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ECONOMIC INCENTIVES AND THE DEFENSE PROCUREMENT PROCESS

by

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Abstract

This paper describes some of the insights that the economic theory of incentives can contribute to defense procurement policy analysis. It describes the underlying incentive problems that shape the defense procurement problem, the nature of current institutions and how they affect actors' behavior, and possible directions for improving the procurement process suggested by viewing it as a solution to a complex set of incentive problems. Incentive problems between government and defense firms and incentive problems within government are both considered.

INTRODUCTION

Two fundamental incentive problems studied by economists are how government should regulate firms and how government should organize and delegate decisionmaking authority within its own bureaucracy. Both types of incentive problems play a powerful role in shaping the nature of the defense procurement process. In its relationship with defense firms, government is essentially engaged in a form of cost based regulation such as occurs in the electric utility, health care, and transportation sectors. However, government not only regulates prices, but is the buyer of the product. Therefore, the nature of the incentives created by the way government organizes its own internal decisionmaking process also plays a key role in determining the outcome of the defense procurement process.

Because of the huge level of public resources devoted to defense procurement, it is of course an area of immense public policy importance. In 1992, defense expenditures were $282 billion (DoD 1993) and $80.5 billion, or approximately 30 percent of this was for new weapons procurement.[1] Even given projected cutbacks, annual defense expenditures are projected to remain above 200 billion 1992 dollars (Office of Technology Assessment 1992a). Given that approximately 30% of the defense budget is devoted to new weapons procurement, this suggests that annual procurement expenditures will remain above 60 billion 1992 dollars. To put this figure in perspective, table 1 displays annual revenues for some of the regulated sectors traditionally of great concern to economists. Even after all projected cutbacks are implemented, expenditures on weapons procurement will exceed expenditures in many important regulated sectors such as gas utilities, local telephone exchanges, railroads, interstate gas and petroleum transmission, and pay and cable TV.

Apart from its direct public policy importance, analysis of the defense procurement process should be of substantial interest to economists because many of the incentive issues that arise in defense procurement arise more generally in the study of regulation and government decisionmaking. Of course every regulated sector of the economy exhibits some unique characteristics and special features, and defense is no exception. However, many of the central regulatory problems in defense are clearly related to problems that arise in other regulated sectors. For example, in both defense and health care, innovation is a key output and a critical regulatory issue is whether pricing rules for products create appropriate incentives for innovation. In both defense and telecommunications, firms produce multiple products, only some of which are subject to cost based regulation, and thus the issue of how joint costs ought to be allocated between products becomes significant. In both defense and electricity generation, regulatory lag creates an incentive for cost efficiency. Historically, lengths of regulatory lag have been set largely by accident or chance with no explicit consideration of their incentive effects and thus the question arises as to whether purposefully altering the length of lag would be useful.

Defense procurement is a particularly interesting environment in which to study incentives within the government bureaucracy. The complex nature of decisions that must be made and the inherent difficulty of determining even ex post whether correct decisions were made, allows wide latitude for strategic maneuvering between various actors. To the extent that economists have studied defense procurement at all, they have largely focussed on the incentive problem between government and defense firms. The issue of incentives within the government bureaucracy has been almost completely overlooked. I believe that

the key to explaining some of the most puzzling inefficiencies in procurement lies in carefully analyzing how current budgeting and planning procedures create incentives for various bureaucrats to make decisions.

The purpose of this article is to describe the underlying incentive problems that shape the defense procurement problem, the nature of current institutions and how they affect actors' behavior, and possible directions for improving the procurement process suggested by viewing it as a solution to a complex incentive problem. Reflecting the relative levels of our current understanding of the two incentive problems, I will devote more of this article to discussing the regulatory problem, i.e., the incentive problem between government and defense firms. I will first provide an overview of the basic economic problem and current institutions. Then I will consider two topics in more detail - incentives for R&D and incentives for efficient production. I will then turn to the incentive problem within the government bureaucracy.

THE REGULATORY PROBLEM: BACKGROUND

Underlying Characteristics of the Regulatory Problem

Four important features of the regulatory problem will be listed and discussed.

1. Research and Development

A defining characteristic of weapons procurement is the constant pursuit of improved performance and capabilities through technological advance. The most important consequence of this is that innovation is at least as important a product of the defense sector as the physical products that embody the new ideas. As will be argued in the next section below, innovation is an inherently difficult product to purchase, and this creates the need for

providing incentives for innovation.

2. Uncertainties

Massive uncertainties permeate the procurement process. Scherer(1964) and Peck and Scherer(1962) distinguish between internal and external uncertainty. Internal uncertainty is uncertainty due to technological unknowns. Internal uncertainty is especially high in the design phase of a new weapon. However, even after production begins, most products continue to evolve in order to incorporate new technologies, fix unanticipated problems, etc. Thus, major uncertainties about cost and design typically continue into production. External uncertainty is uncertainty in the demand for a weapon due to changes in the external threat, changes in the availability of substitute weapons, or simply changes in Congress's willingness to purchase certain weapons. As events over the past four years make abundantly clear, external uncertainties are also enormous for most weapons systems.

A major consequence of these large uncertainties is that the Department of Defense (DoD) is typically unable and/or unwilling to sign long term fixed price production contracts. In the design phase, the ultimate nature of the final weapon is not yet known. Even after production begins, the weapon will continue to evolve in unanticipated ways and DoD's demand will change in unanticipated ways. Thus long-term fixed price contracts for the entire decade or more long production run typical of most weapons systems are thought to be infeasible. Rather, production contracts are signed for one annual lot of production at a time on an annual basis.

In fact, these same uncertainties typically mean that even fixed price annual contracts are difficult to fully enforce. Unanticipated changes almost always occur and result in

substantial renegotiations during the life of the contract. When major portions of a contract are renegotiated due to unanticipated changes, there is an inevitable tendency to ascribe all cost overruns to the changes. Thus renegotiation often effectively turns a fixed price contract into a cost sharing contract. The most interesting evidence I am aware of on this subject is from de Figueiredo (1988), who analyzed GAO (1988) data on a broad selection of major defense production contracts. He found that renegotiation resulted in an average increase in the negotiated target price of 31.3% over the life of the contract. He also found that, on average, renegotiation tended to raise price higher on contracts that ultimately experienced the highest cost overruns. This is consistent with (but does not prove) the hypothesis that contractors are able to recover at least a share of cost overruns through renegotiations.

3. Economies of Scale In Production

Within most sectors of the defense industry, there are multiple firms that would be capable ex-ante of designing and producing a given weapons system. Therefore economies of scale do not appear to preclude the existence of multiple competitors at the beginning of a program. Furthermore, design expenditures are relatively small in the early phases of a program, and, given uncertainties at the design stage, it is often sensible to purposefully pursue multiple design strategies since it is not clear which will work best. The result is that DoD very typically funds two design approaches through to the stage where prototypes are built. Thus, economies of scale do not preclude the existence of competition through to the end of the design phase.

However, production is another matter. Given the relatively small quantities

purchased of most weapons systems, it is generally thought to be completely uneconomic to have multiple firms produce the same weapon system. Furthermore, the same reasoning implies that it is uneconomic to have two or three designs enter production that are relatively good substitutes for one another, and to buy some of each. Dramatic cost reductions could generally be achieved by purchasing larger quantities of only one design. Therefore, it is generally the case that production of almost all major weapons systems occurs in a sole source environment. Although the existence of mild substitutes may create some competitive pressures in some cases, there will not typically be a close substitute for any major system and thus the effects of this competition between substitutes are limited.

The major implication of this is that prices cannot be competitively determined. As explained above, at the end of the design phase when there is still competition, pervasive uncertainties prevent the signing of a single production contract for the entire production run. Thus the bulk of all production contracts will be negotiated with a sole source.

4. Government is the Sole Buyer

Government is the only possible buyer of most weapons.[2] Furthermore, many of the technologies and skills required to create and produce weapons systems are relatively specific to the weapons industry. The main consequence of this is that it creates a hold-up problem (Williamson 1985, Tirole 1986). At the R&D phase, firms may worry that if they invest their own funds to create ideas for weapons systems, they will never recover these sunk expenses. At the production phase, firms may worry that they will never recover their investment in physical capital which has little use outside the defense industry. One of the main assets of any defense firms is its human capital embodied in the knowledge and working relationships

of its design team members. Firms may easily worry that expenditures to create better design teams may never be recovered since there is no good alternative use for this asset.

Government has responded to firms' fears to invest in specific assets in three ways. First, it has become a purchaser of the intermediate product "R&D," as well as the final product , "functioning weapons systems." That is, government directly funds a large portion of defense-related R&D. Second, it has become the purchaser of many specific physical assets for defense firms. Third, through a massive set of regulations and policies, DoD has established an extra-contractual administrative relationship (Goldberg 1976) with firms which provides them with a range of guarantees that their specific investments will not be appropriated. These regulations are contained largely in the Federal Acquisition Regulation (FAR) and the Defense Federal Acquisition Regulation (DFAR).[3] Perhaps the major such regulatory guarantee is that prices will be cost-based when negotiations occur with a sole source. That is, the FAR specifically instructs contracting officers negotiating with a sole source that their job is not to obtain the lowest price. Rather, it instructs them in great detail how to calculate a fair price based on estimated costs and instructs them to obtain this price. Many of the cost elements that the FAR instructs contracting officers to pay for are likely to be sunk at the time of negotiation.

There is a distinct element of reputational enforcement inherent in this relationship. Some of the DoD behavior that provides investment guarantees is simply DoD practice and not mandated by any regulation. Even behavior mandated by regulations cannot be completely relied on because regulations can be changed. Of course, it can be difficult to change regulations, especially when defense firms can directly lobby Congress to intervene,

etc. This difficulty in changing regulation works to DoD's advantage in convincing firms that they can rely on the regulations. Nonetheless, there is also an element of reputational enforcement. Namely, DoD would often benefit in the short run from reneging on all of its commitments and negotiating the lowest possible prices for the current period's contracts. However, in the long run, DoD would be harmed because it would no longer be able to convince firms to engage in specific investments. Thus, it may well be rational for DoD to honor its implicit commitments as codified in its regulations.

The Program Life Cycle

Based on the above discussion, we can view the life cycle of a program as being divided into three phases. The first phase is the design phase. During this phase, multiple firms pursue competing designs. In early portions of the design phase there may be five or more firms, each working on its own design. However, by the end of the design phase, DoD is usually left with two competing firms. DoD directly funds most of this research through cost reimbursement contracts. However, as will be explained below, competition for the production franchise is often intense and thus firms often augment DoD funding with their own private funds.

The second phase is the sole source selection phase. In this phase firms submit prototypes, final design plans, etc. to DoD so it can evaluate the relative merits of the designs. They also typically bid on the next increment of work. This would typically be what is referred to as the engineering and manufacturing development contract which would involve finalizing the design, establishing the production line, and producing the first few items. DoD selects a winner based on its evaluation of the competing designs (their likely

performance, production cost, maintainability, etc.) and the bids on the next increment of work. A single winner is chosen because of economies of scale, as discussed above.

