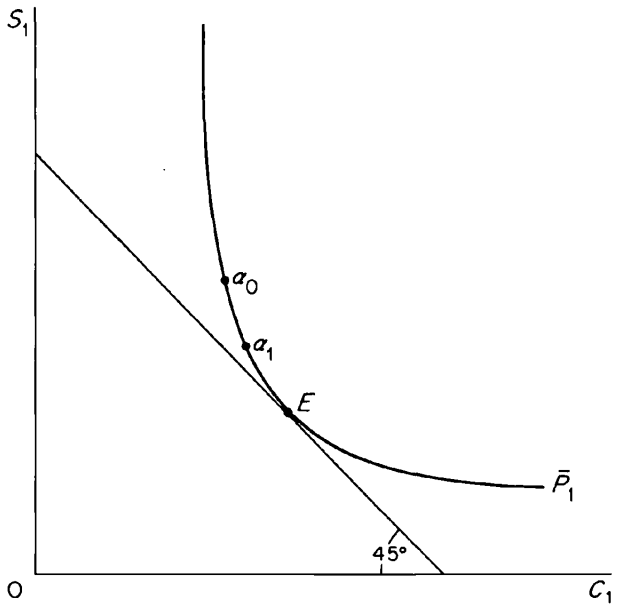

Figure 1

Differentiating (7) with respect to α, and assuming that C_T is unchanged, yields a decrease in the marginal rate of technical-substitution expression, implying that operating costs will be substituted for staff expense as α is increased (say from α_0 to α_1 in Figure 1). Put differently, low values of α induce relatively large expenditures on those costs that most contribute to future-period capability (S_1), and as α is increased, these staff expenditures are progressively reduced.

Replacing the assumption that C_T is unchanged by one in which C_T increases as α increases prevents us from assigning these directional effects unambiguously. This derives from the fact that increasing C_T suppresses the reputation effect. That is, differentiating (7) with respect to α with $\delta C_T/\delta\alpha > 0$ leaves the sign of the change in the marginal rate of technical substitution uncertain and the response of S_1 to α cannot be determined on purely qualitative grounds.

Differentiating (7) with respect to C_T, however, yields unambiguous directional-response adjustments. Here the marginal rate of technical substitution is increased in response to an increase in C_T, implying that S_1 will be increased as C_T increases and reduced as tighter target

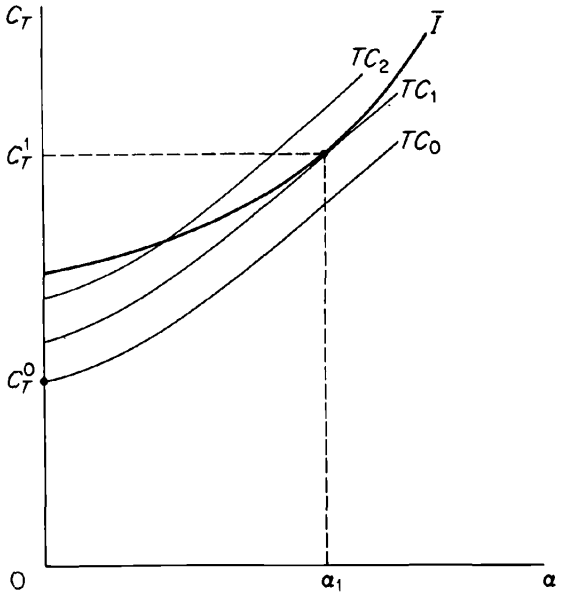

Figure 2

costs are negotiated. In some superficial sense it would appear that more dependable results can be secured through target-cost control than by manipulating the sharing rate, and this implication is reinforced by the fact that the same types of qualitative properties are obtained from a utility-maximization model in which profits, staff, and operating slack (on-the-job leisure) are principal components.[33] Thus we might be led to conclude that although manipulating the sharing rate may lead to tighter expense control, this is by no means inevitable, and thus reducing the target cost is the preferred technique for securing expense control.

Several qualifications are necessary before uncritical acceptance of this line of argument is warranted. First, within the context of the profit-maximizing model, reducing C_T leads to reductions in S_1 only to the extent that the "reputation" effect can be meaningfully enforced. As I have pointed out above, this is difficult where task uncertainty is great. In the utility-maximizing model, reducing C_T shrinks profits directly, and thus induces tighter expense control whatever the reputation effects, but in practice this is effective only if subsequent contract amend-

[33] O. E. Williamson, *Defense Contracts: An Analysis of Adaptive Response,* The RAND Corporation, RM-4363-PR, June 1965, pp. 21–29, 56–62.

ments are not permitted to swamp the initial agreement. Again this latter is a serious threat whenever task uncertainty is great. Second, C_T can be reduced only by mutual agreement of both parties to the contract, and presumably there comes a point below which the marginal reduction in C_T does not justify the bargaining costs. Third, the possibility of using the sharing rate in conjunction with the target cost should be considered. If the contractor possesses a trade-off surface between C_T and α such as that shown in Figure 2, the government negotiator would ideally view his task as choosing that pair of α and C_T values on the indifference locus $\bar{I}$ so as to induce least-cost performance (selection of S_1 and C_1 values close to E on $\bar{P}_1$ in Figure 1) [34] of the contract.

As drawn, the indifference locus $\bar{I}$ is discontinuous at $\alpha = 0$. This implies that the shift in a contract from a zero sharing rate (CPFF) to incentive-fee status produces a difference not merely in degree but in kind. A continuing interdependency relation supported by implicit "understandings" notwithstanding, the circumstances surrounding an incentive-fee contract, even at a low sharing rate, are sufficiently different from the atmosphere that prevails under CPFF that a discontinuity at $\alpha = 0$ appears. Both the shift in bargaining postures (as described above) and in contract-execution relations are responsible for this result. As with a marriage contract, to use a somewhat imperfect analogy, only a "little bit" of infidelity is enough to undermine the relationship.

Both the magnitude of the discontinuity at $\alpha = 0$ and the shape of the $\bar{I}$ curve in the positive sharing-rate region are affected by the degree of contract uncertainty. More precisely, the gap increases and the slope of the indifference curve increases as uncertainty becomes greater, since positive sharing rates are more risky in these circumstances. This is of particular relevance when the properties of the isocost curves are allowed for.

The family of curves shown as TC_i represent isocost curves and derive from the assumptions, implicit in the model described in equations (1)–(7), that

$$TC = g(C_T, \alpha); g_{C_T} > 0, g_\alpha < 0 \tag{8}$$

$$g_{C_T}{}^2 < 0, g_\alpha{}^2 < 0$$

[34] This neglects effects of changing C_T and α on target profit. This simplifies the analysis and does not effect the results in any significant way.

The isocost curves necessarily have the property that $d(TC) = 0$, so that taking the total differential of (8) subject to this condition we have:

$$\frac{dC_T}{d\alpha} = -\frac{\delta g/\delta \alpha}{\delta g/\delta C_T} > 0$$
$$\frac{d^2C_T}{\delta \alpha^2} = -\frac{(dg/\delta C_T)(\delta^2 g/\delta \alpha^2) - (\delta g/\delta \alpha)(\delta^2 g/\delta C_T{}^2)}{(\delta g/\delta C_T)^2} > 0 \tag{9}$$

whence the shape of the family of isocost curves shown in Figure 2 follows directly. As drawn, the lowest attainable total cost is given by the curve that passes through $\alpha = 0$, the corresponding target cost being $C_T{}^0$. If, however, a positive sharing rate is required by the Secretary of Defense, TC_1 is the lowest cost that can be realized, the optimum sharing rate and target cost being α_1 and $C_T{}^1$ respectively. The large increase in $C_T{}^1$ over $C_T{}^0$ should be noted.

As the size of the discontinuity in $\overline{I}$ at $\alpha = 0$ decreases and as the slope of $\overline{I}$ decreases, both of which will occur as contract uncertainty is reduced, CPFF becomes progressively less advantageous and indeed eventually becomes suboptimal. Put differently, least-cost tangency between the isocost curves and the indifference locus at a positive sharing rate becomes more likely as uncertainty is reduced. Since the resulting tangency would occur on a lower isocost curve than that which passes through $\alpha = 0$, expected total costs would decrease. If, simultaneously, reducing uncertainty shifts the family of isocost curves upward, this result is all the more likely. This is not to suggest that lower costs are automatic; this also requires intelligent bargaining behavior. But since reducing uncertainty also limits the range of defensible bargaining postures, such a result seems probable. That the model has the property that positive sharing rates become desirable when uncertainty is relatively low is a condition which has long been intuitively plausible, but has hitherto lacked analytic content.

The relevance of this analysis for optimum institutional arrangements might also be indicated. If tasks are frequently defined in such a way that uncertainty remains large so that $\alpha = 0$ is the preferred contractual arrangement, yet CPFF is known to possess inherent expense control deficiencies, should the government circumvent this condition by performing more of its own research in-house? Although this possibility deserves serious consideration, it takes us beyond the scope of the pres-

ent investigation. I suspect, however, that it is not politically feasible, and that it involves expense control difficulties of its own. Rather, the task-partitioning approach described in the following section seems more attractive instead.

In a related vein, if $\alpha = 0$ is frequently the preferred contractual arrangement for defense contracting, might this also be true within the private sector in circumstances where task uncertainty, for whatever reason, is large? At least occasionally I would expect this to be true, and in such circumstances an economic justification for vertical merger exists. But again this raises a variety of difficult issues that take us beyond the scope of the present paper. My purpose here is merely to point out the relevance of the present analysis for the study of contractual relations outside of the defense-contracting area.

Finally, the question of appropriate contractual objectives deserves mention. It might be argued that least-cost performance imputes too limited a purpose to the government negotiator, and that concern for future-period capability should also be his legitimate concern. In my view, however, capability can be achieved by directly supporting those programs which provide it, and the introduction of considerations of this sort into every contract unnecessarily confuses objectives and leads to precisely that type of loss in reputation effect that we have been attempting to avoid. I therefore propose that the appropriate goal in every contract should be the least-cost performance of a reasonably narrow set of objectives. Where hardware is needed, obscure future-period capability considerations should therefore not be permitted to displace the least-cost achievement of this end. If instead future-period capability is the principal objective, research that is explicitly directed to this purpose should be supported and ongoing or projected hardware programs should not be made to bear expenditures of this sort. Put differently, insistence on global rather than local contracting goals leads to a diffusion of purpose and consequent loss of control that is sub-optimal.

