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OCCASIONAL
PAPER

Determining When Competition Is a Reasonable Strategy for the Production Phase of Defense Acquisition

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Prepared for the Office of the Secretary of Defense

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Preface

Today's defense environment is placing growing pressure on defense policymakers to be nimble and adaptive, particularly with respect to acquisition systems and processes. This occasional paper is one in a series drawing upon the expertise of core RAND Corporation staff to explore issues and offer suggestions on topics that are likely to be of critical importance to the new leadership: the use of competition, development of novel systems, prototyping, risk management, organizational and management issues, and the acquisition workforce. The papers are designed to inform new initiatives for markedly improving the cost, timeliness, and innovativeness of weapon systems that the Department of Defense (DoD) intends to acquire.

In some cases (especially in the procurement of major systems where the nonrecurring cost is large), it may be less costly for the government to forgo competition and to rely on a single supplier. In this paper, we compare the characteristics of a typical business market to those of defense acquisitions and then identify the benefits and drawbacks of competition in defense acquisitions specifically. Using historical data and RAND's cost reduction savings methodology, we also show how DoD can determine when the introduction of competition during production is a reasonable acquisition strategy.

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Determining When Competition Is a Reasonable Strategy for the Production Phase of Defense Acquisition

Introduction

The use of competition in weapon system acquisition is widely advocated in policy statements and widely reflected in requirements issued by Congress, the Office of Management and Budget (OMB), the Department of Defense (DoD), and the military services. This emphasis stems from the conviction that competition during the production phase of the acquisition system will drive the unit cost of a system or subsystem down and reduce overall procurement cost to the government.[1] Other arguments for having more than one producer exist (e.g., providing a surge capability should the services need to expand production quickly), but the crux of the competition issue is procurement cost (or, more accurately, price).

It is not self-evident that a second production source will produce savings—especially when nonrecurring costs are large.

We do not question the value of competition as a means of inducing a firm to reduce prices, but it is not self-evident that a second production source will produce savings for the government in every procurement. In some cases—especially in the procurement of major systems where the nonrecurring costs are large—it may actually be less

[1] A variety of competitive strategies exist. Each strategy addresses particular features of major acquisitions and is applicable to different phases of the acquisition process. The focus of this analysis is on saving money during the production phase.

costly for the government to forgo competition and to rely on a single supplier.

Senior DoD officials must determine whether competition is likely to result in savings or losses for the government. This paper compares the characteristics of a typical business market to those of defense acquisitions, identifies the benefits and drawbacks of competition in defense acquisitions specifically, and shows how to determine when the introduction of competition during production is a *reasonable* acquisition strategy.

Pentagon Acquisitions: Not Business as Usual

The complexity and uniqueness of major defense procurement make it difficult for DoD to follow typical commercial business price-competition approaches. In the typical business market, a buyer examines the available products, requests competitive bids for production from a number of contractors, selects a bid based on a fixed price, and signs a one-step contract for delivery on a specified date. Such a market depends on having complete information about a customer's needs; a standardized, off-the-shelf product; a predictable budget; certainty about the number of items to be purchased; and little reason for concern about the future viability of the losing firm. Major defense acquisitions lack these characteristics.

If the unique characteristics of defense procurement are not taken into account, expectations for the use of price competition may be unrealistic.

In major defense acquisitions, the relationship between buyer and producer is almost completely different from that assumed in the economist's model of the typical business market. For example, defense acquisitions have only one domestic buyer; producers typically compete during the design stage as opposed to the production stage; and concern about sustaining a unique industrial sector factors into the buyer's decisionmaking process. Table 1 summarizes the characteristics assumed for the typical business market (or "perfect market") and compares them to the corresponding characteristics of typical major defense acquisitions during production.