The third phase is the production phase. During this phase, the winner of the source selection phase produces the product. This phase may last a decade or more. Almost all of the production contracts are signed in a sole source environment after the winner has been chosen. Long term contracts cannot be signed when competition still exists because of cost uncertainties, demand uncertainties, and the evolving nature of the product, as explained above. Prices in the production phase are highly cost based. Although production occurs under a series of annually signed fixed price contracts, each contract's price is largely determined by audited historic and audited projected accounting costs.

Discussion

An interesting perspective on the role of the above four characteristics in generating the regulatory problem of defense procurement can be obtained by considering how the regulatory problem would change if only some were true. In particular, it is illuminating to consider the first two features as one group (R&D is important; large uncertainties) and the second two as a separate group (large economies of scale in production imply the absence of close substitutes; government is the sole purchaser).

Suppose that the first group of features was not true and only the second group was true. This would be an industry where technological advance was not particularly important and thus efficient production was the only real issue. However, because of large economies of scale, there would be room in the market for only one firm. This is, of course, the description of a traditional public utility regulation problem. Thus, in some sense, the

production phase of a procurement program can be viewed as a typical public utility problem. What makes defense procurement special, is that each franchise lasts only a decade or so, and firms compete for franchises by performing R&D. Furthermore, generating the correct amounts of the correct types of R&D is a major goal of the regulatory system.

Now suppose that the second group of features was not true and only the first was true. This would be an industry where technological advance was rapid and important and where large uncertainties existed, especially at the R&D phase. However, government would not be the only buyer and economies of scale would not be so large as to preclude competition between substitutes. The obvious example of such an industry is the computer industry. Computer procurement works in a completely different fashion than weapons procurement (Kelman 1990). The government does not directly buy R&D. Rather, it buys final products much as occurs in any normal commercial market. Furthermore, it does not directly fund facilities capital investments. Finally, procurement is usually accomplished through competitive bidding with no element of cost based pricing.

Commentators on the defense procurement problem often stress the importance of technological advance and the uncertainties this creates. However, based on the above discussion, it is clear that this factor alone would not create a severe regulatory problem. It is the additional features that government is the sole procurer and there are large economies of scale in production that cause a severe problem. Thus it is the simultaneous existence of both groups of features that create the distinctive regulatory problem of defense procurement.

Theory of the Internal Organization of the Firm

DoD's long term relational partnerships with suppliers are similar, in some respects, to the type of relationships that large commercial firms such as General Motors, have with their major suppliers. Production of major automobile subcomponents or parts often requires specific investments in R&D or physical capital. Production often occurs by a single source. However, the relationship is nested in a larger competitive environment where GM could turn to different subcontractors for future programs if its wished. Thus, just as in defense procurement, sole source relationships with specific investments occur in the context of a larger competitive environment for future programs.

One of the major differences between the DoD problem and GM's problem regards the make vs. buy decision. Many observers believe that government production of weapons systems would be hopelessly inefficient (due to low civil service pay scales, cumbersome personnel systems, lack of flexibility for decisionmaking, etc.) and thus is not a real option in most cases. If this if true, then government's option to make instead of buy is much more limited than GM's. This difference is interesting, because, as will be discussed further in the next two sections, a major problem faced by the defense regulatory system is how to provide incentives for R&D and the solution to this problem plays a signigicant role in shaping the system. There is some evidence that large commercial firms deal with this problem by moving production in-house. Monteverde and Teece (1982) show that large automotive firms are much more likely to produce a component in-house if it involves significant amounts of R&D. This suggests that provision of incentives for R&D may be a particularly difficult problem in purchaser/supplier relationships.

PRIZES FOR INNOVATION: THEORY AND EVIDENCE

This section and the next section will describe a theory which captures an important aspect of the regulatory problem in defense procurement. The theory is the (i) DoD must supply incentives for firms to exert their best efforts at the R&D phase, (ii) that the way this is accomplished is through allowing mild levels of economic profit to be earned on sole source production contracts, and, (iii) that this appears to be a relatively good solution to a difficult incentive problem. Thus, profit on sole source production contracts essentially acts as a prize for innovation that defense firms compete for in the design phase.

The general idea that the stages of the procurement process are interlinked and that profit at the sole source production stage is used to solve an incentive problem at the R&D stage is, thus far, perhaps the most useful idea that the economic theory of incentives has helped elucidate in defense procurement policy analysis. Prior to work in the last five years of economists interested in incentive theory, this idea and its policy implications were not fully appreciated in the literature on defense procurement. It was well understood that defense firms competed vigorously for sole source production programs (e.g., Scherer 1964) and that losses incurred during development were made back during sole source production. However, this phenomenon was simply accepted as a given fixture of the environment and very little attention was devoted to the question of whether this was a desirable regulatory institution or not and why. Of course, the basic approach of modern incentive economics is to begin by attempting to describe the underlying incentive and informational constraints that characterize a regulatory problem. Thus the idea that DoD must create incentives for firms to exert their best efforts at the R&D stage, and that profit on production contracts

was creating these incentives, was a very natural conclusion for economists interested in incentive theory. Beginning in the late 1980's, a number of papers developed different aspects of this theory. These include Bower and Osband (1991), Guler and Plott (1988), Riordan and Sappington (1989), Rogerson (1989), Tan (1989a,b), Taylor (1991), and Teresawa and Besen (1989). A non-economist published a more institutionally oriented book at about the same time (McNaugher 1989) which also described some elements of this theory. Although the vague outlines of this theory have perhaps always been understood,[4] this modern research has, at a minimum, thrown many of the issues into a much sharper focus and more clearly elucidated the nature of the tradeoffs involved in various policy choices.

This section will describe the theory and also present some evidence supporting it. Then the following section will discuss policy implications of the theory.

The Incentive Problem

DoD is unable to directly purchase the innovative efforts of firms. Therefore it must indirectly give firms the incentive to provide this effort by establishing rewards for successful innovation. This is true for two reasons.

First, there is a moral hazard problem. The amount of innovation produced is obviously only stochastically related to the amount of effort exerted. Furthermore it is difficult to monitor the level of effort a firm is exerting. "Exerting more effort" might include assigning the firm's best engineers to the project, having management devote large amounts of time and effort to deciding which approaches and projects would be most likely to be successful, and keeping a research team together at the firm's own expense for periods of

time when no business exists. None of these is easily observable or measurable by DoD. Therefore DoD's only alternative is to attempt to give firms an incentive to exert this effort by promising to reward successful innovation with prizes.

However, even if level of effort was totally observable, a second factor would still necessitate the use of prizes. This is that firms are very likely to possess private information about which sorts of projects are more likely to yield the kind of results of most value to DoD. Therefore an optimal research program should be somewhat decentralized so that firms can make decisions based upon their private information. However, when delegating some decision-making authority to firms, DoD must simultaneously provide the firms with incentives to make the decisions which are best from the DoD perspective (instead of, for example, choosing projects likely to produce the most commercial spinoffs). Establishing prizes for innovation accomplishes this.

Production Profit As an Incentive

The obvious objectively verifiable signal of whether a firm has created a successful new weapons design is whether DoD chooses to purchase it. Thus a regulatory system could create prizes for innovation by guaranteeing that any firm which becomes a prime contractor on a new weapons system will earn positive economic profit on the production contracts for the weapons system. In such a system, firms which can successfully generate ideas good enough to be adopted by the government would receive prizes in the form of economic profit on the production phase of the system.

Furthermore, if profit was awarded approximately as a percentage of cost (i.e., the profit earned on a system doubles if the system is twice as expensive) this might in a very

rough sense also tend to award larger prizes for better innovations for two reasons. First, systems which prove to be useful are purchased in larger quantities. Second, there is probably some sense in which a 30 billion dollar project is more important to government than a 30 million dollar project. Finally, note that such a system would also provide incentives for the firm to continue to innovate and improve its product even after it is initially adopted. This is because it can guarantee more sales (and thus more profit) by improving the system.

Alternative Incentive Structures

The fact that it is necessary to create incentives for R&D does not by itself establish that it is desirable for defense firms to earn positive profit on production contracts. An alternative approach to creating R&D incentives would be to award zero economic profit on production contracts and provide incentives for R&D by directly rewarding good ideas. There are two problems with this alternate approach. First, as will be discussed below, to some extent it may be desirable to allow economic profit to be earned at the production phase as part of an incentive scheme to encourage production efficiency. Thus, allowing production profits may be a particularly desirable method for creating R&D incentives, because these profits can also be used to create better incentives for cost-efficiency at the production stage. Second, the alternative approach of directly rewarding good ideas may be difficult to implement and operate. Thus it may not work very well.

This second point can be seen by considering the possible ways of directly rewarding innovation at the design stage. One possibility would be legally binding R&D incentive contracts which explicitly described all possible innovations and the rewards that would be

paid for each one. Some R&D occurs within well-defined programs with fairly well-defined objectives. Even in these cases, it seems unlikely that DoD could provide a legally enforceable contract covering all possible design achievements and the reward for each one. However, a large fraction of firms' R&D is directed towards identifying more basic new ideas and concepts for weapons development. To sign a legally enforceable contract directly rewarding the results of this more far-ranging basic R&D would literally require government to list the possible universe of innovations and the prize attached to each one. This is obviously impossible.

Another possibility would be to allow DoD to more informally assess the quality of various innovations and simply award prizes to the innovations it deemed most desirable. For example, on a particular program, DoD could announce ex-ante that the designer of the prototype deemed to be most successful would receive a prize of a certain size. This is a more realistic possibility. The main difficulty here is that it might be politically difficult to award large prizes and that the subjectivity of such awards would open it up to political pressures and manipulation.

The final possibility is that reputation might begin to function in a market where production offered no profit. In such an environment, R&D contracts would have to be profitable in and of themselves, and it might be that firms would have an incentive to do good R&D in order to receive more R&D contracts in the future. This type of incentive would be more attenuated and indirect than the current system. As will be discussed later, there is also some evidence that incentive problems within government make it very difficult for central decisionmaking authorities to be willing to delegate enough authority in order for

subordinates to effectively use reputation as a factor in their purchasing decisions.

It is, of course, difficult to "prove" that the current approach of incentivizing R&D through production profits is optimal. Nonetheless, there is reason to believe that it is a relatively desirable solution to a difficult incentive problem.

Sole Source Profit: Theory

The above discussion has explained why, in theory, the regulatory practice of allowing profit to be earned on sole source production contracts might be desirable. It will now be shown that this practice actually occurs. This part will outline the reasons why defense firms are able to earn this profit and the next part will describe empirical evidence that such profit is actually earned. DoD allows economic profit to be earned in three different ways.

First, as part of its cost based pricing regulations, DoD instructs the contracting officer to include an element called "profit" when calculating the fair price for a contract. The regulations instructing how this "profit" term is to be calculated are usually referred to as the weighted guidelines (DFAR 215.9). Although some of this term is clearly designed to be reimbursement for true economic costs of production not recognized by accounting costs (cost of facilities capital, working capital, risk bearing), it seems likely that the weighted guidelines also generally pay a small economic profit as well, roughly in proportion to accounting costs (Rogerson 1991d).