IV. A Possible Alternative Approach

The principal implications of the foregoing analysis are that (1) the sharing rate cannot be arbitrarily set without regard for target-cost adjustments, and (2) the most dependable way of securing expense con-

trol may be to arrange the task so as to permit binding reputation-effect evaluations. Only when reputation effects are made binding does the negotiation of C_T have genuine significance, and only when C_T is chosen meaningfully does the selection of "optimal" values of α have real cost control importance. In some respects my analysis thus supports the Hitch and McKean proposition that "the real opportunity for savings and strengthening incentives may lie in improving the procedure for the setting of cost targets." [35] Similarly Dupré observes that "the most important initial step that can be taken to improve efficiency in weapons procurement is undoubtedly to strengthen the government's ability to evaluate technical proposals, negotiate contracts, and supervise performance." [36] But correct as this may be, such advice is futile unless it is accompanied by a set of operational procedures by which the indicated improvement can be secured. The fundamental change required in order to realize these objectives is to shrink the range of discretion by reducing task uncertainty. So long as task uncertainty is great, neither contract negotiations nor followup surveillance and subsequent awards can be used effectively to achieve efficient contract performance. *Ex ante* estimates cannot be regarded as meaningful targets, and thus *ex post* evaluations can scarcely be performed with confidence. Consider the effect on negotiations first.

Where knowledge of costs is imperfect and the cost variance is large, a wide range of negotiated target costs can be represented defensibly. Thus the joint preferences of the negotiators can be expected to influence systematically the target-cost outcome. Where knowledge is more complete, however, objective considerations override bargaining attitudes,[37] and the opportunity to bias the outcome is correspondingly circumscribed.

In addition, with cost uncertainties substantially removed, contract performance comes in for closer scrutiny. Discretionary expense items are more difficult to justify. Moreover, such overruns as may occur under these circumstances can be more easily attributed to contractor

[35] Charles J. Hitch and Roland N. McKean, *The Economics of Defense in the Nuclear Age*, The RAND Corporation, R-346, March 1960, p. 232.

[36] J. Stefan Dupré, "The Efficiency of Military Research and Development: Kaysen, Cherington and the Budget Bureau," in Friedrich and Harris, eds., *Public Policy 1963*, p. 298.

[37] Siegel and Fouraker found in experimental sessions that increased knowledge reduced the range of bargaining (*Bargaining and Group Decision Making*, p. 87).

performance rather than chance, so that cost-performance reputation effects can be made binding and future contract awards can be made more contingent on present-period performance. Thus there is an inducement to exercise cost control, not merely for its effect on current profits, but also for the promise of future awards. While incentive practices currently in use may fail to discourage expenditures that enhance the contractor's future capability and current satisfaction, the introduction into the contractual relationship of a binding reputation effect would help to attenuate expenditures of these types.

Among the costs that can be reduced if advance knowledge of the task is more complete are the contract administration costs. Where substantial task uncertainty exists, the contracting officers responsible for the direction of the task are apt to demand detailed progress reports and close, continuing inspection in order to be able to defend the program and their own actions in relation to it. The demands for "full information" that arise out of this *felt need for defensibility* can be reduced, however, if uncertainty is reduced prior to the time of the negotiations. If this can be done, the perceived threat of being assigned responsibility for failure is alleviated, and the incentives to devise elaborate control devices are correspondingly weakened.[38]

The manifold advantages of reducing task uncertainty should thus be clear. The means by which this result can be obtained have yet to be specified. What follows is an attempt, admittedly tentative and preliminary, to suggest how this might be done. I am nevertheless encouraged by the fact that both my study of this problem and Kaysen's [39]

[38] Existing control systems would not automatically disappear. Their elimination would require a determined effort from above. But assuming that task uncertainty can be reduced substantially, the incentives to resort to these control devices will be weakened, and thus the controls, once eliminated, are unlikely to recur.

[39] Kaysen, "Improving the Efficiency of Military Research," pp. 250–253, 264, 268. My failure to acquaint myself with Kaysen's work until my own was in advanced stages of completion opens me up to the charge of a tardy literature search, but I would emphasize a somewhat different aspect. In an area where investigations almost necessarily have a certain conjectural quality, two independent studies reached very similar conclusions with respect to the advantages of task-partitioning. Kaysen is also concerned with the broader problem of what is the preferred institutional arrangement for doing R and D and suggests that the nonprofit research institute or the government laboratory be used in place of the ordinary business enterprise (*Ibid.*, pp. 265–66). Although he makes a plausible case for this, I find it too much at variance with prevailing norms to be politically possible, and since it is not vital to the success of the task decom-

came to approximately the same type of recommendations (albeit via different routes)—namely that a sequential approach to weapons procurement promises much better efficiency (and possibly stability) [40] performance than obtains under the "systems approach" used presently.

My principal proposal is to use task-partitioning as a device for reducing the conditional uncertainty that exists between system components. Thus suppose that a new weapons system is under consideration and that the task is technically separable into two parts, A and B. Assume also that either (1) work on B logically follows at least the exploratory work on A or (2) although A and B must be made compatible at an assembly stage, work on each component can proceed independently of that on the other (or at most only loose, contemporaneous coordination is necessary to assure gross compatibility in the designs). In schematic form, the task can be represented as one of the following two types (where the 0_{ij} refer to outcomes and I to an integrated combination of subsystems) shown in Figure 3.

Consider first the sequential type of task. If the task is contracted for as a unit, the full range of outcomes shown by 0_{11}, 0_{12}, 0_{13} and 0_{14} must be allowed for at the outset. This high degree of variability makes it difficult to specify target costs objectively and this likewise applies to contract administration. Hence, reputation effects can scarcely be assigned with confidence at the termination of the contract. If, however, the stage 1 and stage 2 problems are contracted for separately, and assuming that the distribution of outcomes under 0_{11}, 0_{12} differs in a nontrivial way from that of 0_{21}, 0_{22}, each part of the task will possess a lower degree of variability than does the whole. Thus if the stage 1 investigation yields 0_1, the 0_{21} and 0_{22} outcomes can be dismissed altogether in contracting for the stage 2 part of the task. By shrinking the range of defensible outcomes in this way, the negotiation, execution, and postcontract evaluation can all be performed with more confidence. Both more accurate target-costing and tighter expense control could be expected.

If instead the task tends to be of the contemporaneous variety shown in Figure 3, the advantages of task-partitioning result from sharper accountability and avoidance of those diseconomies of control inherent in

position approach, I emphasize instead the ways by which existing institutional arrangements can be made to work better.

[40] Kaysen does not explicitly concern himself with the stability objective.

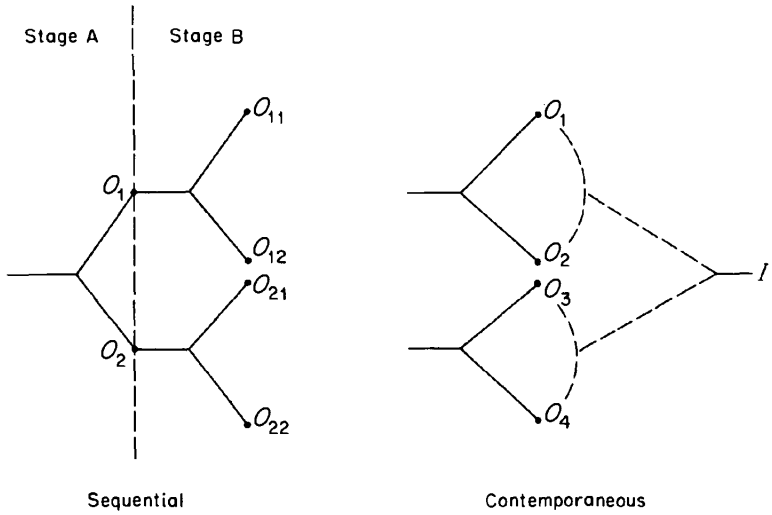

Figure 3

large program size. Accountability is made difficult when both aspects of the task are treated as a unit since an effective *ex post* evaluation requires unscrambling the parts, and this may be virtually impossible. The diseconomies of control that result from large size are due to what I have referred to elsewhere as "control loss," which is an increasing function of the number of hierarchical levels involved in the administration of a task,[41] and where component work is combined rather than contracted for separately, a centralized form of organization for both operations and control may appear "natural." [42] But this requires additional hierarchical levels in the administrative structure, which leads to

[41] My argument is a formalization of the descriptive treatments of this problem by E. A. G. Robinson, R. H. Coase, and more recently by Gordon Tullock and Anthony Downs. The details of the formal model and references to the above literature are given in "Hierarchical Control, Optimum Firm Size, and Regulatory Behavior," unpublished manuscript, November 1965.

[42] Although I regard it as the likely way in which to organize, it is not inevitable. Thus it would be possible to contract for the entire system but to organize subgroups to perform each part of the task separately. There is a common tendency, however, for hierarchical organizations to exaggerate the benefits of planning, coordination, and integration, and this leads to a preference for centralized over decentralized forms of operation. Put somewhat differently, "all large organizations [tend] to overestimate the costs of flexibility and underestimate its benefits." Burton H. Klein, "Policy Issues in the Conduct of Military Development Programs," in *Economics of Research and Development*, Richard A. Tybout, ed., Columbus, Ohio, 1965, p. 324.

greater control loss and thus lower efficiency than that which would result from decentralized management of each of the technically separable components.

It is of course relevant to ask the relative frequency with which tasks tend to be of the sequential rather than the contemporaneous types, since the arguments for partitioning are probably more compelling for the former. Kaysen observes in this connection that: [43]

> Characteristically, the problems to be solved contain a large empirical element, in the sense of questions which can be answered only by experiment and observation, not by analysis and calculation alone. In any but trivially simple cases, the research and development task is sequential; and some questions cannot be answered and indeed, frequently cannot even be asked before other antecedent questions have been answered.

In addition to the direct advantages of task decomposition sketched above, this approach has the additional advantage that it complements two other recent proposals for restructuring the approach to R and D: the Klein-Meckling-Nelson [44] proposal for parallel R and D, and the Enthoven-Rowen [45] proposal concerning the mix of capabilities required.