Table 1
Characteristics of "Perfect Market" Versus Typical Characteristics in Major Defense System Production

Perfect Market	*Major Defense System Market*
Many buyers and producers, none being dominant; each buyer has a choice of many producers.	*Only one buyer. Usually only one producer—the prime contractor who developed the system.*
To a close approximation, price (a firm-fixed price) is determined by the "hidden hand" of the market.	*Production prices (seldom truly firm-fixed prices) are determined by a series of negotiations in a sole-source environment.*
Product is an existing, standardized item, similar for each producer—it is "homogeneous," and its characteristics are stable over time.	*Product is a newly developed item, usually without close substitutes and with a design that continues to change during much of the production phase and often even afterward.*
Competition focuses primarily on price, but other criteria (such as quality, reliability, and performance) are considered.	*Prospective producers compete early in the development phase through "design rivalry." Buyer is concerned with product quality (especially performance), delivery schedule, and other nonprice factors. Price is not the dominant consideration in selecting the producer; quality of the product is normally given priority.*
No producer has an advantage in production technology or economies of scale.	*Production technology is dynamic and may differ among prime contractors and their subcontractors. Economies of scale, including "learning-curve" and production-rate effects, significantly influence producer costs. A superior developer is not necessarily a more efficient producer.*
Market is easy for new producers to enter.	*New prime contractors seldom enter the defense sector—entrance is inhibited by the high capital investment required, the proprietary rights of others, and the administrative and contractual burdens of a highly regulated industry.*

(*continued*)

Table 1 (*continued*)

Perfect Market	*Major Defense System Market*
Buying the product is a simple, quickly completed, one-step transaction between the buyer and the producer, independent of other purchases from the same or other producers.	*Acquiring a major system is a multiyear, multistep, complex process, involving scores of successive and usually interdependent contract negotiations between buyer and producer.*
Market is characterized by near perfect intelligence and absence of uncertainty. Information about product price, standards of quality, number of items purchased, and delivery schedule is freely available to all concerned.	*Uncertainty is a dominant and largely unavoidable feature. Among the market uncertainties are the* • *threat the system will face* • *most suitable system capabilities* • *best design approach* • *feasibility of development* • *time and other resources required to complete development and make the transition to production* • *deficiencies that may be revealed by operational testing.*

As indicated in the table, quality and schedule are often more important criteria than price in defense acquisitions. The high priority the defense buyer usually gives to product quality is sometimes regarded as a defect in the acquisition process. The conventional wisdom is that when programs experience difficulties, expenditure is the first constraint to be relaxed and schedule the second, but that performance goals are adhered to quite rigorously, with the result that the unit price of the product increases.

The data support this description of the way quality, schedule, and price are traded off, but it is by no means clear that this should be accepted as adverse criticism. The Services' emphasis on high system quality is consistent with the long-established national policy that emphasizes quality rather than quantity for defense, and hence calls for the development and production of systems superior to those fielded by possible opponents. If this emphasis is accepted, the

question is not so much whether quality should be given priority, but rather, what kind of quality and how much quality is enough? This latter question, however, is peripheral to what concerns us here. It is sufficient to recognize that major system acquisitions generally aim at a quality of product that requires innovations in design and the application of advanced technologies, with all the technical uncertainty this entails.

Comparison of the typical business market and defense acquisitions helps illustrate the inherent difficulties in introducing effective price competition into defense acquisitions. Unless these differences are taken into account, expectations for the use of price competition in defense purchases may be unrealistic.

The Benefits and Drawbacks of Competition

The basic argument for competition in defense procurement is that it is believed to reduce the government's costs of purchasing goods and services. Nonetheless, in some cases, it may actually be less costly for the government to forgo competition during the production phase and rely on an alternative strategy. In this section, we discuss the general benefits of competition as well as common drawbacks for weapon system acquisition, including time; money; management effort; and a long-term, uncertain benefit.

Benefits of Competition

The value of competition in U.S. society is so much taken for granted that defense procurement officials are often criticized for not relying more frequently on head-to-head competition in awarding production contracts for major defense systems. Those critics argue that competition produces many significant benefits. Competition improves product quality and lowers unit costs, they say, compared with a noncompetitive environment. Competition forces manufacturers to quickly learn about new

Competition can save money, improve product quality, ensure equity, and protect the industrial base.

technologies and production techniques, fostering greater technological progress and industrial productivity. Finally, competition allows for a more equitable process under which acquisition contracts are awarded. The government has the responsibility to treat firms fairly; competition allows companies that believe they can make a competitive bid to do so, which makes the bid process more fair than sole-source procurement.