Second, through using fixed price contracts for production, DoD creates a type of regulatory lag which may allow defense firms to earn some economic profit (Rogerson 1993). A contract for a single annual lot of missiles or aircraft may easily take two to three years to complete. Furthermore, contracts are often signed six months or more prior to beginning

production. The result of this is that a typical defense firm will have a signed backlog of business equal to two to three times its annual revenues. When a defense firms suddenly discovers a new way to lower its production costs, future negotiation will take this new efficiency into account and prices on contracts negotiated from that point on will be lowered by the amount of the cost reduction. However, previously negotiated prices are not changed. Thus, defense firms are able to keep profits created by cost reductions during the one or more years that they continue to operate under previously negotiated fixed price contracts.

Third, even if prices on sole source defense contracts were set exactly equal to accounting costs, defense firms would still generally be able to earn economic profit through shifting overhead between products. Defense firms typically produce multiple products within the same plant. Many costs in such facilities are joint. Furthermore, it would often ge very expensive to directly keep track of all costs that in principle could be directly associated with a single product. Thus, much as most purely commercial manufacturing firms, defense firms are allowed to group large fractions of their costs into overhead pools and allocate these to individual products using various formulas. For example, McCullough and Balut (1990) (reported in Rogerson 1992b, page 684) find that overhead costs comprised 58 percent of in-plant costs for four major aerospace contractors. Defense firms typically have some purely commercial or competitive defense business as well as sole source defense business. For example, in its last major statistical analysis of all major defense contractors, DoD(1985) found that, within their government products divisions, major defense contractors' business was 82.8 percent DoD and 17.2 percent commercial. It is clear that by shifting one dollar of overhead away from a purely commercial product selling at a

competitively determined price and onto a sole source defence product where price is set equal to accounting cost, a defense firm could raise its profit by one dollar. Thus overhead shifting can allow a defense firm to earn positive economic profit over-all even if prices are set equal to accounting costs on its sole source defense business.

There are two ways that defense firms are able to accomplish this type of overhead shifting (Rogerson 1992ab). First, the regulations governing cost allocation give defense firms some freedom to choose different allocation rules and to change rules. Thus, to some extent, defense firms can simply choose rules to accomplish the allocation result they desire. Second, much overhead is allocated in proportion to directly charged labor. Thus, by distorting relative labor usage across products (by labor padding or input substitution) a defense firm can influence where overhead is allocated.

Economic profit earned in all three of the above ways plays a role in creating incentives for innovation. Thus one need search no further for an explanation of why DoD allows economic profit to be earned. However, for the last two ways discussed above, there is probably an additional reason why DoD finds it desirable to allow economic profit to be earned. DoD's goal is to minimize the price it pays, not to minimize firms' profits. A general theme of the principal agent literature is that a principal may find it optimal to allow his agent to earn some profit as part of an incentive scheme which gives the agent a strong incentive to lower costs (Laffont and Tirole 1993). One can interpret both regulatory lag and cost allocation practices as being incentive schemes of this sort.

With respect to regulatory lag, allowing the firm to retain some of the surplus from cost reductions creates incentives for the firm to reduce costs. The same type of argument

can be made with respect to cost allocation. When there are economies of scope, it may be efficient for the firm to accept some purely commercial business. Roughly speaking, DoD attempts to pay for a share of joint costs equal to its share of the business base. One could interpret this as an attempt to give the firm an incentive to diversify when this is efficient, by sharing the gains from diversification.

Sole Source Profit: Evidence

In order to empirically show that defense firms earn positive economic profit on the sole source production phase of weapons programs, the most natural and obvious approach to try would be to obtain data on cash flows for various programs and then calculate their discounted value using the appropriate discount rate. Unfortunately, there are three major problems with this approach. First, accounting data his many problems. For example, instead of measuring cash flows, it attempts to match expenditures to revenues, and allocations to programs are made using fairly arbitrary formulas. Second, the question of what an appropriate rate of return is for investments of this risk class is difficult to answer in any way that would be generally accepted as correct. Third, data on individual programs is generally completely unavailable. All published data such as that in DoD(1985) is on a firm-wide basis.

Rogerson (1989, 1991c) avoided these difficulties by using an event study methodology to determine stock market investors' estimates of the discounted value of cash flows from the sole source production phase. Thirteen major aerospace programs were considered. In each of these programs, a number (usually two or three) of firms competed in the design phase and there was a sole source selection phase where DoD chose the sole source. The

methodology was to observe how contestants' stock market values changed in response to the announcement of the winner and to use these observed changes to infer the value of the prize that firms were competing for.

A simple example will communicate the flavor the analysis. Suppose that two firms are competing for a prize equal to $1 million (i.e., the economic profit from the sole source production phase equals $1 million) and that each has an equal chance of winning. The day before the announcement, each firm should be worth $500,000 since each has a 50% chance of receiving $1 million. The day after the announcement the winner's value should rise to $1 million and the loser's value should fall to zero. Note that the value of the prize ($1 million) equals the sum of the rise in the winner's value ($500,000) and the fall in the loser's value ($500,000). Rogerson(1989, 1991c) generalized the above example (to cases where there are more than two competitors and not all contestants necessarily have an equal chance of winning) to provide a formula for estimating the value of the prize. The result (averaged across all programs) was that the value of the prize was equal to between $47 and $67 million. The average discounted present value of program revenues was estimated to be $1,434 million. Thus, the prize was equal to between 3.3 percent and 4.7 percent of discounted program revenue. One can interpret this as meaning that, on average, when the firm received one dollar of revenue in the sole source phase, between 3.3 cents and 4.7 cents of this dollar was pure economic profit.

The only publicly available data on cash flows by program that I am aware of is contained in the appendix of an industry sponsored study analyzing defense contractor profitability (MAC Group 1988).[5] Using this data, and using the discount rate the authors

of the study suggest is appropriate, the value of the prize (i.e., the discounted value of the after tax cash flows for the sole source production phase) equals $13.5 billion and the discounted value of program revenue equals $307.8 million. Thus, the prize as a percentage of discounted revenue equals 4.4 percent. This is remarkably similar to the estimate of 3.3 percent to 4.7 percent arrived at by Rogerson(1989, 1991c).

Bidding for the Sole Source Franchise

At the sole source selection phase, firms typically bid for the next increment of work which is often the engineering and manufacturing development (EMD) contract. In a situation where firms know that the winner of the sole source selection phase will go on to earn economic profit in the sole source production phase, we might expect to see firms purposefully bid below cost on the EMD contract in order to increase their chances of winning the franchise. In fact, in an extremely competitive auction, we would expect the winner's bid to be below the expected cost of the EMD contract by an amount precisely equal to the discounted value of economic profit on the yet-to-be-negotiated sole source production contracts.

The above empirical analysis suggests that the sole source selection phase is not so competitive as to capture all the profit to be earned in the sole source phase. The above estimate of the prize includes both the profit (negative or positive) on the competitively bid EMD phase plus the profit on the yet to be negotiated sole source production phase.

The fact that competitive bidding at the sole source selection phase does not dissipate all of the rents from the sole source franchise in not surprising. In some cases, the EMD contract is a cost type contract or is at least of the cost sharing type which would blunt

competition. As explained earlier, even fixed price contracts are often de facto cost sharing because of renegotiation. This would be especially true at the EMD phase where substantial design changes are likely. Thus it may be difficult for firms to credibly bid below cost. Furthermore, the fact that design differences exist and that the design is very important in DoD's evaluation would tend to blunt price competition.

The fact that bidding at the sole source selection phase does not dissipate all the rents is not necessarily bad. The major point of this section is that the prospect of earning economic profit creates useful incentives for innovation. At the design stage, the relevant measure of the profit to be earned from winning the franchise is the profit from the sole source phase minus the loss on the competitive bid at the source selection phase. Thus in order for there to be prizes for innovation, it is necessary that bidding for the sole source franchise not be so competitive so as to dissipate all the rents.

Patterns of R&D Expenditures

Table 2 presents defense R&D expenditures by performer and funding source. DoD performs 22 percent of all R&D in its own laboratories and another 8 percent is performed under contract by universities and other non-profits. For-profit firms perform the remaining 70 percent of R&D. R&D expenditures by for-profit firms can be divided into three categories. The first category is R&D conducted under contract to DoD. This is by far the largest category and accounts for 84 percent of for-profits' R&D expenditures. All other R&D expenditures by for-profit firms are usually referred to as independent research and development (IR&D). DoD has a program, called the IR&D program, where it funds a certain fraction of defense contractors' IR&D expenditures. Each year, DoD negotiates an

IR&D ceiling with each major defense contractor. IR&D expenditures below the ceiling amount are viewed as an allowable cost and are allocated to contracts as an element of overhead cost. IR&D expenditures above the ceiling amount are viewed as an unallowable cost and are born entirely by the defense contractor (Alexander, Hill, and Bodilly 1989, Lichtenberg 1990). As part of the negotiations over each year's ceiling, DoD and the firms keep records of firms' total IR&D expenditures judged to have potential military relevance. Table 2 only reports IR&D expenditures judged to exhibit potential military relevance. Below-ceiling IR&D expenditures allocated to DoD contracts are recorded as being funded by DoD. Below-ceiling IR&D expenditures allocated to non-DoD contracts and above-ceiling IR&D expenditures are recorded as being funded by the firms themselves. From table 2, IR&D accounts for 16 percent of for-profit firms' R&D expenditures. DoD funded IR&D accounts for 7 percent and privately funded IR&D accounts for 9 percent.

Four features of the above data are deserving of comment. First, DoD directly funds the vast bulk of for-profit firms' R&D expenditures through R&D contracts. The modest level of economic profit earned on production contracts is not sufficient to make firms willing to privately finance the bulk of R&D. The optimal solution to the regulatory incentive problem must balance the goal of creating desirable incentives for R&D (which calls for firms to fund more R&D themselves) against the goals of protecting firms from the hold-up problem and excessive risk-bearing (which call for firms to fund less R&D themselves).

Second, a relatively significant fraction of total defence R&D is performed by DoD in its own laboratories or under contract by non-profits such as universities. Reference to

more detailed breakdowns of this data in NSF(1992,1993) shows that the bulk of this R&D consists of basic research. More applied research and development is largely performed by for-profit firms. The rationale for this division of labor is fairly obvious. The incentive of profit on production contracts provides a strong incentive for R&D that leads in a fairly direct and immediate way to a new product. However, it provides a much weaker incentive for R&D of a more basic nature. Thus private firms have a stronger comparative advantage in performing more applied R&D.

Third, government funds a fairly large fraction of firms' IR&D. The advantage of IR&D is that it delegates a large amount of discretion to firms regarding what projects they will undertake. The fact that there are prizes for innovations that DoD values insures that firms have an incentive to spend this money on projects of value to DoD.

Fourth, firms do spend their own money on IR&D. Firms for which IR&D expenditures were recorded in table 2, reported total revenues of $183.7 billion for FY1989 (Defense Contract Audit Agency 1990). Privately funded IR&D expenditures therefore equalled 1.4% of revenues. This is a significant expenditure and certainly suggests that firms have an incentive to perform R&D. Lichtenberg(1988) supplies further evidence on this point. Through an econometric analysis he shows that defense firms who engage in more sole source production contracts are more likely to engage in IR&D than defense firms who engage in competitive production contracts.