Klein and Meckling argue that the comprehensive, system-planning approach to development decisions is inappropriate for many or even most developments. They hold that the problem is not "one of choosing among specific end-product alternatives, but rather a problem of *choosing a course of action initially consistent with a wide range of such alternatives;* and of narrowing the choice as development proceeds." [46] They therefore approach the R-and-D problem as a sequential decision problem in which parallel R and D is conducted on components rather than systems. The potential cost savings inherent in this approach (at least under certain ideal circumstances) have been analyzed by Nelson, and the project histories reviewed by Marschak suggest that such savings could be realized.[47]

[43] Kaysen, "Improving the Efficiency of Military Research," p. 250.

[44] Burton Klein and William Meckling, *Application of Operations Research to Development Decisions,* Santa Monica, 1958, and R. R. Nelson, "Uncertainty, Learning, and the Economics of Parallel Research and Development Efforts," *Review of Economics and Statistics,* November 1961, pp. 351–364.

[45] Enthoven and Rowen, "Defense Planning and Organization."

[46] Klein and Meckling, *Application of Operations Research,* p. 352; emphasis added.

[47] Nelson, "Uncertainty, Learning, and the Economics of Parallel Research," and T. A. Marschak, *The Role of Project Histories in the Study of R&D,* The RAND Corporation, P-2850; January 1964.

The argument of Enthoven and Rowen is that a broad spectrum of capabilities is needed and that "research and development policy should aim at preventing the creation of a few, large-scale programs, which large and powerful interests will want to preserve, before the major uncertainties have been resolved." Instead, we should encourage "competition, duplication, and overlap . . . [as] the price we pay for the reduction of uncertainty." [48] Thus technically (parallel R and D), strategically (preserving options), and contractually (my argument), task decomposition appears to be superior to the systems approach.

It is perhaps also relevant to observe that, although the data are incomplete and the details are not entirely clear, task-partitioning has been practiced successfully in French aircraft development. To the extent that crude comparisons are meaningful, the cost of these programs relative to American experience appears to be substantially lower and development time has also been reduced. No doubt there are a number of factors that are responsible for these differences. If my arguments for partitioning are correct, however, task-partitioning would at least appear to be a contributing factor and may explain a significant fraction of these performance differences.

Such a partitioning can lead to further benefits if, as a result of the reduction in the average size of the contract, an increased number of firms can qualify for consideration when contracts are awarded. Where entire systems are contracted for as a package, only a few large defense contractors can fulfill prime-contractor qualifications. Thus, competition for these awards, limited to a handful, may be less effective than it might otherwise be, and confidence in the verity of the negotiations will be impaired. By opening up the bidding to a larger number of firms, task-partitioning may well lead to a more objective determination of costs even if uncertainty remains substantial.[49]

Finally, task decomposition has the additional advantage that it may help to avoid "boom and bust" in the sales and employment of defense contractors. The cyclical adjustment in the volume of operations associated with a large system as it goes through the phases of initiation, rapid growth, peaking, and tailing-off, would be less marked if the

[48] Enthoven and Rowen, "Defense Planning and Organization," pp. 369 and 372.

[49] For a similar view, see Kaysen, "Improving the Efficiency of Military Research," p. 268.

task were partitioned. Instead of a few large programs absorbing the bulk of a firm's (or the industry's) capacity, a number of smaller programs could be in progress simultaneously. Assuming that they were initiated at different times, the result would be a stabilization in employment and sales.

If task-partitioning of this sort is feasible and the merits I claim for it are valid, the question arises as to why partitioning has not been done already. Three answers can be supplied. One (and the one which I believe has been neglected) is that task uncertainty has been valued for the discretionary opportunities that it affords—both to the Services and to the contractor. They have therefore been disinclined to restructure the task along the lines suggested. In a somewhat similar vein, there is the administrative preference of both contractors and the Services for centralized-planning approaches to complex problems. Finally, and most critical to the argument advanced here, the suggested approach has certain costs, and these may be too great to justify the change.

Four possible disadvantages (costs) of task-partitioning deserve our attention. First, task-partitioning may lead to serious subsystem-to-subsystem interfacial problems. Second, the administrative costs of contract proliferation may be substantial. Third, the partitioning may lead to certain diseconomies of small scale. Finally, time may be of the essence and decentralized operations may lead to excessive time delays.

The interfacial problems may appear to be insuperable.[50] If work on the components proceeds in semiautonomous fashion, problems of compatibility and of "fitting" at component and subsystem interfaces may well be neglected. Thus any apparent savings realized by splitting up the task may be more than offset by the costs of achieving component

[50] This appears to be Paul W. Cherington's position. See his "Kaysen on Military Research and Development: A Comment," in Friedrich and Harris, eds., *Public Policy, 1963,* p. 282. A more moderate view of the interfacial problem is provided by Hitch and McKean: "An important reason for early, fairly detailed specification of weapon systems is the need to match the various components under development. . . . This need is real and must be achieved at the appropriate stage. Where a system is being put together from previously developed and tested components . . . , matching and the detailed specifications required by matching may be imposed without too much risk at the preliminary design stage. But where a new system is really advanced, where the components have yet to be developed and tested for feasibility and performance, premature concern over physical matching *can delay development by years.* (Italics added). The urgent thing is usually to get the critical components developed to the point where they can be tested. . . . When it is known that they work is early enough to worry about matching configurations *in detail*" (*Ibid.,* p. 253).

compatibility later. Moreover, as responsibility for making the necessary changes might be unclear, administrative costs and delays can be anticipated. In my opinion, however, these expenses may be easily exaggerated. Thus, the usual procedure in a multicomponent development program (the contract for which now goes to a single contractor) is for the contractor to follow a course not unlike that described here, only without many of the benefits inherent in advance task-partitioning and sequential R and D. The component work is likely to be done contemporaneously by at least partially decomposing the task and assigning parts of it to research groups (some in-house, others to subcontractors) that are responsible for developing a device that meets the principal specifications (among which, of course, are included some crude compatibility requirements). Once this stage has been reached, additional refinements are made to secure more perfect matching between successive "surfaces." However, since all of the work is done under the supervision of a prime contractor, the responsibility for performing the interfacial work is his, and the task goes on to completion without drawing special attention to interfacial costs of this sort. Although they may be disguised, these expenses are nonetheless real. If the need to make interfacial corrections is recognized and the funds for this purpose are provided, task decomposition would merely make these costs at least partly explicit. Moreover, by recognizing the costs explicitly and providing for the work separately, the problem of responsibility can be reduced. It is by no means certain, therefore, that interfacial costs would be significantly greater under the proposed task-partitioning approach than they are under a prime-contractor-system approach.

There is a real possibility that contract administration costs would proliferate if tasks were partitioned into components and proposals were split off from development. But the felt need for defensibility tends to be reduced when uncertainty is reduced, so that the demands for Service control are apt to be less under the proposed approach. Furthermore, competition for contract awards is likely to be improved and individual contract negotiations shortened and made less costly. Although the number of negotiations and the number of contracts will increase substantially if the task-partitioning approach is adopted, it is not clear that over-all contract administration costs would increase.

With regard to the argument that economies of scale may be sacrificed by reducing the average size of the contract award, I would point

out that: (1) the reduction in the average contract size in shifting from the systems to the sequential approach is probably on the order of 10 rather than 100, so that while the individual parts are smaller they still remain sizeable; (2) if the large firms realize economies of scale they will presumably secure more of the component work by submitting lower bids and performing at lower cost than their smaller rivals; (3) the evidence suggests that "in most industries, the productivity of an R-and-D program of given scale seems to be lower in the largest firms than in somewhat smaller firms," [51] so that on those parts of the task for which they possess sufficient size to qualify, awarding contracts to smaller firms may yield cost economies; (4) the task decomposition approach should help stabilize sales and employment so that diseconomies associated with large variation here can be reduced; and (5) the problem of expense control is largely one of incentives and opportunities—to focus on economies of scale narrowly conceived is to miss entirely the dysfunctional aspects of current performance.

Finally, we have the "time-is-of-the-essence" argument. Here I would point out that although an occasional program will demand a crash effort, and that for this purpose a systems approach may be the preferred procurement strategy,[52] it does not follow that the same strategy is equally appropriate for more routine affairs. Almost by definition, crash programs subordinate resource-conserving objectives to secure time advantages. But, clearly, if every task is given crash-program priorities, and assuming that the defense budget is limited, the eventual effect is to reduce the number of programs that can be brought to completion.[53] The near-term advantage must therefore be weighed against the loss of long-term capability. Unless, therefore, crash programs are no longer the exceptions but have become the rule (the time-discount rate is ordinarily very high), the time-is-of-the-essence argument must be qualified to apply to a few programs rather than defense procurement

[51] Edwin Mansfield, "Industrial Research and Development Expenditures," *The Journal of Political Economy*, August 1964, p. 338.

[52] This is a debatable point. If, however, the systems approach possesses an advantage it is probably in connection with crash program type efforts.

[53] This raises a difficult point. If the size of the defense budget is increased significantly when programs are given a crash-priority status, so that budget augmentation alleviates the need for budget reallocation to favor the so-called crash efforts, the Services may experience little or no loss of long-term capability by maintaining a crisis orientation in their appeals to Congress for funds. The social welfare effects of resorting to such sales appeals are nonetheless real.

generally. My concern here has been with a continuing defense effort rather than any particular crisis,[54] and I would urge that my remarks be considered in this spirit.

V. Conclusions

The trend of defense spending is toward R and D rather than procurement. While the sum of spending on research, development, technology, and engineering by the Department of Defense and the National Advisory Committee on Aeronautics in 1953 was 11 per cent of total expenditures for defense development and procurement, this had increased to 37 per cent by 1963.[55] Moreover, procurement now tends to be in smaller quantities than previously. Hence, if expense control is to be realized at all, it must be realized early. It is no longer sufficient to postpone attention to the problem and resort to breakout and second-sourcing late in the procurement stage to achieve efficiency.