We do not question the value of competition as a means of inducing a firm to reduce prices. When competition or the threat of competition is perceived as real, a firm may act in a number of ways to cut costs and price. Managers will often assign their best people to a competitive program, allocate corporate capital for equipment, and fund value-engineering studies (rather than expecting the customer to fund them). A company may also transfer production from an area of high labor costs, such as California or Massachusetts, to locales where labor costs are lower. Management may take measures to substitute capital for labor, accelerate cost-reduction schemes, and seek out alternative vendors. A firm may be able to operate at an economical rate by producing enough parts in a few months to satisfy the contractual requirement for an entire year, and then assign the workers to other tasks for the remainder of the year. In addition, a company is usually able to reduce the number of engineering and manufacturing support personnel assigned to a program. Noncompetitive programs tend to be heavy in such personnel, often because the customer wants to retain the services they provide.

Saving money is not the only benefit of bringing a second producer into a program. Improved quality assurance is often cited as a reason for introducing a second production source. In some instances, the underlying reason for a second source has been a profound dissatisfaction with the initial contractor, which may be a good developer but an inefficient producer. The nature of defense procurement is such that, once a contractor is chosen to develop a major new system, the responsible military service is locked into a relationship with that contractor that could last 20 years or more. Bringing a second company into a program is an effective way to encourage greater cooperation from the initial firm.

Drawbacks of Competition

Barriers to competition in defense acquisitions also exist. Analysts note that competition requires additional time and money and also entails extra management complexity and effort. At the same time, most of the benefits of competition are long term, providing program managers with little incentive to implement competitive steps because payoff is well in the future. Further, competition has uncertain and mixed results. In a risk-averse environment, this uncertainty also reduces the program manager's incentive to use competition.

We discuss each drawback separately below. Throughout the discussion, we attempt to distinguish among different problems that arise during discrete phases of the acquisition cycle.

Additional Time and Money At almost every phase in the acquisition cycle and for almost every kind of competition, adding a second competitor requires current-year investment above what a sole-source would cost. During the planning phase, such funds are relatively small in absolute terms. However, when the program moves to the production phase, the magnitude of the funding required for a second, competitive source becomes large relative to program costs and in absolute terms, reaching tens or hundreds of millions of dollars.

Such a funding commitment can be difficult to obtain. It will have to come from higher up the chain of command, which means that many people will have to be "sold" on the competitive action. At every level in the organization, there will be some who are sympathetic to the request for funds and others who will see themselves as competing for the same funds. Some groups will tend to underestimate the difficulty of developing a particular system or have an interest in fielding it very quickly, thus they will resist competition during full-scale development on the grounds that it wastes time and money. The situation is even more complex in multiservice programs, wherein all the armed services must agree to put up the extra money.

Funding for a second source is substantial; it can be difficult to secure and maintain throughout a development program.

When substantial amounts of money are involved, DoD and multiple congressional committees must be sold on the competition as well. When there is no great pressure for competition and when other acquisition initiatives are being emphasized, DoD and the congressional committees involved can be difficult to convince. Congress tends to dislike programs with heavy front-end cost; other, less obvious political problems sometimes intrude as well. Funding requests are reviewed by four different congressional committees, which do not automatically coordinate their decisions, so each must be persuaded separately. It is not unusual for one committee to support a competition and another to delete the funds for it. DoD and Congress can also hold strongly differing positions.[2]

Further, once funding for a competition is approved, there is no guarantee that it will be maintained. Money for competitive programs is a prime target in a budget squeeze, and initial high-level support for competition may evaporate. In the Services and in DoD, there are frequent changes in top-level personnel; when new people take over, they inevitably change priorities. Written policy supporting competition remains fairly consistent, but interest in competition changes with personnel. The result is that it can be difficult to maintain all the funding necessary to conduct a competitive program.

An additional barrier to competition is the time involved in testing or qualifying a second contractor. Schedules can also lengthen due to adjudication of protests by the losing firm and because competition can increase program complexity and bureaucratic involvement. By lengthening schedules, competition carries the risk of raising program costs. The risk of increased program length is a disincentive to competition because there is usually a strong desire to deploy the system as rapidly as possible.

[2] For example, the Services have strongly fought against having a second General Electric engine developed to compete against the Pratt & Whitney engine for the F-35, but Congress continues to insist on funding the General Electric engine in order to maintain competition.