Bid and Proposal Expenditures

Bid and proposal (B&P) expenditures are defined to be expenditures firms incur in preparing and presenting proposals to win government contracts. From a theoretical

perspective, B&P expenses can be viewed as very applied and very short run R&D. In particular, the prize of profit on production contracts provides an incentive for firms to incur B&P expenditures, and indirectly creating incentives for B&P instead of directly funding all of it can be argued to have some desirable incentive properties (Rogerson 1991d).

Because B&P expenditures have such a direct and immediate effect on firms' chances of winning contracts, DoD has not found it necessary to directly pay for B&P expenditures the way that it directly pays for R&D expenditures through R&D contracts. Rather, it pays for a fraction of B&P expenditures through a program analogous to the IR&D program. It negotiates annual B&P ceilings with firms. Below-ceiling amounts are viewed as allowable costs and allocated to all contracts as an overhead item.

Table 3 shows B&P expenditures by funding source for FY1989. Just as for table 2, below-ceiling expenditures allocated to DoD contracts are classified as DoD funded. All other expenditures are classified as firm funded. By comparing IR&D expenditures in table 2 with B&P expenditures in table 3, it can be seen that firms spend almost twice as much on IR&D as B&P. A larger share of B&P than IR&D is funded by government.

Many people have argued that B&P expenditures of firms have a large element of "slick brochuremanship" to them and are excessive relative to what would be efficient (Scherer 1964). If this is true, the obvious solution would be to fund a smaller share of B&P expenditures. This is a special instance of the more general point, that the creation of prizes will induce a variety of types of rent seeking behavior and that government may have to differentially subsidize and tax these different types of rent seeking behavior to obtain the right mix.

Over-All Profit

The fact that profit is earned on sole source production and that this profit is not all bid away at the sole source selection phase does not mean that defense firms earn economic profit over-all. This is because they spend their own funds on R&D and B&P. DoD periodically conducts studies of the accounting profitability of the defense industry, the most recent of which is DoD(1985), and these studies generally conclude that, while accounting profitability varies from year to year as procurement budgets change is size, when viewed over longer time horizons, the defense industry appears to earn approximately a normal rate of return when compared to commercial industry.

This is not surprising. Entry and exit are certainly possible over the medium run in this industry. Peck and Scherer (1962) document that, if anything, rates of turnover of firms in the defense sector appear to be higher than in similar non-defense industries. One reason for this may be that potential entrants are able to easily establish a toehold in the industry by first becoming a subcontractor,i.e., by producing a sub-system of a major weapons system under contract to one of the larger prime contractors dealing directly with government. Between 50 and 60 percent of a weapons system is typically subcontracted, so this is a potentially significant source of entry (Gansler 1980, page 127). As an example of this phenomenon, Northrop was a subcontractor prior to winning the F18 and B2, and may well become a subcontractor once again as defense budgets shrink.

A "back of the envelope" calculation using data presented above supports the proposition that it is plausible that zero economic profit over-all may be earned in the defense industry. From tables 2 and 3, major defense contractors' privately funded

IR&D/B&P expenditures totalled $3.5 billion in FY1989. These same firms' revenues on DoD business equalled $118.6 billion in that year (Defense Contract Audit Agency 1990). Approximately 83.7% of this total, or $99.3 billion was received on production contracts (DoD 1992). Using the lower estimate from Rogerson (1989) presented above, suppose that 3.3% of the revenue on production contracts consisted of economic profit. Then firms earned $3.3 billion in economic profit on their production contracts. This is essentially equal to the figure of $3.5 billion that they spent on IR&D/B&P attempting to earn these profits.

Other Countries

A natural question to ask is how other countries deal with the innovation incentive problem. Western European countries have much smaller procurement budgets than the United States (Office of Technology Assessment 1991a, 1992b). It is quite typical that there will only be a single firm capable of designing and producing a given type of weapon system and therefore there is essentially no competition at the design phase for the sole source franchise. In France, these firms are referred to as "national champions." Thus, intense competition at the design phase for the sole source franchise is not a part of most European countries' procurement systems. However, a different type of competition substitutes for this. Foreign sales are a major goal of most European weapons programs and this market is generally intensely competitive. Thus, the prospect of earning large profits on foreign sales creates innovation incentives for European defense firms. This factor is not generally as important in the United States because the United States generally does not allow its most advanced systems to be sold to foreign buyers.

The pre-collapse Soviet Union provides another interesting example. Alexander

(1973 page 10) reports that multiple competing design bureaus existed and that successful designs were rewarded lavishly.

Thus different countries with differing circumstances and differing economic systems have all adopted procurement systems that provide large financial rewards for successful innovations. This provides some evidence that the incentive problem associated with innovation is a significant one.

PRIZES FOR INNOVATION: POLICY IMPLICATIONS

The major policy implication of the above theory is that firms' behavior across the three stages of procurement - design, sole source selection, and production - is interconnected. Thus, adjusting policy variables at one stage is likely to have consequences at all stages. This means that one must approach procurement policy by simultaneously considering behavior and policy options at all stages. For example, at the production stage, government can influence the profitability of sole source production. At the sole source selection phase, government can influence the competitiveness of bidding for the sole source franchise. At the design stage government can decide how much R&D to fund directly through contracts and how much to fund indirectly through the IR&D program. All of these policy decisions combine to affect the over-all amount and quality of R&D that is performed. Furthermore, many of them may also be related to efficiency at the production stage. Determination of an optimal policy must be approached by identifying the goals to be attained over the entire procurement life-cycle and identifying how different combinations of policies at different stages affect the achievement of these goals.

Nine more focussed policy implication which illustrate this general idea will now be

briefly outlined.

1. The Role of Profit Policy

Defense policy analysts often use the term "profit policy" to refer to the entire set of DoD policies and regulations that influence the profitability of defense contracts. This would include the weighted guidelines, regulations on the allowability and allocability of costs, policies on when to dual source, etc. A deeply help mind-set of most of the defense community is that the main role of profit policy is to control firms' profits. According to this view, once or twice every decade DoD should conduct a study to determine the over-all profitability of defense contracts. If profits appear to be too high or too low then profit policy should be adjusted to raise or lower profit. This is, in fact, much the procedure that actually occurs. Since profit policy is seen simply as a tool for regulating firms' overall profit levels, the entire debate thus focuses on whether overall profits appear too high or too low.

If the theory described above is correct, the most important function of profit policy may be to regulate the level of innovative activity in the defense sector. Therefore an important focus of the debate should be whether an adequate level of innovation currently exists or not. Even if entry and exit into the defense sector were impossible, a share of any increase in profit levels earned on production contracts will be transformed into increased innovative activity. If entry and exit are possible, long run profits will necessarily be zero. Thus profit policy has no effect at all on long run profits! Rather the only long run effect of profit policy is to determine the rate of innovation.

2. Competition at the Production Stage

Competition at the production stage is often suggested as the "solution" to the

procurement problem. The main approach to creating competition that has actually been used is usually referred to as dual sourcing. Under this approach, two producers compete for shares of each annual buy (Anton and Yao 1990, Crocker and Reynolds 1993, Daly and Schuttinga 1982). This has been widely used for systems with relatively large annual volumes such as missiles where the cost penalty due to scale economies from dividing production between two sources was not thought to be too great. However, it has not been used on the majority of systems because the cost penalty due to loss of economies of scale was thought to be too great.

The standard analysis of the costs and benefits of this practice is as follows. The obvious cost is that the non-recurring costs of setting up the production facility must be incurred twice. A not quite so obvious cost is that the individual firms will move more slowly down their learning curves given that they are splitting production. These costs are offset by two benefits. The first benefit is that firms will strive to minimize production costs as part of the competition to win more production. The second cited benefit is that any economic profit which would have been earned in a sole source situation will be competed away.

From the perspective of this article, the second cited benefit may in fact be an additional cost. Namely, the removal of all economic profit on production contracts will also remove firms' incentives to innovate in an effort to win them (Riordan and Sappington 1989).

An approach which has been suggested for systems where economies of scale would not permit two producers, is to separate the design and production phases (Archibald et. al. 1981, Carter 1974, Hall and Johnson 1967, 1968, Johnson and McKie 1968, Kaysan 1963).

The basic idea would be to have the design firm transfer sufficient technical data and knowhow to other firms to enable them to be able to produce the system as well. Then, at the end of the design phase, government would hold a one-time auction for the right to be the sole source producer. This approach has not been used primarily because of doubts that government could effectively force the original design firm to fully transfer sufficient technical data and knowhow to other firms to compete effectively. Most of the policy debate over this issue has focussed on the feasibility of transferring this knowhow.

The debate has overlooked a more fundamental economic question. Even if transfer of technical information was costless, it may not be desirable to force the winner of the design competition to transfer its information to other firms. The main effect of this policy would be to intensify bidding competition for the sole source franchise. This would almost certainly reduce the price government pays. However, it would also reduce the prize for creating the winning design and thus reduce incentives for innovation.

3. Regulatory Lag

As discussed earlier in this paper, a general theme of the principal agent literature is that in situations with asymmetric information, incentive schemes which cause the agent to reduce costs often necessarily also leave the agent with economic profit (Laffont and Tirole 1993). Therefore, even if a principal placed no value at all on profit earned by the agent, a principal might want to choose incentive schemes which left the agent with some economic profit. However, the situation in sole source production is somewhat different than this, and more favorable to the principal. DoD does not necessarily lose profit earned by the sole source producer. This is because this profit may be bid away at the sole source

selection phase or competed away in innovation expenses at the design phase. This suggests that creation of efficiency incentives at the production phase through using incentive schemes that leave profit to the agent may be a particularly desirable policy for DoD to consider. This is essentially an application of Demsetz's (1968) observation that allowing monopoly profit may not be particularly harmful if one can create ex-ante competition for the franchise. Riordan (1993) creates a formal model of this idea applied to the procurement process.

In the procurement context, the main way that this issue arises concerns the speed and certainty with which DoD learns of and adjusts prices in response to new cost efficiencies introduced by the firm. This can be viewed as the "length" of the regulatory lag. There are two natural ways to consider lengthening the period of regulatory lag in defense procurement. The first would be to use multi-year contracts, i.e., to sign a single contract for more than one annual lot of weapons. The second would be to relax the cost disclosure requirements and/or degree of auditing. Both of these approaches will be discussed in more detail in the next section which considers incentives for production efficiency.

4. Production Efficiency vs. Innovation Incentives

The above discussion suggests that whether a tradeoff exists between creating incentives for efficient production and creating incentives for innovation depends on the method being used to create incentives. When incentives for production efficiency are created through introducing competition, this tradeoff clearly exists. Competition creates incentives for cost efficiency but also reduces profit, thereby reducing incentives for innovation. However, when attention is restricted to incentive schemes used for sole source

production, this tradeoff no longer necessarily exists. Increasing the length of the period of regulatory lag both increases incentives for cost-efficiency and increases profit, thereby increasing innovation incentives.