Hopefully the analysis given here produces a better understanding of the potential identities of interest that pervade the Service-defense contractor relationships. The triad of discretion, defensibility, and uncertainty is particularly vital to an understanding of the adaptive responses that have been devised by these two groups to the problems of defense contracting. As I view it, the attainment of efficiency requires a shrinkage in the range of discretion available to the Services and their defense contractors. Lacking this, a wide range of performance results can be made "defensible," and efficiency objectives are apt to be displaced in favor of other goals. The incentives of neither the contractors nor the Services are such as to make least-cost performance a high priority objective in these circumstances. These remarks apply whether a CPFF or incentive-fee form of contracting is employed; so long as the latitude in

[54] The "missile gap" that was anticipated in the late 1950's and early 1960's is one such crisis. Cherington argues that if a sequential approach had been taken to the Atlas program that completion would have been delayed for three years ("Kaysen on Military Research," in *Public Policy 1963*, p. 275). As Dupré indicates, this estimate is rather dubious ("The Efficiency of Military Research and Development," in *Public Policy 1963*, p. 296), but what I would like to emphasize here is that even if it is correct, it does not justify a systems approach for programs that lack this crisis atmosphere. In short, the time-cost trade-off that may have been appropriate in one class of circumstances and led to one type of development and procurement strategy should not be uncritically generalized to apply to all circumstances.

[55] Scherer, *The Weapons Acquisition Process*, p. 57.

administering the contract remains large, manipulating the sharing rate over the range which is ordinarily used (zero to 30 per cent) [56] seems to me unlikely to change this cost-performance result significantly. This does not deny that in some superficial sense an improvement may appear to have occurred (cf. the statement by the Secretary of Defense, pp. 228 ff.). But considering the ways in which the joint preferences of the two parties favor other than least-cost objectives and given that the basic structure of the task remains unchanged, naive projections that fail to allow for the full range of adaptive responses are hardly grounds for confidence. Manipulating incentives or providing administrative direction at the contract execution stage may give the appearance of tight control, but the critical dimension is in definition of tasks. Until the degree of uncertainty that typically prevails under the systems approach to weapons procurement is reduced so that task specifications can be made more objectively, these visible manifestations of change remain generally suspect.[57]

My proposal for limiting discretionary opportunities involves restructuring the problem by partitioning the task into technically separable components. This bears some similarity to a proposal previously made by Kaysen. But whereas his concern for an optimal research strategy also leads him to advocate reasonably drastic changes in the institutional arrangements under which R and D is performed, I propose somewhat less ambitious change. My concern is with attainable rather than ideal results, and my analysis of incentives, controls, and associated performance consequences indicates that simple task redefinition would appear to yield net benefits within the context of existing institutional arrangements. And although "true" cost minimization requires that the target-cost and sharing rate be selected coordinately, task-partitioning

[56] Of one hundred and thirty incentive contracts examined by Frederick T. Moore, the highest contractor sharing proportion was 30 per cent, and only five contracts had this high a sharing proportion. The median sharing rate was 20 per cent. *Military Procurement and Contracting: An Economic Analysis,* The RAND Corporation, RM-2948-PR, June 1962, p. 46.

[57] I am less than sanguine over Scherer's proposal that after-the-fact evaluation by an impartial board would improve contractor performance (*The Weapons Acquisition Process,* Chapter 12) for precisely this reason. Until the degree of task objectivity is improved, this adds a "visible" but otherwise ineffectual control device. If task redefinition can be successfully performed so as to achieve a greater degree of objectivity, however, review by an impartial board may well help secure better performance (by ensuring that the Services perform their control functions effectively if nothing else).

would appear to produce net benefits short of such an arrangement. Among the advantages that partitioning promises are:

1. It reduces the amount of uncertainty and hence increases objectivity in contract negotiations, reduces the felt need for defensibility in administering contracts, and permits more reliable evaluations which in turn allow cost-performance reputation effects to be assigned with confidence. Each of these effects should help to prevent excessive contract costs.

2. It creates a contract environment in which the full potential of parallel R-and-D approaches (as previously advocated by Klein, Meckling, and Nelson) can be exploited.

3. It complements R-and-D strategies which emphasize the need for maintaining options by providing support for work on adaptable components and flexible capabilities (as argued for by Enthoven and Rowen).

4. It permits greater competition by increasing the number of eligible contractors.

5. It lends itself to sales and employment stabilization.

Against these advantages must be weighed the costs associated with (1) possible interfacial problems, (2) contract proliferation expenses, (3) sacrifice of scale economies, and (4) possible time delays. It is not obvious, however, that interfacial costs need be significantly greater under a sequential program than under the systems approach, especially if advance allowance is made for them in planning a development effort. Likewise, although contracts will increase in number they will decrease in complexity—both at the negotiation and administration stages—so that administrative cost increases for this reason may be kept within quite acceptable limits. The scale-economies issue appears to be mainly a bogus one. Thus the principal objection would appear to be the time-cost trade-off. Although "missile-gap" crises may have required a massive concentration of funds and a time-favoring strategy for missile development in the recent past, it is unclear that the same type of strategy is appropriate when consideration is shifted to over-all defense posture on a continuing (noncrisis) basis. In this I support Kaysen's observation that it is not "the elapsed time between the initiation and completion of *particular* new-weapons projects or even the average length of that interval over all successful development projects" that counts.[58] Rather, for

[58] Kaysen, *"Improving the Efficiency of Military Research,"* p. 263 (Italics added).

any given level of expenditure, the objective is to design a system which performs efficiently and optimally balances the short-term against the long-term defense posture. For such a purpose, the research, development, and procurement strategy should be treated as a variable rather than a parameter.

Appendix

CORRECTIONS FOR INDUSTRY EFFECT [1]

If total industry sales fluctuate because of variations in demand for the output of the industry, the variability of sales among the firms in the industry will clearly be affected. Thus, to examine the sales variability experience of firms without correcting for an industry effect is to impute variability to the firms that, in some sense, might be considered unavoidable. My objective here is to show how, in principle, it is possible to separate out the industry effect on firm variability. Thus, let

S_{ijt} = sales of the i^{th} firm in the j^{th} industry in period t,

$R_{jt} = \sum_{1} S_{ijt}$ = sales of the j^{th} industry in period t,

$\sigma_{S_{ij}}^{\,2}$ = variance about a linear trend of sales in firm i of industry j.

Our hypothesis of a linear trend is given by:

$$S_{ijt} = \alpha_{ij} + (\beta_{ij})t + \epsilon_{ijt} \tag{1}$$

where α_{ij} and β_{ij} are constants, and ϵ_{ijt} is a random error term decomposible into an industry and firm effect as follows:

$$\epsilon_{ijt} = (S_{ij}/R_j)\, u_{jt} + v_{ijt} \tag{2}$$

$$\text{where } S_{ij} = \text{mean firm sales} = \frac{1}{T} \sum_{t} S_{ijt}$$

$$R_j = \text{mean industry sales} = \frac{1}{T} \sum_{t} R_{jt}$$

and $E(u_{jt}) = E(v_{ijt}) = E(u_{jt}\ v_{ijt}) = E(v_{ijt}\ v_{kjt}) = 0$. Letting $(S_{ij}/R_j) = \gamma_{ij}$, we have

$$\sigma_{S_{ij}}^{\,2} = \text{Var}\,(\gamma_{ij} u_{jt} + v_{ijt}) = \gamma_{ij}^{\,2}\, \sigma_j^{\,2} + \sigma_{ij}^{\,2} \tag{3}$$

[1] I am indebted to Roy Radner for helpful comments on this part of the argument.

TABLE A-1

Sales And Employment Variability Adjusted For Linear Trend, 1954–1963

Industry and Firm	Sales Rank of Firm Among 500 Largest Industrials 1963	Standard Deviation of Residuals as Percentage of Mean	
		Sales	Employment
Aerospace			
Lockheed	20	8.8	9.5
North American	21	16.3	13.6
Boeing	25	12.2	8.9
General Dynamics	30	20.8	13.6
United Aircraft	33	13.1	5.1
Douglas	75	16.3	11.4
McDonnell	101	20.8	16.9
Hercules	120	30.4	10.2
Grumman	123	13.7	8.6
Republic	155	29.8	11.8
Northrop	162	15.2	10.8
Curtiss Wright	245	18.7	12.6
Total Aerospace Industry		7.5	7.0
All weapons and space development and procurement		9.3	n.a.
Chemicals			
DuPont	11	4.5	4.1
Union Carbide	27	5.7	5.0
Dow Chemical	52	2.7	1.8
Olin-Mathieson	67	3.8	5.2
FMC	87	11.3	21.0
Koppers	189	12.8	11.2
Stauffer	222	9.3	10.9
Total Chemical Industry		3.1	1.6

(continued)

TABLE A-1 (Concluded)

Industry and Firm	Sales Rank of Firm Among 500 Largest Industrials 1963	Standard Deviation of Residuals as Percentage of Mean	
		Sales	Employment
Electrical Equipment			
General Electric	4	6.7	8.2
Westinghouse	16	6.8	4.2
Bendix	63	5.4	4.4
Square D	360	8.4	9.3
ITE Circuit Breaker	424	13.3	7.6
Total Electrical Equipment Industry		3.6	5.2
Steel			
U.S. Steel	6	9.5	5.6
Bethlehem	17	10.7	7.4
Republic	46	11.8	9.2
Inland	64	6.8	3.1
Youngstown Sheet & Tube	84	12.4	8.1
Crucible	218	13.4	8.7
Wheeling	238	8.9	7.8
Total Steel Industry		9.1	5.5
Aluminum			
Alcoa	51	5.8	6.1
Reynolds	100	5.8	5.0
Kaiser	129	9.2	9.0
Total Aluminum Industry		4.9	n.a.

Sources: Total aircraft industry and weapon space development and procurement data from Frederick M. Scherer, *The Weapons Acquisition Process: Economic Incentives*, Boston, Mass., 1964, pp. 57–58.

Firm data on sales and employment from *Fortune's 500 Largest Industrials,* 1955 through 1964.

Total industry sales and employment data, except aerospace, from *Moody's Industrials* and *Monthly Labor Review*, respectively.