Extra Management Effort Competition increases the workload of the project office. This extra work stems from several sources: additional planning, qualifying a second producer, and quality control and configuration management issues. If a competition is to be beneficial, considerable planning for the competitive steps is necessary. The request for proposal (RFP) must be prepared and the source selection process must be designed. The program office must comply with regulations designed to ensure the fairness of the competition. This process involves special security to deal with "competition sensitive" material, special reports, et cetera. Competition also introduces the possibility of lawsuits, disputes, and charges of unfairness by the contractors who lose the competition. Consequently, the source selection must be carried out in a way that not only chooses the best design, but also raises a minimum number of questions about fairness. In addition, if awards are granted to more than one contractor, each additional contractor the program office must deal with usually means more work. This is especially true when cost-type contracts are involved because the program office must monitor the costs of each contractor.

Competition involves additional planning, extra work to qualify the second producer, and difficulties in configuration management.

Competition during production can introduce more management complications and can be a major effort, especially when qualifying a second producer after production has begun. It is difficult and expensive to get a good technical data package (TDP) for the second contractor to use in starting production, and even more difficult to persuade the first producer to pass along to a competitor the benefits of its manufacturing experience.[3] Program managers can choose to develop their own TDP, but for major programs this is almost impossible. Not all Services have in-house capability to evaluate a TDP, and

[3] There are various levels of detail for a TDP that must be validated, at government expense, by a competitive producer before submitting a final bid for production. An alternative to using a TDP is the form-fit-function (FFF) approach for the second-source product.

without this capability, it is difficult to judge the adequacy of a TDP. Even with a good TDP, it frequently takes a major effort by the program office to help the second source through all its technical problems and into production. In some cases, the second source never succeeds in producing a usable product. Even in those cases where the second source is not successful, the pressure on the first contractor may still make the effort worthwhile.

Another source of additional work in developing a second source is that the program office must work with both contractors on such things as quality control and configuration management. It is generally quite difficult to get two contractors to produce systems and components with interchangeable parts. If they do not do so, the program office faces additional problems in spare parts procurement and logistics. Further, each added production line means an additional set of nonrecurring costs whenever there is an engineering change.

Few High-Confidence, Near-Term Benefits The costs of competition are short-term and clear, but the benefits are long-term and uncertain. Programs can last for a decade or more. Given that the typical tenure of program managers is about three years, it is unlikely that they will be around to receive the credit for any benefits that finally accrue; consequently, they make look for strategies that return short-term benefits. In any case, they are unlikely to be rewarded merely for introducing competition; apart from exhortations in policy documents and the conventional wisdom that competition is good for everyone, few direct incentives for introducing competitive practices exist.

The benefits of competition occur over the long term and are inherently uncertain—a disincentive for program managers.

Retrospective studies of second production source procurement programs have not been conclusive about the benefits of competition, partly because the answers depend heavily on the analytical methods used. A 1981 RAND study of the Shillelagh missile, for example, showed that analysts using the same data but different analytical procedures could produce vastly different estimates of the effect that a second production source had on

procurement costs (Archibald et al., 1981). Those estimates ranged from a cost savings of 79 percent to a cost increase of 14 percent. A follow-on to the 1981 report describes five methods of estimating the cost benefits of a second production source (Birkler et al., 1990). For each method, we estimated the hypothetical single-source cost for four air-to-air missile programs (AIM-7F, AIM-7M, AIM-9L, and AIM-9M). None of the five analytical methods was unanimous in indicating that a net cost savings accrued to the government through competition in any of these programs. However, three of the five methods did show a net savings for two programs (AIM-7F and AIM-9L), and four methods did show a cost increase for one procurement (the AIM-7M).