It is generally thought that the result of the weighted guidelines is that defense firms earn at least a small amount of economic profit roughly in proportion to accounting costs (Rogerson 1991d). Therefore, a tradeoff between production efficiency and incentives for innovation also exists for this regulatory instrument. Increasing the profit rate creates larger incentives for innovation at the design stage. However, it also creates larger incentives for firms to purposefully inflate costs at the production stage.

5. Prototype and Shelve Strategies

Because of perceived reductions in the current threat, defense expenditures are being cut back dramatically. The DoD budget has already been cut by 30 percent since the peak of the mid-eighties and it is likely that the budget will fall be another 30 percent by the end of the decade (Office of Technology Assessment 1992a, pages 3-5). Many defense policy analysts have suggested that DoD should respond to this new situation by devoting a greater share of its resources to R&D and a smaller share to production (Office of Technology Assessment 1991b 1992a, Drezner et.al. 1992). The basic idea is that, by investing in R&D, the United States can maintain a technological lead and preserve the existence of specialized design teams so that, if future events warranted, production of larger numbers of superior weapons systems could be resumed fairly quickly. R&D is relatively inexpensive compared to production, so it is argued that the strategy of cutting back production much more heavily than R&D will both save large amounts of money and preserve the capability of the United

States to respond quickly should the perceived threat change. This revised procurement strategy emphasizing R&D over production would be implemented by adopting a "prototype and shelve" strategy. That is, designs would be pursued through to the stage where a prototype was created. Then, instead of entering production, the idea would be "shelved."

The current debate over the advisability of this strategy has focussed largely on the issue of whether there is any need at all for technological advance in weapons technology given the reduced threat and whether it is possible to effectively design new weapons and maintain design capability without actually producing the new designs and using them in the field.

The theory of this article has two important implications for the prototype and shelve strategy. First, the apparent cost of R&D as measured by current DoD expenditures on R&D, underestimates the true cost of R&D because production profits are implicitly funding part of the R&D that defense firms currently perform. Thus, in a program with no production, R&D would be more expensive because firms would be unwilling to fund any themselves(Office of Technology Assessment 1992a, page 12).

The second and more important implication has not been recognized. This is that the alternative of directly funding R&D efforts will not create the same incentives for high quality R&D as the current system which offers a prize to the winner. One possible avenue for DoD to explore would be the strategy of literally offering a dollar prize to the winner of the design competition. That is, it could run a design competition much as under the current system, with multiple firms competing early on and perhaps two firms carried through to the end of prototype development. At the start of the program DoD could

announce the size of a dollar prize and the prize would be awarded at the end of the design stage to the firm creating the prototype judged to be the best. Such a scheme might substitute fairly well for the prize created by production profit.

6. Merger Policy

The current downsizing of defense expenditures has resulted in a number of mergers of defense firms and many more may occur (Kovacic and Smallwood 1994). The theory outlined above suggests three important points that regulators should keep in mind when evaluating the desirability of mergers.

First, generally speaking, the relevant market for antitrust analysis purposes will be the market for the design of new weapons. This is the phase where competition now plays an important role in defense procurement.

Second, and related, competition at the design phase does play an important role in the procurement process. Based on a superficial analysis of the procurement process, one might point to the highly regulated cost based sole source procurement phase of a program and conclude that competition was largely irrelevant to the procurement process. This is completely untrue. The stages of the procurement process are interlinked and competition at the design phase plays an important role in the over-all process. It creates desirable incentives for innovation at the design stage. It also competes away profit earned in the sole source production phase. Finally, in the production phase, one incentive firms have to perform well is to preserve their reputation. They know that they will participate in future design competitions and one factor which may influence their chance of winning these future competitions is their reputation for good performance on past programs. For all of these

reasons, competition plays a useful role in the current procurement process. Thus merger analysis should be based on the realization that, historically, competition has existed and it is worth preserving if possible.

Third, even in situations where it is clear that there must be a reduction in the number of firms, it may be that it is to the government's advantage to prevent, or at least delay, mergers. In many sectors, it may well be the case that there will only be one or two major programs begun in the next decade and the winners of these programs will be the only firms that survive. However, the fact that only one or two firms will ultimately survive, does not necessarily mean that allowing mergers to occur immediately would be desirable. Competition at the design phase creates desirable innovation incentives. Furthermore, R&D at the design phase and bidding at the sole source selection phase will compete away profit to be earned on the sole source phase. The current existence of multiple design teams is a valuable resource that DoD has essentially paid for over the years. Even if it must eventually be sacrificed, it seems reasonable to seek its advantages one last time. After competition determines winners and losers, the winners could be allowed to buy the resources of the losers.

The current downsizing of defense may, somewhat paradoxically, make the value of the prizes for some of these final competitions much larger than they otherwise would be. This is because in some cases there will ultimately only be room for one firm in a particular sector. That is, the winner of some competitions may become not only the sole source producer of the system in question, it may also become the sole source producer of all future related systems. Firms competing for such a final program would be aware of this, and their

R&D expenditures and bids at the sole source selection phase should reflect this fact. Thus maintaining competition for the "final round" might allow government to recover some of the economic profit that firms will earn as sole source designers in the new world of reduced procurement budgets.

7. Vertical Integration

It is clear that firms which design new weapons will have an incentive to integrate downstream into production if the rewards for excellent designs are in the form of profits on production contracts. Thus the vertical integration of the R&D and production functions in the United States defense industry may be due to the regulatory structure rather than to any natural economic advantage of performing both functions within the same firm.

8. Nationalization

It is periodically suggested that the defense sector should be nationalized (e.g., Galbraith 1969). One problem with this would be that it would probably be difficult to award large prizes for succesful designs to executives of nationalized companies.

9. Bidding Effects of Production Contracting Methods

Bower and Osband (1991) show that allowing higher profit rates on sole source production contracts may actually reduce expected contractor profits and government expenditures by affecting bidding behavior at the source selection phase. The intuition for their result is that the differential subsidization induced by profit policy (higher cost producers receive larger absolute markups) encourages more aggressive competition at the source selection phase. This paper provides a very interesting example illustrating the idea that the procurement stages are interrelated and that policy instruments applied at one stage

may have quite surprising and unintended consequences for behavior at another stage which need to be taken into account.

INCENTIVES FOR EFFICIENT PRODUCTION

This section will discuss incentives issues that arise at the production stage.

Regulatory Lag

As discussed in the last section, defense firms' incentives to identify and implement cost reductions at the sole source production stage are affected by the speed and certainty with which DoD learns of these cost reductions and adjusts prices downwards in response. This delayed response can be viewed as a type of regulatory lag. If the period of regulatory lag is longer, a defense firm will keep the gains from cost reductions for a longer period of time and thus will have a greater incentive to identify and implement cost reductions.

This issue was raised in the last section because the profit firms earn due to regulatory lag may not represent a complete loss to DoD. Instead, it may be competed away at earlier phases of the program. This would increase the desirability of regulatory lag. However, appealing to this argument requires one to argue that increased innovation is desirable and that innovation expenditures would increase on a dollar-for-dollar basis with production profit or that government could fine tune the competitiveness of the sole source selection phase to compete away the extra profit that was earned. A more conservative approach would therefore be to assess the desirability of regulatory lag under the assumption that production profits of firms are retained by them. In this section, I will argue that DoD may make insufficient use of regulatory lag even under this more conservative approach.

There are two main policy variables that affect the length of regulatory lag. The first

is obviously the length of the fixed price contracts that are signed. DoD uses almost entirely annual contracts for production. The sense in which production contracts are annual requires a bit of explanation. Production of an individual unit of a complex weapons system such as an aircraft may require two or more years. DoD always signs contracts for complete end-items, i.e., it does not sign a contract to produce just the wings of an airplane, it only signs contract to produce complete airplanes. Under annual contracting, DoD signs a contract for one annual lot of airplanes each year. Each annual contract may require two or more years to complete and overlapping contracts for different annual lots will be in force at the same time. The contracts are annual in the sense that a new contract is signed each year. For example, if DoD was purchasing aircraft at a rate of 20 per year, it would sign a new contract each year for 20 aircraft. Under a multi-year contract, DoD would sign a single contract for multiple annual lots of airplanes. For example, in the previous example, under a five year multi-year contract, DoD would sign one contract for 100 aircraft to be delivered over the next seven years or so. It would not sign another contract for five years.

Annual contracting is the norm for DoD. Multi-year contracting requires special Congressional authority and review. Three characteristics of the way in which multi-year contracting is implemented are worth noting:

(a.1) Congress evaluates the desirability of a particular multi-year by comparing prices paid over the duration of the multi-year, i.e., it compares (estimated) prices to be paid under the multi-year with (estimated) prices to be paid under a series of annual contracts over the same time period.

(a.2) The maximum length of multi-year that Congress allows is five years. Almost all multi-years are, in fact, five years long. That is, when a multi-year is used, the longest possible multi-year is always chosen.

(a.3) Congress restricts use of multi-years to mature programs with a stable design. Thus,

multi-years are typically used near the end of a program.

Two different theories can be used to explain why multi-year contracting might be advantageous to DoD. The first theory, which is the focus of this section, is that it induces cost reductions through increasing regulatory lag. An important fact to note about this theory is that the desired cost reductions that regulatory lag is used to induce are unpredictable by DoD, i.e., the firm has private information about its ability to lower cost. If DoD could predict these cost reductions, it would have no need to use multi-year contracts. It could simply negotiate lower prices on annual contracts. Under a multi-year contract, DoD essentially makes the following bargain with the firm. In return for revealing its ability to lower costs, DoD will let the firm keep the benefits for the duration of the multi-year in which costs are lowered. However, on subsequent contracts, DoD will take the benefits itself. That is, cost reductions will not translate into lower prices until the second contract is signed. This has three important implications for how multi-year contracting ought to be implemented:

(b.1) It is essential to consider a longer time horizon than the duration of the first contract. This is because the benefits to DoD will not begin to accrue until new prices can be negotiated based on the lower costs.

(b.2) Even if the demand for a weapon could be predicted with certainty and the design was unchanging, it would not necessarily be optimal to sign the longest possible multi-year. This is because the gains from cost-reductions are not obtained until the first multi-year ends and a new contract is negotiated.

(b.3) Ceteris paribus, multi-year contracting becomes less desirable near the end of a program because there will be no future contracts to capture the gains on.

A comparison of (a.1)-(a.3) with (b.1)-(b.3) shows that multi-year contracting is implemented in ways that are quite inconsistent with what should be observed if multi-year

contracting was being employed optimally to implement regulatory lag. The explanation for this is that a very different theory of why multi-year contracting might be advantageous to DoD has actually been used by policy makers and analysts. There is a large applied literature which both theoretically and empirically attempts to assess the benefits of multi-year contracts (e.g., Bodilly, Camm, and Pei 1991, Dews and Rich 1982, GAO 1988, Utgoff and Thaler 1982). Surprisingly, the idea that multi-year contracts might induce unpredictable cost reductions due to regulatory lag has been completely overlooked by the entire literature. Instead, it has essentially focussed on the possible benefits multi-year contracts may have in reducing costs through alleviating the hold-up problem. The basic idea is that firms can produce various items more cheaply if they produce them in larger "batches." Thus, producing one batch of components sufficient for 100 airplanes is cheaper than producing five batches of 20 each. Firms are, of course, unwilling to produce a batch of 100 unless government has provided a contractual commitment to buy 100, and multi-year contracts provide this commitment. The literature has also implicitly viewed these potential cost reductions due to batch production as being predictable ex-ante by government. Thus it has implicitly assumed that government is able to capture the benefits from multi-year contracting on the first of a series of multi-years.