Now, since

$$R_j = \sum_i S_{ijt} = \alpha_j + (\beta_j)t + \sum_i (S_{ij}/R_j)\, u_{jt} + \sum_i v_{ijt}$$

and since $\sum_i (S_{ij}/R_j) = 1$, we have

$$R_j = \alpha_j + \beta_j t + u_{jt} + \sum_i v_{ijt}\,, \tag{4}$$

and given our assumptions with respect to the residuals,

$$\sigma_{R_j}^2 = \text{Var}\,(u_{jt} + \sum_i v_{ijt}) = \sigma_j^2 + \sum_i \sigma_{ij}^2. \tag{5}$$

We thus obtain N equations of the form shown in equation 3, and one equation of the form shown in equation 5 to estimate the N variances, σ_{ij}^2, and the industry effect, σ_j^2. In short, we have $N + 1$ independent equations in $N + 1$ unknowns and can thus obtain corrected estimates of the amount of sales variability for each firm. Unfortunately, however, the technique indicated requires that we obtain data on all of the firms in the industry, and hence is impractical for our limited purposes. A rough correction can nevertheless be obtained by observing that from (5)

$$\sigma_{R_j}^2 \geq \sigma_j^2\,,$$

so that on substituting into (3) we have

$$\sigma_{ij}^2 \leq \sigma_{S_{ij}}^2 - \gamma_{ij}^2\, \sigma_{R_j}^2\,, \tag{6}$$

where all terms on the right hand side of the inequality are observable. Thus (6) provides a tighter upper bound on firm variability than can be obtained from $\sigma_{S_{ij}}^2$ uncorrected for any industry effect.

COMMENTS

JACK W. CARLSON, Council of Economic Advisers [1]

Mr. Bailey's paper, as well as comments from other participants, highlights the fact that governmental organizations need to experiment with market mechanisms.

Although the Department of Defense has provided many innovations (five-year planning, system analysis and programming), the incentives and flexibility of low-level managers have remained untouched or have deteriorated. The following situation prevails:

1. Lower-level managers are "charged" with only a small proportion (20–30 per cent) of the resources they actually consumed. Conse-

[1] Formerly with the Departments of the Air Force and Defense.

quently, there is a tendency to overconsume other seemingly free goods (70–80 per cent).

2. Among the goods given or "charged," lower-level managers are unable to substitute one resource for another (e.g., car for truck, contract for civilian personnel) even if the substituted resource is less expensive.

3. Managers at lower levels are frequently required to budget and manage by input (appropriations) accounts. Even though the programming concept is being employed for top-level management, it has failed to permeate lower levels. When the programming budget is used it is superimposed upon lower-level organizations without first withdrawing the system of managing by appropriations (inputs).[2] This leads to conflicting and at times, perverse incentives.

4. Lower-level managers do not have a satisfactory method for relating inputs and resources to organizational outputs in a meaningful and systematic way. The program budget for management purposes is confined to only higher-levels.

Among general efforts to overcome these problems, the Department of Defense (primarily the Air Force) has initiated a project appropriately entitled Project FIRM. Although the acronym means "Financial Information for Resource Management," its ultimate value will be to demand that lower-level managers act like managers in business firms. The financial information system for this project is being developed for implementation July 1, 1966 at Laughlin AFB, Del Rio, Texas. The Project will test the feasibility and efficiency of

1. relating inputs to outputs—e.g., various kinds of equipment and personnel to produce trained pilots (presently the programming system is operative for only the broadest programs—e.g., General Purpose Forces)

2. computing marginal costs for resources consumed (transfer prices)

3. allowing resource substitution

4. tying promotion of managers to success in reducing cost for given levels of performance (or in the cases with variable effectiveness, relative levels of cost-effectiveness).

If successful, a pyramid of organizational relationships can be built to

[2] The Resource Management Program of Assistant Secretary of Defense (Comptroller) Robert N. Anthony will help to alleviate this problem commencing in the fall, 1966.

finally merge with the Program Packages used at the highest management levels.

Thus, the Department of Defense will act more like a multiplant or multifirm corporation with several levels of management. Hopefully, significant efficiencies will be realized.

In any case, experimentation in this direction is worthwhile and exciting for economists concerned with the Defense Department.

EVSEY D. DOMAR, Massachusetts Institute of Technology

My assignment consists of discussing the papers by Bailey and by Schlesinger. I must confess that I have had trouble with both. First, I am no expert on defense problems; second, both papers are so general that it is difficult to find issues to argue about.

Bailey's paper deals with the use of the market mechanism in the Defense Department. All well-intentioned economists are in favor of that. Since economic analysis, like charity, should begin at home, I have tried, with my ignorance of the Pentagon, to imagine how the market mechanism might be used in our, or any other, economics department. As things stand now, if I need a blackboard for my office, I have to ask our chairman for one. Naturally, he is worried about setting a precedent for other members. If he has to buy an extra dozen blackboards, the marginal cost of my request may run into a thousand dollars. How is he to decide who *really* needs a blackboard? Would it not be better to give each of us an annual allowance for office furniture, supplies, and even for secretarial help, and let each member spend it as he sees fit?

This looks like a step forward, but some members may buy things they don't really need, since they derive no enjoyment from unspent balances. Why not let them pocket such balances? Imagine the improvement in the economic calculus! Imagine the saving of resources!

To be honest, I am becoming a bit uneasy: suppose some of my distinguished colleagues spend their valuable time typing their own letters, or don't write letters at all. Still, I am willing to try. But why stop here? Why not give the department a lump sum of money to be used (at the discretion of the full professors, of course) for their own salaries, salaries of nontenured members, student scholarships, various expenses and books. Will they hire a first-rate assistant professor by foregoing a

raise in their own salaries? Will they get the best students? And will they buy enough books for the library? Now books involve external benefits—they are used by students as well. Shall we bring in the students and let them allocate the funds between their scholarships and the books? Pity the library! [1]

So the market mechanism can be of help in some situations, but not in others; it can improve things up to a certain point but not beyond. What I had expected from Bailey's paper was an analysis, based both on theory and on the actual experience in the Defense Department and elsewhere, of the kinds of organizations, situations, and problems which are, or are not suitable for the use of the market mechanism. Is the synchronization of the welfare functions of the dispenser of funds and of the decision-maker both a necessary and sufficient condition for success? If so, the measurability of performance is not needed. But perhaps the synchronization is not necessary, not sufficient, or neither. These are some of the interesting questions which were unfortunately not analyzed in the paper.

With the general tenor of Schlesinger's paper we all sympathize. Of course, bureaucratic organizations should be shaken up from time to time to let fresh air in. Naturally, planning for research should not be too rigid. In the first stages of a research program there should be a good deal of duplication, and as the program proceeds there should be less. The program should look like a triangle, with a broad base (the early stages), gradually tapering off to the apex. But how broad should the base be? And how quickly should it taper off?

Following the precedent set by Eisner, let me add two thoughts of my own. The public is always irritated by the bureaucrats, by their seeming stupidity and rigidity. In my dealings with them (via the Operations Research Office of the Army in 1949–51), they always gave me the impression that faced with a choice of winning a war by breaking a few rules, or losing the war according to all rules, they would inevitably choose the latter. But perhaps the system of rewards and punishments set by their superiors, by the public, and particularly by Congress is to blame. Called before a congressional committee, a bureau-

[1] After my talk, John Meyer told me that Harvard professors (at least in economics) do get a $1,000 annual allowance for office supplies, secretarial services, telephone, and the like, and that this system works quite well. There was a time, he said, when salaries had been set high enough to allow professors to make these expenditures out of their own pockets. That did not work.

crat can justify his acts, however stupid, by reference to regulations and instructions. But suppose he does use his mind and fails. Will the committee forgive him for his use of his own judgment?

My second thought refers to our obsession with atomic weapons. True enough, some progress since the Dulles administration has been made, but ideas die hard. We have behaved like a person who tries to do his daily shopping with a thousand-dollar bill. His wealth will impress all the clerks in the store, but will he be able to buy anything? Should he not keep the thousand-dollar bill in the safe where it belongs, and acquire some change instead?

JOHN R. MEYER, Harvard University

Schlesinger's paper would seem to represent another contribution to what one might call the second round in the organizational or planning revolution now underway within the U.S. government and pioneered within the DOD using concepts developed at The RAND Corporation and elsewhere. Perhaps it would be better to call it a "reformation" rather than a revolution. Then it is not so entirely surprising that a mild counterreformation also seems to be in progress. Perhaps, too, it is not surprising that some of this counterreformation is being instigated by those very closely associated or even responsible for some of the earlier reforms; these individuals obviously bring into the discussion a considerable advantage in knowledge and experience.

Thus we find Schlesinger making such interesting remarks as:

> In the DOD one route to further improvement would be a willingness to abandon detailed control in [some] cases . . .
>
> A good plan should be viewed as a complicated structure to foster intelligent hedging . . . [and] not be viewed as a prescription of future activities. . . .
>
> Overoptimization—by designing forces for the most obvious possible wars—may be the surest way of hampering the use of our potential power. . . .
>
> It [is] unwise to attempt precise advanced planning.

All the cautions about too much optimization or planning are carefully collated, however, with a basic endorsement of the underlying value of the modern managerial or decision-making techniques that have been brought to bear on defense problems. It should be added that Schles-

inger's combination of pride of achievement and caution about over-extending the applicability of the new techniques is hardly a view shared by Schlesinger alone. Many others even more intimately associated with implementation of the new techniques have expressed similar views.

Schlesinger specifically contrasts two different approaches to planning: a "Cook's tour" procedure based on "the supposition that the future is sufficiently certain that we can chart a straight course years in advance" and "Lewis and Clark planning" which attempts to incorporate "many alternative courses of action" though recognizing that "their precise character in time cannot be anticipated." As noted by Schlesinger no one can really disagree with the proposition that flexibility in a plan is highly desirable when he does not have to pay a price for its achievement. The trick is to achieve Lewis and Clark flexibility without having to spend too many cold winters in Lolo Pass.

What we see emerging, apparently, is a very healthy tendency to reassess or reevaluate and in particular to worry more about the human problems of applying modern decision-making techniques to the management of large organizations. In a sense, it is a return to older concerns—to the problems studied in graduate business schools in the 1920's under the headings of administrative practice and human relations. Let us hope that there is no suggestion in this counterreformation that the existence of very human problems of communication, bureaucratic lethargy, or finding the right balance between the need for flexibility while maintaining organizational control, represents any excuse for suppressing logical procedures or substituting intuition for rationality. Counterreformations like reformations can go too far. Still, it should be quite healthy to have the problems of administrative practice or human relations given a fresh review by many of the same individuals who pioneered the development of optimization techniques for government management.