Some uncertainty is inevitable because the various methods used for measuring savings are unavoidably judgmental. In particular, if two sources are used, one cannot know the cost that would have been incurred with a single source only. That cost must be estimated and compared with the actual cost incurred through second-source procurement. Some uncertainty about the benefits of competition is also inevitable because real cost reductions are difficult to prove and can be masked by other factors, such as changes in production quantities, requirements growth, and inflation. RAND's analysis of the Tomahawk and the Advanced Medium-Range Air-to-Air Missile (AMRAAM) programs—both of which introduced competition during the production phase—indicated cost savings were achieved (Birkler and Large, 1990). However, it was exceedingly difficult, if not impossible, to isolate and quantify a distinct cost benefit for competition from other program aspects, such as stability and maturity of the design, a firm's business base and future outlook, availability of competing systems, government and the firms' management approaches, profit levels, and overall economic environment. The path not taken is always an educated guess. When the results are very sensitive to the assumptions made, one must be cautious in drawing any conclusions.

In addition to all of the drawbacks discussed above, competition is simply seen as impractical in many cases. There may be few qualified contractors to participate in a competition, and they may not wish to compete. Contractors are sometimes deterred from entering a competition due to uncertainties about how a competition will come out

and the criteria to be used in the source selection. Qualifying a second production source can also be seen as impractical because the production run is too small, the tooling for the second production line is too expensive, or the design is too complex to be transferable. In the case of subsystem components, there simply may not be enough money involved to justify the cost of funding another source.

Conditions Favorable to Competition via a Second Production Source

When is the introduction of competition a reasonable acquisition strategy? The question is not easy to answer because it is difficult to measure the future effects of competition, as suggested by the various, and sometimes conflicting, answers produced when measuring the past effects. Estimates of cost savings from competition are contingent on

- speculation about what might have happened if a second contractor had not been brought into a program
- assumptions about estimates of program cost without competition. If that estimate is too high, savings from competition or other causes would be easy to achieve. If it is too low, savings would be unlikely.

If the likelihood of breaking even on production costs is high, competition might be reasonable; we use historical data to help calculate a breakeven point.

Using historical data, we can estimate the likelihood that the government would "break even" on the introduction of a competitive second source; that is, that the cost reductions would be great enough to pay for the incremental costs of introducing competition.[4] If the likelihood is high, the government might

[4] Incremental costs include any nonrecurring or recurring development costs, nonrecurring investment in a manufacturing plant (facilities, general-purpose tools, general-purpose test equipment), and recurring materiel and labor costs.

reasonably elect to introduce competition in the expectation of achieving other potential benefits. Likewise, a low expectation of breaking even on production cost would discourage the government from introducing competition because the net dollar cost of production might increase enough to outweigh other possible benefits.

Unfortunately, no data or cost estimating relationships exist that enable one to directly estimate production costs in a competitive environment. Instead, we have historical data showing the amount by which production cost changed when competition was introduced into ongoing sole-source production programs. Multiple studies of competition in procurement have been conducted over the past 30 years, with the most recent completed in the early 1990s. Those historical studies cover a wide variety of weapon systems, subsystems, and components.[5] In all of those cases, the program started with a sole-source producer, and a competitive second source was introduced later in the production run.

Whether and how much a second producer of a weapon system generates cost savings for DoD depends on the type of hardware or system that the competitors are developing and manufacturing. Our examination of the DoD's past experience with introducing competition into weapon programs suggests that second producers of electronics[6] have been more likely to generate savings in production costs than have second producers of missiles and ships.[7] As Table 2 shows, half of the DoD programs in our historical survey that involved two or more competitive producers of electronics were able to reduce overall costs by 30 percent (which turned out to be the break-even point), but

[5] For more detailed information about these data, see Birkler et al., 2001. Of the many sources we reviewed, we were able to obtain data from one that appears to be methodologically consistent: Birkler et al., 1990. The savings are based on actual costs or projections to the end of the program.

[6] By electronics, we are referring to those items that are mainly subsystems or small components (e.g., radios, radars, transponders, and signal converters).

[7] Our analysis treats the electronics systems and hardware separately. Most of the nonelectronic items are ships and missiles; there have been no instances since World War II in which aircraft were produced by competitive sources.

Table 2
Fraction of Programs Examined That Achieved Savings

Savings Achieved (%)	Missiles and Ships	Electronics
> 0	8/10	10/10
>10	7/10	9/10
>20	4/10	7/10
>30	2/10	5/10
>40	Nil	4/10

SOURCE: Birkler et al., 2001.

only one in ten competitive missile and ship production efforts were able to do so.