If the benefit of multi-year contracting is that it allows predictable cost reductions due to batch production economies, the following qualitative implications for how multi-year contracting ought to be implemented hold true.

(c.1) It is sufficient to evaluate the desirability of a particular multi-year by considering prices over the duration of the proposed multi-year.

(c.2) If demand can be predicted and the design is stable, a longer multi-year is always

better since increased batch economies can be obtained and there is no offsetting cost.

(c.3) There is no particular disadvantage to multi-year contracting at the end of a program.

By comparing (a.1)-(a.3) with (c.1)-(c.3), it can be seen that current practice is fairly consistent with the "predictable cost reductions due to batch economies" theory of multi-year contracting. My own sense is that multi-year contracting has been both under-used and misused because its effects on regulatory lag have been overlooked. The lack of use of multi-years can be explained to some extent because Congress and DoD have focussed on benefits accruing on the immediate contract rather than benefits accruing on future contracts. Although multi-year contracting may well allow firms to lower costs through batch economies, I suspect that even many of these cost reductions are unpredictable and thus may not benefit DoD until the second round of contracting. Multi-year contracting also has the potential to induce significant unpredictable cost reductions unrelated to batch economies. Furthermore, the pattern of use would be different than the observed one, if regulatory lag was taken into account. It may well be that a contract length of 2 or 3 years often strikes the best compromise between giving the firm an incentive to reduce costs and receiving the benefits as soon as possible. The basic reason that contracts are one year long is that the earth take one year to circle the sun, i.e., one year contracts conform to a one year budget cycle. DoD has never formally investigated the question of how long contracts should be to induce the optimal length of lag, and what factors affect this, because it has not recognized the role of contract length in affecting regulatory lag.

Multi-year contracting of course has some costs. DoD must commit itself to a certain level of demand and a type of design over a longer time period. Thus it reduces flexibility.

From Congress's point of view, a main drawback of multi-years is that they may allow DoD to "trick" Congress into committing to higher levels of expenditures on particular programs than Congress would later find desirable. This will be discussed further below in the section on incentives within government. Thus multi-years may never be used in all cases. However, I suspect that they would be used more often if the overlooked benefit of regulatory lag were taken into account.

The second policy instrument that government has available to influence the length of regulatory lag is the vigor and ferocity with which it audits cost projections, actual incurred costs, and compares them. The key law governing government's behavior in this area is the Truth in Negotiations Act (TINA), PL 87-653 (Oyer and Mateer 1987). Under this law, defense contractors must submit detailed cost estimates when they negotiate the price of a contract with DoD. A senior executive of the company must sign a certification which states that all of the cost data being submitted is "current accurate and complete". Violations of the law are usually referred to as defective pricing cases. Violations are subject to both civil and criminal prosecution, and the bulk of fraud cases involving defense firms that one reads about in the newspaper are defective pricing cases. The bulk of all defective pricing cases come to the government's attention when auditors determine the actual ex-post cost of a given contract and find that it is lower than the cost estimate submitted at the negotiation stage. The issue then becomes determining what caused the discrepancy and whether the firm fully disclosed all information related to this possibility at the time of negotiation. Thus there is a sense in which the mere achievement of non-predicted cost reductions subjects a firm to significant risk of prosecution. There is an extremely large body

of case law describing precisely what sorts of information a contractor must disclose. The answer, roughly speaking, is "everything." In the days before a certification is signed, for example, contractors go through highly elaborate "sweeps" of their entire organization to make sure that any information possessed by any member of the organization is passed on to government on the day of signing.

What economic sense can be made of this law? There is a sense in which TINA converts a fixed price contract into something much more closely resembling a cost reimbursement contract (Kovacic 1991, section 3.2). TINA cannot force defense contractors to reveal the lowest possible cost that they could produce at if they exerted an optimal amount of effort. Rather, it can only force them to reveal the cost that they actually will produce at. It essentially tells them that the price they negotiate must be close to the cost they actually incur. A cost reimbursement contract makes these two figures exactly the same instead of close to the same. Thus TINA has the same type of effect as does a cost reimbursement contract. Firms will be unwilling to exert effort to locate or implement cost reductions to the extent they are unable to retain the benefits from cost reductions.

From an economic point of view, the main point is that stricter enforcement of TINA is by no means unambiguously better than lax enforcement. When it is truly uninformed, government already has the option of signing cost reimbursement or cost sharing contracts to protect itself. It might be that weakening TINA would therefore simply expand the range of contracting instruments available to DoD in the sense that "true" fixed price contracts (where the firm is free to lower costs as much as it is able to without risking prosecution) would be possible. This might be especially useful in on-going programs where government

would capture the benefit on future contracts. The issue of how and why TINA should be weakened strikes me as an important subject for future research.

Physical Capital

Defense production requires substantial investments in physical assets. DoD divides these assets into two groups for purposes of reimbursement. Some assets are called special tools and test equipment. These are generally assets that in principal would be of absolutely no value to any other production effort besides the program they were designed for, such as specialized fixtures and jigs and specialized testing equipment. DoD pays for these assets directly. Most other assets are purchased by defense firms. Depreciation plus an imputed rate of return on the non-depreciated book value of assets is treated as an allowable cost for purposes of negotiating contract prices.

This practice can, theoretically, have one of two possible effects. First, there may be an under-investment effect due to the hold-up problem. Most physical investments for defense production facilities have a substantial nonrecoverable component. Defense firms might quite justifiably fear that negotiations over price after they purchase such specific investments would not compensate them for this investment. They might rationally respond to this fear by choosing more labor intensive production technologies. The DoD practice of basing negotiated prices on estimated costs and including both depreciation plus an imputed return on capital as a cost is meant to deal with this problem. To the extent that it solves this problem, however, another problem is created. To understand the nature of this new problem that is created, suppose that the regulations worked perfectly and military services felt completely obligated to negotiate prices which included payments for sunk

assets. From the military service's perspective, these sunk costs would now become variable. That is, the military service must pay these costs if it purchases the weapon but can avoid them if it does not purchase the weapon. Therefore, the service would make inefficient purchasing decisions by treating sunk costs as variable. A related problem concerns calculating the "risk premium" that must be attached to the imputed rate of return. Since the firm is only paid when the program proceeds, the imputed rate of return paid when the program proceeds must be increased to compensate the firm for the fact that it will not be paid in states of the world where the program is canceled.[6]

Historically, it appears that the actual effect of DoD policies has been to reduce investment below efficient levels (DoD 1985 page VI-1, Gansler 1980 page 54). The reason appears to be both the hold-up problem and the fact that DoD may not have attached sufficiently high "risk premiums" to the imputed return to physical investment to compensate for the chance that programs would be canceled.

The obvious alternative policy to consider would be for government to provide more long term investment guarantees either through directly purchasing more assets or through signing contracts which promise to pay for certain physical assets in the event that a program is canceled. The issue that would arise under such a policy is that firms might have a strong incentive to ask for "too much" capital investment. The reason is that such capital might be of value to other programs and thus improve the firm's competitive position vis a vis other firms who did not receive as much free capital. DoD could counteract this incentive by including imputed costs for government owned assets when it evaluates a firm's bid. However, once again, this would cause DoD to treat sunk costs as variable and thus distort

its decisions. It is also possible that military services might find it advantageous to "conspire" with defense firms' requests for too much sunk investment. This is because increasing the sunk costs of a program reduces its variable cost and thus reduces the chance that Congress will cancel it. This issue will be discussed further in the next section. It may also be that, to the extent that assets have alternate uses, they will be more efficiently redeployed in alternate uses if firms own these assets instead of government. Whether this is true clearly depends on the type of incentives created by the regulatory treatment of used asset sales and purchases. It appears that the current rules do create some desirable incentives of this sort (Rogerson 1992c). Finally, government ownership of all physical assets clearly is a large step towards the polar extreme of complete government ownership. Thus the entire question of how government ownership of assets differs from complete government ownership in terms of the incentives it creates needs to be addressed.

The question of how DoD should reimburse defense firms for capital investments in order to create desirable incentives is an important policy question for economists to devote more research to. At this point, it seems clear that the current system has problems, but we do not have a good enough understanding of the entire incentive problem to determine if better solutions exist.

Overhead Allocation

As explained earlier, a defense firm has an obvious incentive to try to allocate as much overhead as possible to products where price is cost based. By shifting one dollar of overhead away from a competitive product and onto a well funded sole source product, the firm essentially makes a dollar of profit. (Its over-all costs do not change and neither does

the market determined price for its competitive product. The only result it that the price of the sole source product increases by one dollar.) Government is aware of this problem and has created regulations governing the types of overhead allocation practices firms are allowed to use to help control it. The result is that firms allocate a large share of their overhead in proportion to directly charged labor use. The implicit justification for this practice seems to be the view that products using more direct labor are probably using more overhead inputs as well, so this procedure is "fair."

It turns out that this regulatory solution does not really solve the problem. In fact, there is a sense in which it exacerbates it, because it creates an incentive for firms to produce inefficiently in order to shift overhead (Rogerson 1992ab). This is because a firm can still shift overhead by altering its relative use of direct labor across products. In order to cause more (less) overhead to be allocated to a product, the firm must increase (decrease) its direct labor usage on the contract. One way to increase direct labor usage is hiring purely superfluous direct labor. Firms can also alter direct labor use by distorting their input substitution choices. One obvious substitution is between capital and labor. Thus, a defense firm can shift more overhead onto its sole source defense business by under-capitalizing its sole source defense business and over-capitalizing its commercial and competitive business. A more subtle example concerns the level of subcontracting. Subcontracted components are charged as direct material to a contract and typically bear very little overhead. Thus, subcontracting a greater share of a product will decrease direct labor and increase direct material, so subcontracting is a way of substituting between direct labor and direct material. Therefore, a defense firm can shift more overhead onto its sole

source defense business by engaging in too much in-house production on its sole source defense business and too much subcontracting on its commercial and competitive defense business. Rogerson(1992a,b) estimates the potential size of these incentive effects using data on the cost accounting systems of four major aerospace contractors and shows that the size of the incentive can be significant. Given these firms' overhead rates and mix of business, incurring a dollar of purely excess direct labor on a sole source defense contract is estimated to increase the firms' revenues by between $1.20 and $1.50.

The above theory suggests two possible policy approaches (Rogerson 1992a,b). The first is to require defense firms to allocate more costs directly, to the extent this is possible. The second, is for DoD to begin paying for some types of joint costs on a firm-wide basis. Joint costs do not inherently belong to any particular product. The current DoD practice of insisting that all costs be fully allocated and then only paying for joint costs to the extent they are allocated to well funded sole source programs, simply creates an incentive for firms to distort their behavior to influence the allocation.