Furthermore, before we proceed too far, I would like to insert at least a few words in defense of a Cook's tour. There are planning situations in which reasonably precise detail may be very worthwhile, e.g., situations where there is very considerable room for improvement, only limited administrative or managerial skills, and in which a good deal of the problem is simple "getting organized." These conditions would seem to describe reasonably well the circumstances of several countries of Asia, Africa and Latin America now embarking upon ambitious pro-

grams of economic development. In short, Cook's tour and Lewis and Clark planning should be viewed as polar extremes of many possible combinations or gradations available between.

Perhaps as a consequence of the resurfacing of old "human relations" problems, I was continually reminded as I read Schlesinger's paper of the story, perhaps apocryphal, that the major lesson taught by the Harvard Business School has traditionally been "when in doubt, reorganize." Schlesinger tells us that "any organizational structure needs an occasional shaking-up or breath of fresh air" and that "McNamara has succeeded in stirring up a very stale mill pond . . . [but this] would have come even in the absence of [the new] techniques." Indeed, at several points in his exposition Schlesinger comes dangerously close to suggesting that the main contribution of the new techniques has been to provide a convenient vehicle for reorganizing a rather stodgy bureaucracy and, more specifically, "ruthlessly pruning" some of the more "wasteful activities" of that bureaucracy. The new techniques are, in short, a convenient way of constructing a brief for overthrowing an old regime.

I have few doubts that there is considerable truth in this contention, but I would also like to think that the new techniques have done more than this. The really troublesome prospect raised by Schlesinger—quite properly I believe—is the possibility that the new techniques are primarily a vehicle for negation. Schlesinger never explicitly asserts this, but I do not consider it unfair to suggest that it is implied. Specifically, he leaves one with a very uneasy feeling that the new techniques are an uncommonly good way of justifying an answer of "No." Not only are the new techniques a means of ruthlessly pruning wasteful old practices but they are also a convenient device for denying experimentation with radically new technologies or retention of some organizational slack, often necessary for flexible adaptation to uncertain situations, particularly within a defense organization. Schlesinger, in fact, worries that the whole paraphernalia of new techniques may well be diverting energy away from important long-run problems to relatively unimportant mechanistic or administrative problems of the short run. We seem to need a cost-effectiveness analysis of the cost-effectiveness tools themselves!

I must confess that I share some of his worries. Again, though, the solution would not appear to be in any major retreat in the application

of the new techniques. Rather, I would suspect that the next logical step is not too unlike that being implemented in the management of business enterprises. Specifically, the introduction of more flexible decision-making techniques in which the role of accumulated experience or intuition is more explicitly incorporated into the process of decision. In short, the time would seem to be at hand when we should think about Bayesian priors and the application of statistical decision theory to defense planning—which indeed is already happening.

MERTON J. PECK, Yale University

The two papers upon which I have been asked to comment—Williamson's and Schlesinger's—are both inquiries into the centralization and decentralization of resource-allocation decisions in the defense sector. Economists have traditionally counted such questions as their own and, as Schlesinger remarks, the American defense sector has the size and complexity of the economy of a medium-sized nation.

Williamson's paper deals with the most obvious form of decentralization—the use of private firms to develop weapons. It goes beyond viewing such an arrangement in terms of simply business and government, and instead distinguishes between the Service and the higher authorities —the Office of the Secretary of Defense and the Bureau of the Budget. Such a three-sector model permits the explicit statement of what others have noted more in passing: that the Service and contractor may form a coalition to frustrate some of the objectives of the OSD.

Williamson treats a cost-plus-fixed-fee contract as a principal device in this coalition. Such a contract allows the understatement of costs, thereby enhancing the chances of project approval by OSD without making the contractor absorb the understated costs. Uncertainty as to project costs is the more traditional explanation of the prevalence of CPFF contracts. While uncertainty is clearly present, the evidence confirms the importance of Williamson's coalition explanation. In the twelve major weapons projects studied at Harvard Business School, actual cost on the average was three times the original estimates—but even more notably, in only one of the twelve was actual cost less than the estimate.[1] Similarly, Marshall and Meckling found average errors in the same range with

[1] Merton J. Peck and Frederic M. Scherer, *The Weapons Acquisition Process: An Economic Analysis,* Boston, 1962, pp. 21–22.

only one of the twenty-two projects studies with costs less than planned.[2] Neither sample displays an uncertainty pattern of errors where there would be a fair proportion of underestimates.

As Williamson points out, the incentive contract in such a situation may be as much a device for OSD to obtain the contractor's help in realistic cost estimates as a device for encouraging cost reduction. With the CPFF contract, the contractor's loss from a low-cost estimate is limited to a lower fee; the fee tends to be a function of the initial estimate. The government pays all of the cost overrun. With an incentive contract, the contractor's loss from a low estimate is further increased by his share of the cost overrun. Apparently this additional loss makes a significant difference. Moore reports that, for a large sample of contracts, "CPFF contracts have a cost overrun of escalation about 55 per cent of the time . . ." Incentive contracts have a cost underrun almost 75 per cent of the time.[3] With the CPFF contracts, actual costs were within 20 per cent of the initial estimate in less than two-thirds of the contracts; for incentive contracts, 90 per cent were within this range.[4] Incentive contracts may not conserve resources because of generous initial targets, but they do represent an improvement in cost-estimating. Lacking accurate cost estimates, much of the kind of planning Schlesinger describes is meaningless. The objective of better cost estimates may justify the importance OSD places on the incentive contract.

Williamson also explains CPFF contracts by noting that many of these costs have utility to the firm; they permit the firm to increase its assets in the form of capability for future contracts. This raises a complicated question of public policy.

As Williamson points out, "concern for future-period capability should also be legitimate concern (of the government)." But he proposes no way of dealing with such a concern except to urge "that research that is explicitly directed to this purpose should be supported and on-going or projected hardware programs should not be made to bear expendi-

[2] A. W. Marshall and W. H. Meckling, "Predictability of Costs, Time and Success of Development," in *The Rate and Direction of Inventive Activity,* ed. Richard Nelson, New York, 1963.

[3] Frederick T. Moore, *Military Procurement and Contracting: An Economic Analysis,* The RAND Corporation, RM-2648-PR, June 1962, p. 49.

[4] *Ibid.,* Tables 13 and 15. Of course some of the difference must be assigned to the fact that incentive contracts are used for the more technically certain situations.

tures of this sort." But future capability is more than collecting research personnel or carrying on research projects. The way an aircraft firm learns to build ballistic missiles is to have such a project. Thus, creating future capability and carrying out current projects are joint endeavors. One can visualize "learning" projects and, indeed, some developments may fit that description. The present system does recognize these joint cost characteristics.

And yet, the ad hoc and unconscious way in which future capability is now created seems dubious. Just how one provides for the future, as well as present, has to be solved in any serious agenda of weapons industry reform. Williamson fails to address this problem; surely a critical omission with the rapidly changing technology of weaponry.

I have some further difficulties with his approach. Williamson argues that by partitioning the weapons system into separable and sequential tasks, conditional uncertainty may be reduced. But I am puzzled by his contention that "each part of the task will possess a lower degree of variability than does the whole." The larger task can, of course, net out offsetting errors. For instance, the Army Ballistic Missile programs were run at least partially on a task basis; as one would expect, some individual tasks produced nothing; others were remarkable successes, with the range vastly exceeding the missile program of which they were a part. With costs, Moore finds, "there is a tendency for actual costs to be bunched more closely around the target cost for the larger contracts than for the smaller contracts." [5] Larger contracts are, of course, composed of many more tasks. Contracting for each task separately may raise the uncertainties and thus recreate the occasion for CPFF contracts.

Still the stress that Williamson places on tasks gives an analytical clarity to the two critical issues of project management—the relative emphasis placed on what Williamson calls sequential and contemporaneous timing of the tasks and the coordination and definition of tasks. My own interpretation of these two issues, however, differs from Williamson's.

Both issues arise because weapons-development projects are largely composed of small groups of five to ten professionals engaged in providing a certain kind of design information. This information, however, often aids the completion of other tasks and sometimes makes certain tasks unnecessary.

[5] Moore, *Military Procurement*, p. 49.

With respect to the time sequence of tasks, one could visualize each task done in strict sequence so that weapons would be developed by one group working centuries. But time does matter, and so every development has large elements of what Williamson calls the contemporaneous as well as the sequential. Thus, I would argue there are not two radically different development styles nor is one always optimum. Rather the optimum mix depends on the preferred time-cost trade-off. I suspect that past projects, partly because the services overvalued time relative to money, have tended to be more contemporaneous than desirable. Yet such a judgment must be a cautious one since the valid *ex ante* strategic risks of delayed development are always greater than they appear *ex post*.[6]

The foregoing view of a systems project as composed of a multitude of individual technical tasks implies a critical role for management. The managerial task in this situation is fivefold: (1) defining a set of tasks, (2) deciding which tasks to undertake in which order, (3) determining which tasks are successful, (4) insuring a flow of information between the separate task groups, and (5) maintaining technical compatibility between subsystems. These are not easy functions. Only at a very high level of aggregation are there established industry, skill, and technical divisions that sort out tasks; even in generously funded projects resources are limited and choices must be made; success is ambiguous, particularly when the task itself is an intermediate input for another task; successful development requires capitalizing upon the information in one task as it is gained; and technical compatibility must be insured.

The prime contractor, in large part, has carried out these management functions. It is certainly possible to substitute Service management for contractor management. The distinguishing feature of the Army Ballistic Missile programs of the fifties was a closer approach to task-oriented development than the corresponding Air Force projects. This was successful largely because the Army, in Von Braun's group, had a technical capability lacking in the Air Force. I suspect that since then the Air Force technical capability has increased; hence, it can afford to move away from the prime weapons system concept.

[6] I would also grant the possible validity of negative marginal returns in a few projects—that the last billion may have brought resources whose addition to the management confusion served to increase rather than decrease completion time.

Yet there are limits in centering management in the Service; even the Army Ballistic Missile programs had to rely partly on contractors. The greater attractiveness of private employment permits contractors to muster greater talent pools than the government. The complexities of coordination requires considerable decentralization to decision units below the central one.