To gauge the likelihood that a government agency would recoup its costs if it were to invest in a second producer, we next applied a RAND-developed tool—the required cost reduction (RCR) methodology[8]—that determines whether competition can be reasonably introduced into the development and production phases of a variety of weapon systems. In particular, the model has allowed us to look at whether lower production costs engendered by the presence of a second producer would offset the investment in bringing that second source into the program. In recent years, we have applied this methodology to the Joint Strike Fighter, the DD(X) program (as the destroyer was then known), and to the United Kingdom's Type 45 Destroyer, as well as to numerous other acquisition programs.

A RAND-developed tool calculates the percentage of savings in production needed to offset inefficiencies with a second producer.

The RCR methodology calculates a ratio of required savings necessary to offset the additional costs introduced by multiple production sources (under competition) relative to the

[8] This methodology was introduced in Birkler et al., 2001. It is a modification to the original break-even analysis developed by Margolis et al., 1985.

sole-source production cost.[9] In other words, it answers the question, "How much do I need to save relative to the sole-source production costs to make competition break even?" To determine whether competition might be reasonable, we compare the RCR ratio to the values in Table 2. If the RCR is lower than the value for savings achieved where 50 percent of the programs saved at least that amount (i.e., there is a high likelihood of offsetting the additional costs of competition), then we view a competitive strategy as being a reasonable approach. If the percentage is higher, then competition is not a reasonable strategy to reduce costs.

The RCR factors in the cost inefficiencies that are introduced with competition. The two cost inefficiencies that are typically considered are loss-of-learning and higher investment costs.[10] Loss-of-learning occurs under a competition option because no one producer manufactures every unit. Learning (or, more formally, cost improvement) is the phenomenon where unit production costs decrease with each successive unit. However, each producer under a competitive approach will typically produce *fewer* total units over the entire production run. This reduction in the total quantity each source produces indicates that the average unit cost under competition could be higher.

Additional investment costs also occur with a competitive approach. For example, each producer must invest in tooling and manufacturing facilities to produce enough units if it wins a competition, so the overall facilities cost for a program are higher because each manufacturer needs redundant capability. Further, each manufacturer may need to engage in production design in order to produce an item (even under a build-to-print competition). Therefore, development costs may also increase under a competitive strategy.

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[9] This RCR ratio is defined as RCR = $(TC_1 + TC_2 - TC_{SS} + I_C - I_{SS}) / TC_{SS}$, where,
TC_1 = Recurring cost for contractor 1 under competition
TC_2 = Recurring cost for contractor 2 under competition
TC_{SS} = Recurring cost for single-source contractor
I_C = nonrecurring cost (investment) required under competition
I_{SS} = nonrecurring cost required under sole-source production

[10] One could consider other influences, such as changes due to production rate efficiency and overhead. These influences are beyond the scope of this analysis.

To illustrate the potential range of answers with the RCR methodology, we built a simple spreadsheet model to evaluate competition using different key assumptions. The model calculates production costs based on three key inputs: 1) a cost-improvement slope, 2) a value for the total number of units, and 3) the nonrecurring investment cost. The model includes some simplifying assumptions:

- First, competition will equally split the quantities between the two producers (it is not a winner-take-all situation). This first assumption represents a "worst case" scenario.
- Second, the model assumes that the additional investment cost is equal to the sole-source investment cost. That is, each competing producer's nonrecurring costs are equal and do not change with production quantity.

Table 3 presents the results of this calculation, based on a case where the total production quantity is 1,000 units. The first column of the table represents the nonrecurring cost relative to the first production unit cost; for example, a value of 5 in the first column means that the nonrecurring cost was five times greater than the cost of the first production unit, and a value of 50 means that the nonrecurring cost was 50 times greater than the cost of the first production unit. The remaining column headings represent (in percentages) an extent to which cost improvement may occur. For example, a cost improvement of 95 percent means that unit production cost decreased by 5 percent each time total production quantity doubled; a cost improvement of 100 percent means that unit production costs remained the same when total production quantity doubled.