These policy conclusions are tentative, however, because the theory described above is only partial. It explains how a defense firm will act if it is assumed that government sets prices based on fully allocated costs. However, the larger question of why government would choose to follow such a rule is left unaddressed. Presumably, government's goal is to provide firms with an incentive to diversify into commercial production or competitive defense production by "splitting the gains" with them. Constraints of the regulatory process may also require government to adopt fairly simple rules based on objectively verifiable data. Whether the observed system is in some sense the optimal solution to such a problem is an

interesting topic for future research.

INCENTIVES WITHIN GOVERNMENT

The previous sections of this paper implicitly viewed government as a single rational actor to focus attention on the incentive problem between government and defense firms. In reality, government consists of may different actors with potentially conflicting objectives. DoD's budget is the size of a small country's GNP and decisionmaking must necessarily be decentralized among thousands of individuals. Thus, government is faced with a massive planning, organizational, and incentive problem of its own independent of any problems it faces with defense firms (Baron 1993).

Analyzing the underlying incentive problems within government and how government organizes its decisionmaking in response to these problems is interesting for two reasons. First, many of the most fundamental decisions affecting the total cost and effectiveness of defense are made by government, and the way that government organizes it decisionmaking procedures affects these decisions. For example, many observers have argued that decisions over what types of weapons to develop have a much greater impact on both military effectiveness and cost than the decision over what contracting methods to use once the weapons have been selected (Lietzel 1993). Second, incentive problems within government often impact solutions to the regulatory incentive problem. For example, procurement practices that allow contracting officers greater personal discretion may appear optimal when one implicitly views the contracting officer as the good faith agent of the social will. However, they may appear less desirable when we recognize that contracting officers may

be motivated by other concerns such as career enhancement, minimizing their workload or even person enrichment through bribes or kickbacks.

This section will describe three underlying factors that characterize government's organization and decision problem within defense. It will then discuss in more detail two aspects of this problem that economic research has shed some light on.

Underlying Factors

Three underlying factors characterize the defense decisionmaking process. The first, is that final decisionmaking authority rests with elected officials - Congress and the President. The main consequence of this is that there is no single rational actor with well-defined preferences in control of defense procurement. Elected officials exhibit a range of conflicting goals and preferences regarding defense procurement and the political process produces decisions which reflect compromises between these goals. Individual Congressmen have very different views on how much defense is enough. In many cases, goals other than "providing adequate defense at minimum cost" play extremely significant roles in shaping procurement decisions. Paramount among these other goals is job creation for constituents.

This paper will not discuss political aspects of the procurement process any further (Mayer 1990). The focus of this paper will instead, be to describe the organizational problem that remains even if a single rational principal were in charge of defense procurement. The remaining two underlying features of the procurement process relate to this problem. Formally, I will abstract away from political dimensions of the problem by assuming that Congress and the President can be viewed as a single rational principal whose goal is to provide adequate defense at minimum cost. For convenience, I will often refer

to this single rational principal as Congress.

The second feature of the defense decisionmaking process is that it is enormous and complex. This means that Congress must delegate substantial amounts of decisionmaking authority to lower levels of decisionmakers where technical expertise exists to make these decisions. Within DoD, the form that this delegation has taken is that individual military services (i.e., the Army , the Navy, and the Air Force) are powerful decisionmakers with enormous influence. Each service is essentially in charge of buying its own weapons and the Office of the Secretary of Defense and Congress play a supervisory role.

The third feature of the defense decisionmaking process is that many aspects of DoD's performance are very difficult to objectively measure. The military services' performance in the occasional armed conflicts they engage in provides only limited information about how effectively prepared they are for more major conflicts. Furthermore, this sheds little light on the questions of what level of preparedness is necessary and whether the existing level of preparedness was accomplished at minimum cost. The main consequence of this lack of objective performance measures is that it limits the desirability of delegating decisionmaking authority. In the absence of any convenient bottom-line measures of over-all defense performance, it becomes necessary for Congress to control and manage more details of the process.

Thus, while the technical complexity and sheer magnitude of the procurement process make delegation of decisionmaking authority desirable, the lack of objective over-all performance measures limits its value. The observed result is that Congress (of necessity) delegates considerable decisionmaking authority but also retains considerable authority both

through direct oversight and through exercising detailed control over many of the procedures used to procure weapons.

An analogy to the organizational problem of a profit maximizing firm is illuminating. The board of directors, representing shareholders, is analogous to Congress and the firm's management is analogous to DoD. Just as in the defense case, a large firm will generally face a large, complex decisionmaking problem. This creates a need for delegating authority to management. However, in the firm's case, relatively good objective performance measures exist. These include accounting measures of the firm's profit and the firm's stock market value. These measures are admittedly, imperfect. Nonetheless, they provide a reasonably accurate bottom-line measure of management's performance. Thus the board of directors is able to delegate considerable discretion to management regarding the actual operation of the firm. They can motivate management by basing compensation on these objective performance indicators and use them to assess the over-all performance of the firm without necessarily examining details of the firm's operation. There is no analog to profit or stock market value in the Congress/DoD relationship and this makes the delegation problem more difficult.

Strategic Decisions Early in the Program Life

A theme of the literature on government decisionmaking dating at least back to Niskanen(1971) is that a goal of government bureaucrats may be to maximize the size of their own budget. It is a well accepted stylized fact that military services appear to act as though this is one of their primary goals (Fox 1988, McNaugher 1989, Stubbing 1986).

In Niskanen's(1971) theory, bureaucrats are assumed to be able to maximize their

budget by exercising a sort of monopoly power. He assumes that an individual government bureau is the only possible suppler of a particular product and is able to make Congress a take-it-or-leave-it offer. Rather than offer Congress the first best quantity (where marginal cost equals marginal benefit), the bureau offers Congress the largest quantity that Congress would prefer to having nothing (where total cost equals total benefit). Faced with the offered quantity or nothing, Congress chooses the offered quantity. The bureau then receives a budget sufficient to produce this quantity.

A problem with this theory is explaining why bureaucrats have monopoly power. Why can't Congress simply choose the quantity it wants to? In the case of defense procurement, a different, though somewhat related, theory which does not exhibit this problem can be created to explain how bureaucrats are able to increase their budget. The key fact which this theory is based on is that defense programs are executed over many years. Congress exercises budget authority and thus decides how many units to purchase each year. However, many relatively complex and technical decisions made early on in the program's life affect the marginal benefits and marginal costs that Congress will face when it makes annual quantity decisions. In many cases, these early decisions are delegated to the military services and Congress has a difficult time evaluating the technical merits or consequences of these decisions. This means the military services can strategically manipulate Congress's future decisions through their decisions made early on in the program's life which affect future marginal benefits and marginal costs.

In this theory, the source of the bureau's power to influence its budget is its informational advantage. Congress can still be viewed as "moving first" or as designing the

over-all mechanism that is played. At the outset, Congress has two choices. If it delegates certain decisions to the military, better decisions will be made in a variety of technical dimensions because of the military's greater technical expertise. However, the military may also purposely distort its decisions to alter future marginal benefits and marginal costs of the program and thus manipulate Congress's future decisions over quantities to procure. Congress must weigh the benefits and costs of delegation and then determine how much authority to delegate. Three example of such decisions will now be described. In the first one, Congress has delegated very little authority while in the latter two it has delegated more.

The first example is the decision over how much long term contractual protection to provide defense firms with. Because of the holdup problem, defense firms may require long term contractual protection in order to be willing to undertake these cost reducing specific investments. As discussed earlier in this paper, there are at least two such types of specific investments. The first type is long lived physical capital. The appropriate type of long term contractual protection in this case would be for DoD to either purchase the assets outright or promise to purchase them in the event the program was canceled. The second type of specific investment is production of subcomponents in batches larger than one annual lot. The appropriate type of long term commitment in this case would be a multi-year contract which promised to pay for the entire batch of subcomponents even if the program was canceled. As discussed earlier in the paper, DoD engages in very little of either of these types of long term commitments, and the extent to which it does so is tightly monitored and regulated by Congress. One reason is surely that such long term commitments reduce

Congress's and DoD's flexibility to respond to unexpected changes. However, the fact that Congress tightly regulates DoD's use of long term commitments and that DoD would apparently make more long term commitments in the absence of Congressional control, suggests that an agency problem between Congress and the military services also explains part of this lack of use.

The agency problem is that, from Congress's perspective, increased use of long term commitments at the start of a program effectively converts variable costs into sunk costs. Consider the case of a physical asset. In the absence of a long term commitment, Congress pays for the asset only if it continues to purchase the program. In the presence of a long term commitment, Congress pays for the asset whether or not the program is continued. Thus, increased use of long term commitments reduces the probability that Congress will cancel a given program. At the beginning of a program, there is presumably an optimal level of long term commitment which is calculated by weighing the benefit of cost reduction against the loss of reduced flexibility. Calculation of this optimal level requires knowledge of the likely performance characteristics of the weapon, the probability that problems will develop, the production technology, the nature of substitutes and potential new threats which may arise, etc. The military services presumably are in the best position to make this judgement. However, they also know that increasing long term commitments will essentially reduce the marginal cost of the program and thus make it much more likely that the program will not be canceled even if unforeseen problems develop. One can interpret the tight Congressional restrictions on long term commitments as a response to this problem. McNaugher(1989) stresses the idea that this strategic factor plays a large role in the

relationship between Congress and the military services.[7]

This is a good example of agency problems within government intruding upon the agency problem between government and defense firms. Focussing solely on the agency problem between DoD and defense firms, the lack of long term commitments seems puzzling since there appear to be efficiency gains to be taken advantage of. It may be that the explanation is that Congress is unwilling to delegate such decision authority to DoD because of its fear of being tricked into sinking costs into programs that it will ex-post wish that it had not invested in.

The second example concerns the trade-off between quality and quantity. Many institutional analyses of defense procurement have raised the issue that the military's choice along the quality-quantity frontier seems to be biased toward too high a level of quality. That is, it is argued that the same expenditures would produce a more effective defense if larger numbers of less elaborate and less technically sophisticated weapons were purchased (Gansler 1980 pages 15-21, Peck and Scherer 1962 Ch. 13, Stubbing 1986 ch.8). This result is explained as the result of an agency problem between Congress and the military in a formal model by Rogerson (1990). The decision made early in the program is the design of the weapon. In particular, it is assumed that the military makes a decision over a scalar variable called quality, where increased quality increases military effectiveness.[8] Then, given the military's quality decision, Congress chooses quantity. Congress's goal is to maximize the benefits of military preparedness minus the costs, and it chooses quantity to maximize this objective. The military's goal is to maximize the benefits of military preparedness. It chooses quality to maximize this objective, taking into account the fact that its choice of

quality affects Congress's subsequent choice of quantity. The major result is to show that when quality and quantity are not good substitutes, that the military will purposely choose a quality higher than the efficient level. In the resulting equilibrium there will appear to be too much quality and too little quantity relative to the efficient levels. The intuition for the result is that the military can increase military preparedness by purposely increasing quality above the efficient level because this induces a relatively small decrease in Congress's quantity choice.