Finally, I would argue that there are limits, or at least problems, in making various tasks equally attractive to contractors. Some tasks have *ex ante* a greater probability of success and a greater utility in building capability and, as a result, contractors place a great premium on obtaining some tasks and avoiding others. When the awards are in large units, each is a mix of attractive and unattractive tasks. If such tasks were handed out separately, they would have to carry differential profit rates in order to equalize their attractiveness, which itself would be a complicated question. In the past the markets have cleared only because the weaker organizations have taken the less attractive tasks, but I am not sure this is optimum.

Schlesinger's paper is more difficult for the commentator. It deals with questions of power and status, of knowledge and ignorance, and of compliance and dissent; all matters on which many hold firm convictions, and yet no one really is informed. Further, my experience is limited to an era in the Pentagon when the old ways had obvious defects and the new ways were unsullied by experience and untarnished by bureaucratic limitations.

The use of the five-year planning period was intended to recognize the future implication of present decisions. This was not being done; as a result, the Defense Department went through a succession of financial surprises and crises in the late fifties. To ignore the future is option denying; the Defense establishment in the late fifties gave up highly valued options for lower valued ones whose costs were unforeseen at the time of commitment. Schlesinger's comments indicate that this planning objective in part was unattainable, given the bureaucratic process; a five-year conditional forecast came to be regarded as a binding contract between the Services and the Secretary of Defense. There are several possible reasons for this: (1) the Services tend to promote this interpretation when it was to their advantage, (2) the notion of tentative formulation was rapidly lost as the plan was circulated downward, and (3) within the Services pet projects of particular Service groups were rejected not on

their merits (the real reason), but by pointing to their absence in the financial plan thereby implying its sacredness.

In any case, an approach that was intended as a conditional forecast has sometimes resulted in implied promises as to future actions, according to Schlesinger. A strong Secretary can reverse these decisions but still there may be costs in such reversals. Early decision then could conflict with option preserving.

And yet the discussion of option preserving and uncertainty occurs frequently in the statements of the Secretary of Defense and his immediate advisors. The practice in the early sixties was to keep new weapons in the R-and-D stage, thus postponing commitments and preserving options. It may be option-preserving is still not stressed enough, as Schlesinger implies.

Furthermore, there is always the question of what options are worth preserving—and here the OSD and the Services may differ. Thus, what looks like an option-preserving strategy when viewed from one side of the bureaucratic maze, may be option denying from another. Schlesinger points this out, "Leaders tend to be interested in their options."

I turn finally to the issues Schlesinger places under bureaucratic problems. The conflict between civilian systems analysts and the military is certainly the titillating aspect of the McNamara era. But it cloaks a very real issue of civilian leadership and option preservation on the part of the Secretary of Defense. Without his own staff, a Secretary can create choices either by vetoing and hoping for a resubmission closer to his preferences, or by playing off one Service against another. The former tends to be somewhat ineffective; the latter is partially nullified by reluctance of the services to trespass on one another's market. These devices do work after a fashion; the pre-McNamara Secretaries used both; the nay-saying by imposing stringent over-all budgetary limits and the Service rivalry by favoring the Air Force which advanced the strategic ideas then in favor.

Still, a strong Secretary will want a more effective way of option creation. This requires a staff. And since the purpose of such staffs is to provide the Secretary of Defense options other than those proposed by the Services, they are bound to be unpopular.

While a Secretary of Defense could become a prisoner of the prejudices of his own staff, there are built-in avenues for Service opposition to make itself known. Schlesinger points out that "preserving a channel

for intelligent dissent is even a greater problem within the military." Here the OSD staff may play a special role as a conveyor of minority Service views. This kind of role would further aggravate civilian-military tensions; to the Services it may look like the unmanly act of tale bearing. And the Services may believe that professional military opinion should be unified; that it is confusing for a Secretary to have several views. Yet diverse opinions increase the options for civilian leadership.

The problem of dissent as an aid to effective decision-making within the Pentagon or any other large bureaucracy has yet to be fully examined. The literature on decision-making is largely barren of the discussion of kinds, sources, and amounts of useful dissent. In this respect, Schlesinger's paper is novel. There is well established literature on the value of dissent in the political process at large, not only for its libertarian contribution, but also as an aid to more rational decision-making. But with more and more decisions being made by bureaucracies there must be corresponding value to dissent here as well.

D. J. ROBERTSON, The University of Glasgow

I am not an expert in the economics of defense, though, like most people, I am interested in defense planning because of its human implications. My comments will, therefore, be general in character.

I should like to speak briefly first on the purposes of defense policy, secondly on some differences which I detect in the economic analysis of British defense expenditure as compared with that of the U.S.A., and thirdly on each of the papers of Bailey, Schlesinger, and Williamson.

The Context of Defense

I would categorize the possible purposes of expenditure on armed strength in contemporary circumstances in seven ways, and argue that only the last three of these are relevant to our discussion. (a) Armed strength may be needed to maintain internal order. This has no more than marginal relevance for Britain or the U.S.A. (b) The purpose might be merely to provide a display of military pomp and circumstance for the delight of tourists and the locals. Though we seem from time to time to make rather a lot of this in Britain, it is not a very important reason for spending in either Britain or the U.S.A. (c) We might pre-

pare our forces to meet the conditions of the nuclear age wholly on the basis of defensive armaments without any offensive power. This is a somewhat unreal possibility, since for it to be warranted antinuclear defenses would need to be so perfect that they would themselves deter an aggressor from trying to make any headway against them, or defeat his efforts if he tried. Otherwise we would neither provide an effective defense nor an effective deterrent. The appropriate mixture of defensive and offensive armaments will alter from time to time reflecting both policy and technology, but whether the intentions of policy include aggression or are wholly directed to defensive or deterrent purposes, a mixture of defensive and aggressive armaments would seem to be an inevitable requirement. (d) The nuclear resources of the armed forces might be developed mainly for offensive purposes with the intention of going to war and destroying the enemy without being destroyed oneself. I hope I am right in assuming that nuclear aggression is not part of the policy of the U.S.A. or of the Western alliance as a whole.

The three versions of defense policy which do appear to me to be relevant to contemporary discussion are the following:

1. We might develop our nuclear capability so as to be able to feel some assurance that if we were attacked we would be able to destroy the enemy without being destroyed ourselves, but wait for such an attack before acting. I would call this a policy of active nuclear defense.

2. We might develop our resources of nuclear weapons both for defense and attack for the sole purpose of effective deterrence, holding to the view that we can preserve the "balance of terror" and rule out an actual nuclear war.

3. We have a responsibility to have resources available to fight limited wars; and both Britain and the U.S.A. have actually found themselves engaged in such conflicts at various times in the postwar period. The resources needed for this type of war are conventional in the sense that they rule out the use of major nuclear weapons. There is, of course, some debate on whether limited wars are compatible with the use of tactical nuclear weapons, but the balance of nonmilitary opinion appears to be that the risk of using them in limited situations is too great. In practice the context of limited wars tends to be that of "colonial" wars both in the locations in which such wars occur and in the complicated political and military objectives and situations to which they give rise. It is hard to have much confidence in the idea of a limited war involv-

ing a direct confrontation of major powers on their home ground—for example in Europe. The use of nuclear weapons of a tactical sort in the odd corners of the earth in which such struggles are likely would seem to be of mixed value on a number of grounds, so that the descriptions "conventional" and "colonial" probably apply to the types of military resources required as well as to the type of struggle.

Almost everybody would agree on the need for the last of these (conventional-war capacity) and the majority opinion in both countries seems to accept the need for the second (nuclear deterrence)—that is certainly my personal view. I want to differentiate this second position, however, from the first (active nuclear defense). I suggest to you that few people in Britain can feel that the first—actually finding ourselves in a nuclear war (however innocently)—will result in anything other than complete or almost complete, annihilation. May I remind you that the geographical dispersion of the British economy is small by your standards—about the distance from San Francisco to Los Angeles! I, together with almost half the population of Scotland, live less than forty miles from the major Polaris submarine base at the Holy Loch. Even a single moderately successful nuclear attack on such an obvious target would be likely to cause us to lose further interest in the outcome of the arithmetic of the success or failure of the war effort; and other populous parts of Britain have other potential targets in close proximity. From the point of view of the British civilian, it is difficult to regard the balance of advantage in active nuclear defense as anything other than an "academic" question. I would not deny that some military experts may have sufficient confidence in defensive strength to dismiss this as an unduly pessimistic position, but with stakes as high as those at issue here some pessimism is warranted. I would, therefore, like to rule out active nuclear defense as well as nuclear aggression as a possible outcome of policy. You may be thinking that as an expression of hope this is unexceptionable, but that such a result can hardly be unilaterally guaranteed. I agree; but the realization that a nuclear war is not an acceptable policy is worth constant reiteration to ensure that the bias of the minds of the policy-makers does not drift unconsciously into the feeling that, if peaceful or limited-war strategies should fail and a nuclear war be forced upon us, we shall always be able to win it.

My thoughts on this matter do not lead me to suppose that those parts of the economics of defense which are concerned with calculating the

advantages of one form of nuclear strategy and defense expenditure as against another are a waste of time, since they are concerned to deal with a situation that is itself "unthinkable." A strategy of deterrence requires calculations of the "returns" to defense expenditure, and I would accept the idea that it is necessary for economic analysts to act out the game as though action were possible, to assess the effectiveness of a proposed item of defense expenditure as a deterrent. On the other hand, it is always important to avoid any tendency, for reasons of brevity or because the point is thought to be automatically assumed by the reader, to omit any reference to the gamelike or hypothetical character of the debate, and this does not always seem to be done in the American literature. I would also suggest that accepting deterrence and limited-war capacity as the only possible policies influences the balance of advantage among alternative expenditures. The need for effective limited-war capacity is greater if there is to be no risk of drifting into a situation which cannot be resolved short of all-out war. The case for multi-purpose weaponry improves in the deterrence/limited-war combination as against the active-nuclear-defense context. If resources are held back for active nuclear defense at the expense of conventional-war capacity, the result may be to bring the former nearer. Propaganda, and even publicity, for the extent of available resources of a deterrent character, are in order for deterrence more than for an active-defense assumption. From this point of view the recent exchange of statements on the extent of nuclear resources is an appropriate development of policy, and the build-up of U.S. power in conventional armaments which has been brought about by the Vietnam situation may be regarded as a long-run desirable shift in the balance of U.S. defense expenditure. (I hasten to add that I am not in any way offering a comment on the war in Vietnam itself—that is neither my purpose nor my business.)