Table 3 clearly illustrates that competition is more reasonable for situations where the nonrecurring costs are relatively low and the cost improvement is minimal (flat)—for example, when nonrecurring costs are only 5 times greater than the cost of the first production unit and cost improvement is 100 percent, then the percentage of savings in production needed to offset the costs of competition is only 1 percent. Note that RCR values (i.e., the results of the calculation) over 100 percent are cases where it is impossible to achieve savings. Even if the

Table 3
Notional RCR Values: Savings in Production Needed to Offset Inefficiencies with Dual Sources, for 1,000 Units

Nonrecurring Costs (T1)	Cost-Improvement Slope (%)					
	100	95	90	85	80	75
1	0	5	11	18	25	34
5	1	6	12	19	28	38
10	1	7	13	21	31	43
50	5	13	23	37	56	85
100	10	21	35	56	88	137
500	50	82	132	211	340	553
1,000	100	160	254	405	655	1,073
5,000	500	777	1,224	1,956	3,176	5,237

entire production was free, one could not offset the additional cost inefficiencies with multiple sources.

To understand when it might be reasonable to utilize competition (have dual sources), we compare the historical savings values for the ships, missiles, and electronics systems discussed in Table 2 with the notional RCR values in Table 3. We view competition as being reasonable where there is at least a 50-50 chance of achieving savings (i.e., at least half of the programs in our historical sample achieved that level of savings or more).[11] For ship and missile systems, the cases where the cost-improvement slope is greater than 90 percent and the nonrecurring costs are less than 100 times the first unit cost are favorable (see

Our analyses indicate that competition is more reasonable in situations when both nonrecurring costs are low and cost improvement is minimal.

[11] At least half of the ship and missile programs in Table 2 achieved cost reductions of at least 17 percent. Similarly, at least half of the electronic systems programs in Table 2 achieved cost reductions of about 30 percent.

values shaded in green). For no cases where the cost-improvement slope was lower than 85 percent was competition seen as favorable for these weapon systems. For electronics-type systems, the range of competition-favorable values expands to include more cells (shown by the cells in green type, including those in the area shaded in green). Now, some favorable values extend to cost-improvement slopes as low as 80 percent, but the relative nonrecurring cost is still limited to values of 100 times the first unit cost and less.

Competition may also be more reasonable in situations where a greater number of units will be produced.

Table 4 shows a similar analysis, but where the production quantity has been cut in half (500 units). Again, a similar pattern emerges, but now fewer cells are identified as favorable. This leads to the final observation on competition: Situations with many production units are generally more favorable.

Table 4
Notional RCR Values: Savings in Production Needed to Offset Inefficiencies with Dual Sources, for 500 Units

Nonrecurring Costs (T1)	Cost-Improvement Slope (%)					
	100	95	90	85	80	75
1	0	5	11	18	25	34
5	1	7	13	21	29	40
10	2	8	15	24	34	48
50	10	20	33	50	75	111
100	20	35	55	83	126	189
500	100	152	229	347	530	817
1,000	200	299	448	678	1,036	1,603
5,000	1,000	1,473	2,196	3,319	5,083	7,885

Conclusions

In major defense acquisitions, the relationship between the buyer and producer is almost completely different from that assumed in the economist's model of the marketplace. While the use of competition in weapon system acquisition is widely advocated, *savings are not inevitable*. Splitting production between two contractors may in some instances result in a higher cost to the government.

As described in this paper, RAND has created a unique methodology that senior decisionmakers have used to determine if and when introducing production competition is a reasonable acquisition strategy. Over the past decade, we have developed and refined a "break-even" model, built upon previous RAND studies, that identifies how competition might be introduced into the production phases of a variety of weapon systems. Using this model, we have been able to gauge the likelihood that a government agency would recoup its costs if it were to invest in a second producer. In particular, the model has allowed us to look at whether lower production costs engendered by the presence of a second producer could offset the investment in bringing that second source into the program. In recent years, we have applied this methodology to the Joint Strike Fighter, the DD(X) program (as the destroyer was then known), and to the United Kingdom's Type 45 Destroyer, as well as to numerous other highly visible acquisition programs where the benefits of competition were being hotly debated.[12]

Because each and every acquisition is unique, our experience is that one must carefully evaluate whether introducing competition is *reasonable*. This is not an academic problem. Decisions involving billions of dollars in future procurement will be based, to some extent, on estimates of single-source versus second-source cost.

[12] Birkler et al., 2001; Schank et al., 2006; Birkler et al., 2002.

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