An interesting feature of this model is that the military is assumed to be as good an agent as one could realistically hope for. The military agrees with Congress's definition of military preparedness and makes a good faith effort to maximize this. The "flaw" in the military's preferences is that it does not consider the social cost of military preparedness, i.e., more is always better than less. Thus, if it were given a fixed budget, the military in this model would always choose quality and quantity to maximize military preparedness given the fixed budget. The distortion arises because the military is able to strategically manipulate Congress into increasing the budget by increasing quality.

Thus, the military's direct goal in this model is not to maximize its budget but to maximize the social benefits (ignoring costs) of its activities. However, the end result is much the same as if the military were attempting to maximize its budget directly since larger budgets allow the military to produce larger levels of benefits. Thus, budget maximizing behavior on the part of bureaucrats need not be caused by purely venal empire building motivations. It may be caused by the relatively idealistic goal of maximizing the bureau's production of social benefits.

The third example concerns the decision over what scale of production facility to build. In a model related the above quality vs. quantity model, Rogerson(1991b) shows that the military can induce Congress to increase the quantity purchased of a weapon by purposely selecting a production technology of too high a scale. The idea is that higher scale technologies exhibit higher fixed costs but lower marginal costs. Thus, so long as Congress does not cancel the program, it will buy more when faced with a higher scale technology.[9] This model explains the well accepted stylized fact that weapons production systematically occurs in production facilities designed to produce at much higher rates than they are actually operated at (Congressional Budget Office 1987, Gansler 1989, Rogerson 1991a).

The above three examples show that three significant instances of seemingly difficult to explain inefficient behavior on the part of the military (insufficient use of long term contractual commitments, inefficient tradeoffs between quality and quantity, choice of inefficiently large production facilities) can all be explained as attempts by the military to strategically manipulate Congressional budget decisions. I suspect that many more significant examples can be identified. Thus this is an important phenomenon. It may be that no solutions exist to this problem. It may that Congress fully understand the agency problem and has already made the optimal second-best agency decision given the information constraints it faces. However, there are two possible avenues worth exploring.

The first is increased use of commitment to fixed budget levels. The various problems described above occur because the military believes that it will increase its budget by adopting the various strategies describe above. If budgets were fixed, this incentive would be removed. Of course, it may be difficult for Congress to credibly commit to budget levels

and there would be disadvantages from commitment due to loss of flexibility. One possibility might be for Congress to commit to a funding level for an entire program at the outset and then not revisit the decision unless truly major problems occurred. It would be interesting to experiment with such an approach to see if it produced significantly different behavior on the part of the military.

The second approach would be to attempt to increase inter-service competition by purposely increasing the overlap in missions between the services. Traditional military analysts have noted these overlaps and sometime cited them as examples of inefficient organization within the military (Stubbing ch. 7). There is undoubtedly some truth to this point of view. Having two services each perform overlapping portions of the same mission and compete for the right to perform new related functions may well produce outcomes that seem inefficient relative to the full-information first best standard. However, overlapping jurisdictions may play a more useful role in a world where the military services do not necessarily have identical preferences as Congress, and where Congress is not as fully informed as the military. In this case, Congress can use rivalry between competing services to improve the performance of each service. McNaugher (1989) stresses the idea that increased use of inter-service competition might allow Congress to delegate more decisionmaking to the military services.

Discretion

When designing the legal institutions and regulations governing the procurement process, one general type of qualitative decision that Congress repeatedly faces is how much discretion to allow individual decisionmakers. By "discretion," I mean allowing individuals

to make decisions based on their over-all judgement and evaluation of a range of factors and not requiring that the decision can be completely justified based on objective criteria. Even in a world where all bureaucrats were good faith agents of the social will, there would be a reason to limit discretion in some instances. This would be to allow DoD to credibly commit to follow certain types of behavior (such as not expropriating specific investments) in its relationship with defense firms. However, many of the restrictions on bureaucratic discretion in the procurement process clearly are based on the fear that bureaucrats might use this discretion to further their own personal goals such as career enhancement, minimizing their own workload or personal enrichment through bribes or kickbacks. It appears that tighter limits are often placed on DoD officials than officials in private industry performing similar types of procurement tasks (Kelman 1990). Part of the explanation is surely that the performance of DoD is much harder to objectively measure than the performance of management teams of private profit maximizing firms, as discussed above. Therefore it may be optimal for Congress to delegate less authority than than does the board of directors of a profit maximizing firm.

The most interesting study of this subject that I am aware of is by Kelman(1990). He analyzes the procedures used by the Federal government to purchase computers based on case studies of a number of actual procurements. Although he does not specifically study defense procurement, I believe that many of his observations apply to some extent to defense procurement. His basic argument is that good performance of a contract to install a complex computer system cannot be completely specified in a contract in an objectively verifiable legally enforceable way. In private industry, firms have responded to this lack of

enforceability by relying on reputation, i.e., private firms procuring computer systems tend to develop relationships with particular computer suppliers and continue to do business with them so long as past performance has been good. The fact the future business is contingent on good performance on current business provides the computer firm with an incentive to provide good performance. Kelman argues that performance on past contracts plays almost no role in determining how the Federal government awards computer procurement contracts and that this has resulted in extremely poor performance on these contracts. Award selection is typically made using rigidly applied mechanistic formulas where points are allocated to various criteria, each bidder is scored on each criterion, and the firm receiving the highest number of points automatically wins. The criteria tend to be factors subject to objective verification such as technical performance specifications. In particular, personal judgements on the quality of performance on past contracts are generally not included as an evaluation factor because it is perceived that such evaluations are too subjective and cannot be objectively supported.

It is not clear whether the solution to this problem would be to allow more. discretion. Contracting officers might abuse this discretion (Marshall, Meurer, and Richard 1993). Kelman's judgement is that there would be gains from allowing more discretion. Kelman also suggests that it might be possible to have reputation play a larger role within the context of the current approach which requires awards to be based on relatively objective data. Namely, he suggests that a formal procedure be established to gather evaluations and ratings on past performance and that these scores be made available to contracting officers as one of the criteria to use when making future awards. Obviously, any

formal rating will not be able to capture the same nuances of behavior and performance that could be captured by allowing an informed individual to exercise his own judgment based on a complete evaluation of all the facts. However, it might represent a large improvement over the current system and still be consistent with the perceived need to limit contracting officers' discretion. Kelman has recently been appointed head of the Office of Federal Procurement Policy which plays a large role in overseeing procurement regulation, and it will be interesting to see how he is able to implement his ideas over the next few years.

Laffont and Tirole (1993, ch. 11) have suggested that Congress might find it desirable to restrict contracting officers to using cost type contracts when the possibility of kick-backs is taken into account, in order to decrease the ability of contracting officers to give undeserved profits to defense firms by awarding them fixed price contracts with overly generous prices. This idea might also help explain why fixed price contracts are so highly cost based. It might be that TINA is so tightly enforced, not because this is thought to be the ideal solution to the agency problem between government and defence firms, but because this is thought to be necessary to deal with the agency problem between Congress and contracting officers. Thus, once again, the agency problem within government affects the types of solutions that are possible to the agency problem between government and defense firms.

CONCLUSION

Defense procurement is unique among regulated industries in the Unite States in that economists have played virtually no role in helping shape its regulatory practices and institutions. Perhaps this is due to the barrier to entry created by the need to first learn

about procurement practices, or to a lingering distaste for military matters among academics left over from the Vietnam war. For whatever the reason, this lack of economic input into the policy debate is unfortunate because many of the regulatory issues in defense procurement revolve around the types of incentive issues that economists are very good at analyzing. In this article I have attempted to provide an overview of some of these incentive issues and what progress economists have recently made in analyzing them. My own hope is that economists are well on their way to colonizing a new policy frontier and that some of the ideas discussed in this article will play a role in shaping policy debates over the next decade.

Table 1
Annual Revenues of Various Regulated Sectors
Compared to Weapons Procurement Expenditures
(Billions of Dollars)

Sector	Revenue
Electric Utilities	$175.5
Trucking	$120.2
Weapons Procurement (Current Level)	$80
Long Distance Telephone	$68.1
Weapons Procurement (Projected Level)	$60
Airlines	$58.0
Gas Utilities	$45.1
Local Telephone	$39.2
Railroads	$28.4
Interstate Gas Transmission	$25.7
Cable and Pay TV	$21.3
Interstate Petroleum Transmission	$ 7.1

Source: U.S. Bureau of the Census(1992).

Table 2
Defense R&D Expenditures by Performer and
Funding Source for FY1989
(Billions of 1989 Dollars)

Performer	Funding Source	Amount	Percent OfTotal
DoD	DoD	$9.3	22%
Non-Profit Firms	DoD	$3.6	8%
For-Profit Firms	DoD (Contract R&D)	$24.7	58%
For-Profit Firms	DoD (IR&D)	$2.2	5%
For-Profit Firms	For-Profit Firms (IR&D)	$2.6	6%
Total		$42.4	100%

Source: All entries except the IR&D entries are from NSF(1993) and are obligations. The two IR&D entries are form Defense Contract Audit Agency(1990) and are incurred costs.

Table 3
Defense B&P Expenditures by Funding Source for FY1989
(Billions of 1989 Dollars)

Funding Source	Amount	Percent Of Total
Firm Funded	$.9	39%
DoD Funded	$1.4	61%
Total	$2.3	100%

Source: Defense Contract Audit Agency(1990).

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1.In FY1992, the Department of Defense (DoD) awarded $67.1 billion to for-profit firms for the research, development, and production of new weapons systems (DoD 1992). It also obligated $13.4 billion for in-house R&D and R&D by non-profits (NSF 1992). The sum of these two figures equals $80.5 billion.

2.Government strictly regulates foreign sales so can be viewed as exercising control over these sales as well.

3.The FAR is a codified set of procurement regulations meant to apply to the entire federal government. Each agency has its own supplement which describes practices of particular interest to the agency in more detail. The DFAR is the DoD supplement.

4.See, for example, McNaugher's(1989, page 26) description and quotations from Congressional debate occurring in 1924 over the effects of competition on R&D.

5.This data has some problems. Although the study itself is based on data from actual programs, the data reported in the appendix is described only as an "illustrative cash flow example" and thus may not be based on any actual program data. Furthermore, the study does not explicitly indicate where (in the time series of data) the competitive design phase ends and the sole source production phase begins. By examining the data it is fairly clear where this point is (the point where investment in facilities begins), but it is important to note that one must make this deduction to perform the calculation reported below. In some other respects, the data is fairly good. For example, the authors clearly devoted considerable effort to identifying cash flows, as opposed to accounting costs, and carefully considered tax rules to calculate after tax cash flows.

6.Note that a risk neutral firm would require payment of this risk premium. It is a payment to compensate for expected losses due to possible program cancellation.

7.He considers a different issue than long term commitments. He argues that military services may purposefully rush programs from development into production in order to create large sunk costs before complete information on the weapon's performance is available to Congress.

8.It is simply assumed that Congress delegates this decision to the military. In a larger model, one would also model Congress's decision of whether or not to delegate this decision.

9.Note that this argument does not require Congress to incur any sunk costs by providing long term investment guarantees. Thus it is conceptually different than the sunk cost issue discussed above.