Some Differences for Britain

There are three respects in which, it seems to me, analysis of British defense expenditure may differ from that appropriate to the U.S.A.

1. In some ways our problems of weapons acquisition can be founded on better estimates of their probable cost. As the major partner in the alliance, with the economy which has the greater capacity for develop-

ment of new techniques, the U.S.A. is more likely than Britain to put resources into new-weapon development, and less likely to buy such weapons from us. It is, therefore, more frequently possible for us to choose between independent research and development, and production of new weapons and buying overseas—from the U.S.A. Problems of terms and delivery can naturally arise in the uncertain nature of weapon development, but the U.S. is likely to be willing to quote its terms for the supply of new weapons, and thus our developmental costs can be related to an external estimate, and our own estimates of the "returns" from a new system can also be put against those derived from outside. (Such a decision, however, raises a new uncertainty, which merits attention, that of the extent to which British industry may suffer from the loss of the associated benefits of a large program of research and development, and the economy as a whole suffer from the loss of the production program, both in terms of the consequences for particular industries—for example, the aircraft industry—and the balance of payments effects.)

2. We have fewer resources in total, and need conventional armaments reflecting our world commitments, and so we have to give considerable weight to a "conventional" range of choices and decisions in determining our defense budget. While there are, of course, plenty of uncertainties about the possible needs to be met by conventional forces, the routine obligations for garrisons and "fire-brigade" forces can probably be assessed with greater certainty than wholly hypothetical nuclear needs, and to this extent our decisions can be reached with the benefit of more data. Additionally, the weapons required for these purposes are more familiar, and there are fewer uncertainties in development and production costs. (There are, nevertheless, the usual penalties for failure to relate returns to outlay and to make the necessary choices: for example, it is now being alleged that we have both decided to maintain forces east of Suez and held our expenditure below the level needed to achieve this together with our other stated objectives.)

3. We are able to some extent to proceed in assessing the proposed level of our defense budget by deciding on the level of expenditure that we are prepared to face, and then allocating that amount to the various objectives that we wish to serve. We ought, of course, to assess the needs of armed forces for limited-war purposes, especially insofar as our needs in this respect are likely to differ from those of the alliance as a whole.

We cannot hope, however, to be independently fully adequate in providing an effective deterrent against nuclear attack, and for this we have to rely on the strength of the alliance and in particular on the U.S.A. On the other hand we are very much implicated in the deterrent policy, and in a matter of such importance to us we would like to have a say in the policy actually followed by the alliance. Our interests in nuclear weaponry might be put as providing in some small way for our own protection while staying in the game and seeking to influence the more important players. (I am conscious that some would argue that we have no hope of being effective in our influence, while others might claim that we can be effective in deterrence on our own—but the way I have put the matter represents a middle-ground opinion to which I would adhere.) With these objectives we have to fix a minimum level of defense expenditure which provides for our decisions on conventional forces and makes some provision for nuclear capacity: to that extent our defense expenditure reflects our commitments rather than the reverse. But the amount of expenditure on nuclear resources required to meet the need for influence and minimum capacity is, it may be argued, a variable which will defeat precise quantification—though its size may be more closely defined in the course of negotiations with our allies and in particular with the Americans (and, indeed, the same process will operate to refine the scale of commitment to provide conventional military resources to the common purposes of the alliance). I would argue that this set of circumstances forces our defense budget up to the scale it has attained in the postwar period, but allows us to operate to a degree on the basis of choosing a level of expenditure and then allocating it while maintaining to our allies that this is the most we can afford.[1]

[1] This and the preceding point are related to the remarks I made on the Olson and Zeckhauser paper. They argued that defense for the allies is a collective good, and that policy for the alliance ought to reflect the economies of scale to be achieved from specialisation in supplying the collective needs. While accepting this argument in part, I would contend that defense in the alliance (like health expenditure—an analogy on which some of their argument is based) is both a collective good and one which satisfies individual needs. The nearest to a pure collective item is deterrence from nuclear attack, though even here allies may wish to take part in the "production" to make sure that they are fully party to the decisions. Conventional-war capacity serves a number of different purposes, and these are not necessarily the same for each ally. (For example, the U.S. did not share the load of our Cyprus troubles or in Malaya.) Thus the extent to which allies will specialise their conventional war capacity is limited, and they will want some freedom of resources and action.

Price Mechanism and Planning in Defense

Both Bailey and Schlesinger are concerned with questions of the use of market mechanisms and of planning in defense, and I have one comment on each of their papers.

Bailey, in examining the actual use of pricing techniques in U.S. defense policy, may appear to the outsider to underemphasize the influence of marginalism, reflecting economic thinking and the contributions of economists, in the determination of choices between alternative uses for military resources. I quite accept that this is far from the same thing as allowing the free play of market forces in defense, but it is none the less an important contribution. Even if the sole outcome of the work of economists in defense planning were to produce an increased tendency to ask what we get for what we spend, this would be a valuable result. The point might be illustrated by a comment on Bailey's remark at an early point in his paper that the economy and the operation of the armed forces move away from the market mechanism in time of war. In one sense that is very true—decisions are not simply a reflection of price movements. But at the same time an economy on a full war footing —such as the British economy from 1940 to 1945—is forced in its planning to take the greatest cognizance of the economic logic of choice. The objectives can be stated with some clarity and the range of objectives is narrowed, both in the defense sector where the "shadow boxing" of prewar strategy gives way to actual situations, and in the civilian sector where much of the immense range of consumer choices is set aside. The mechanism of choice is operated by a more tightly knit group of those responsible for the war effort. The resources can be reckoned and aligned to the objectives. The needs of the civilians can be, and have to be, tailored to the needs of the war, and the objectives for them are reduced to matters of health and morale. The reconciliation of resources and objectives is not put to the test of the market, but it is very much a product of marginal thinking none the less.

Schlesinger, in discussing the need to "hedge" against uncertainties, appears to suggest that the problem is the same for civilian and military examples. He illustrates his thesis by the case for constructing a wider underpass on a new highway so as to be prepared for the possibility that additional lanes will be required later. This may be warranted expendi-

ture, but it need not be so. The highway planner, though he may well make mistakes in his predictions, can project trends in the demand for his product, and can set out with considerable clarity the time sequence of possible developments, though he will be less certain of the precise timing. He may then go on to produce a reasoned estimate of the return to be expected from additional expenditure now as a precaution against future needs. The military planner seems to me to have much less ability to produce a time-flow of expected returns from nuclear weapons, and to this extent, at least, the task of planning in the civilian sector is much the easier.

Incentive Fee Contracts

Williamson criticises "cost-plus" contracting on the grounds that it allows the authorities to claim that contractors have been kept under control because their profit is fixed without actually securing for the spenders of the money any real control over production efficiency. He also points to the tendency for such a contractual method to build up extra production resources in the hands of the producers as an unplanned consequence of their method of payment. He proceeds from these legitimate criticisms to consider the merits and demerits of the obvious alternative, which requires the introduction of some element of incentive to efficiency on the part of the producers. He suggests, however, that the present form of incentive-fee contract used in U.S. defense spending lacks the necessary amount of specificity and control, and in consequence recommends "a shrinkage in the range of discretion available to the Services and their defense contractors" to be obtained by greater partitioning of the tasks allocated to the contractors. The merits of this proposal appeal to me and I want to offer only one possible criticism before ending by drawing what I think is a useful comparison with the incentive payment of labor.

The risk of greater specificity is that efficiency is lost by missing opportunities for economies of scale and reducing the long-run commitment of producers to the needs of defense. The case of research and development expenditure is different from that of production, since in the former there are more prospects of returns to small-group working. An apparent duplication of research and development effort may yield benefits in the form of viable proposals that can be combined in the

production stages, though even here it is difficult to push the case for disaggregation too far. Economies of scale are usually to be found in production. The need to maintain specificity and detail in contracting need not, however, necessarily imply small production units, since the contracts fixed on the basis of detailed pricing, including an incentive element, can then be let out to the contractors in linked parcels, each item of which is separately priced. Williamson's case is really one for more care in pricing and task definition as well as incentive, and the argument for more control need not also be an argument for separating out the actual establishments being given the work. (It is however, also an argument for more expertise in the detailing of contracts among Government employees, and it may be worth mentioning in passing that there may be grounds for the government's undertaking some—though not all—of its production in establishments under its own control, in part, as a means of developing detailed knowledge of costs.)

Labor economists have some considerable acquaintance with the snags of incentive-pricing since this is a familiar form of payment of labor, whether in the shape of piecework, where the workers are offered a price per unit of production, or as a time-allowance scheme, in which—with variations—the workers are allowed a particular time to do a job and are paid for some or all of the time that they saved against the time allowed, as well as for the time they have actually taken to do the work. An incentive-fee contract for defense purposes would seem to be rather close in form to the fixing of an incentive basis of payment for workers in a jobbing (or "one-off") production situation or in small-batch production. The manager trying to assess the price he is prepared to pay a worker or a group of workers in such a situation has the basic difficulty that the task in question has, either wholly or in part, not been carried out before. There is a strong temptation to be so keen on the incentive idea as to rush into a somewhat arbitrary guess at a price or time. This procedure leads to disenchantment: if the price fixed turns out to be too generous the workers receive an unnecessarily large payment and need not work very hard to obtain it, but if the price fixed is too low then the workers force a revision on the management. There has, therefore, been an increasing tendency to avoid such large prices and to shift towards disaggregating the task to be carried out and pricing it in smaller portions. Alternatively, managements—realizing that the incentive basis of payment requires more and not less active super-

vision—have moved towards relying more on detailed supervision and less on the pricing system itself to obtain efficient work from their employees. They have indeed sometimes actually reverted back to payment on the basis of time worked, without an explicit incentive in the weekly rate but with a progressive over-all payment policy. The moral of this for defense contracting is exactly the point Williamson makes—that incentive payment requires detail in its supervision and pricing if it is to be effective, and that, therefore, the prior need is for "limiting discretionary opportunities."