

Using Explicit Demand Curves in an Acquisition Strategy

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This report examines sole-source and competitive economic environments; sole- and dual-source production and their cost implications, and suggests the use of explicit demand curves.

INTRODUCTION

The two principal acquisition strategies in the production of major weapon systems are sole-source procurement and competition between two producers. These are actually two families of strategies as each can be applied in different ways. This article examines sole- and dual-source production and their cost implications.

The economic concept of price elasticity of demand is essential to understanding the difference between sole- and dual-source production. This concept further suggests a new subfamily of strategies in the sole-source regime, namely, using an explicit demand curve.

PRICE ELASTICITY OF DEMAND

This is a standard tool in economic theory. It measures the responsiveness of quantity demanded to price. Its equation is:

$$E = \frac{\% \text{ change in quantity}}{\% \text{ change in price}}$$

I will quantify E as we examine different acquisition strategies.

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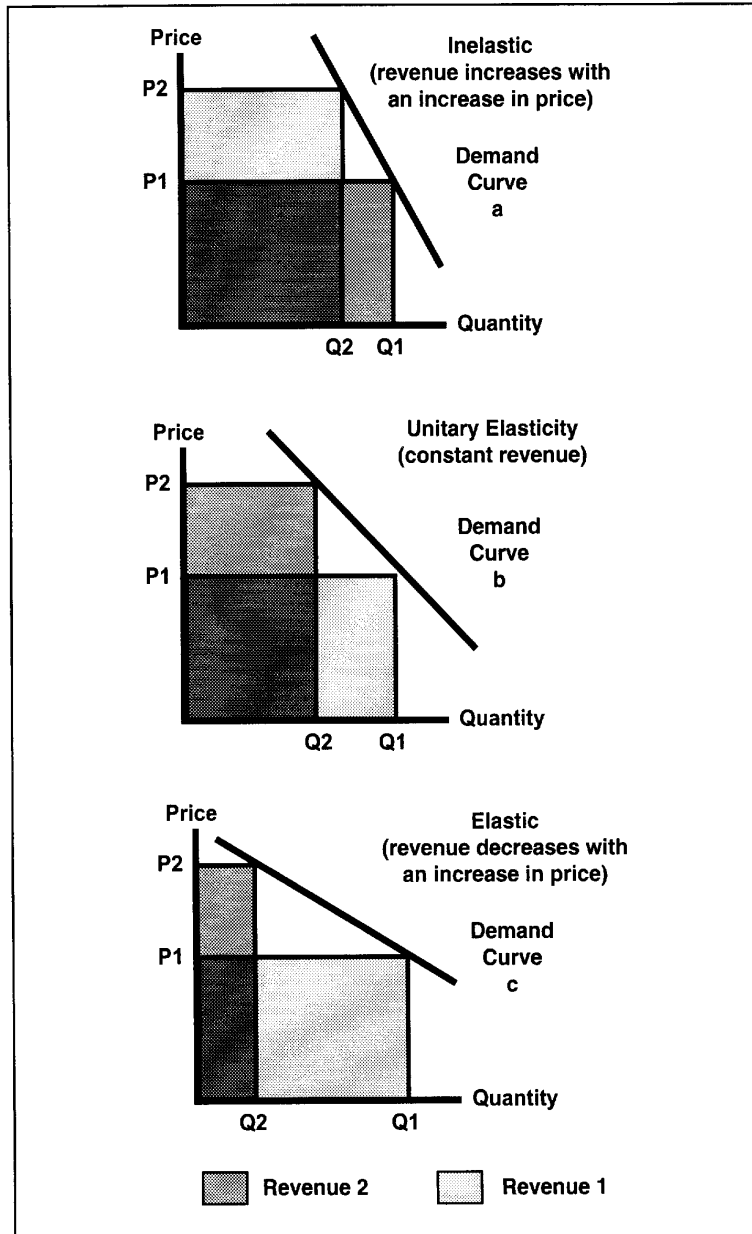


Figure 1. Explicit Demand Curves

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The charts in Figure 1 show the relationship between elasticity of demand and revenue. In each case price goes up from P1 to P2. However, the impact upon quantity and total revenue varies. The result varies because the reaction of the buyer is different in each case.

Demand curve **a** is said to be inelastic; $E < 1$. The buyer buys slightly less. This does not fully offset the price increase. Total revenue increases. Curve **b** is unitary elastic; $E = 1$. The impact of reduced quantity exactly offsets the higher price. Revenue stays the same. Curve **c** is elastic; $E > 1$. The buyer so reduces quantity that the higher price is more than offset, and revenue declines.

The number of suppliers is one factor which determines elasticity. The demand curve that a monopolist sees is the market demand curve. By contrast, a firm in a competitive environment faces a demand curve which is not the market demand curve. When he raises price, he loses sales to his competition. His demand curve is more elastic, i.e. price sensitive, than the market demand curve. This divergence between the market demand curve and the demand curve facing the firm generates a lower price, a higher production quantity, and greater economic efficiency. By greater economic efficiency I am referring to an approach toward the standard economic concept of a *pareto optimality*.

IMPORTANCE OF REVENUE

Conventional DoD contract management procedures target profit directly. This paper emphasizes revenue instead. Standard contract administration emphasizes such things as risk, the appropriate selection of contract type, target cost, target profit, and share ratios. This is fine as far as it goes. However this isn't the entire story. If it were, there would be no reason to consider competition

In the defense industry, revenue maximization may be a particularly good strategy for strengthening a firm and maximizing its profits over the long-haul. Economic theory postulates that firms act to maximize profits. However sometimes best results are achieved by approaching goals indirectly rather than directly. Firms that set other goals as their highest priority (quality, or consumer satisfaction, or revenue) may achieve higher long-term profits than firms that seek to maximize profits directly.

Defense is a quasi-regulated industry. This includes the regulation of profit percentages. It is easy, perhaps too easy, to conclude that profit, expressed as a percentage, is too high. A high profit percentage will likely result in a hue and cry and a strong reaction. As a result profit percentages do not vary much and do not get very high. This is especially likely to be the case for large defense firms and large contracts because they are monitored more intensely .

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Higher revenues have numerous advantages. Higher revenues signify more resources: personnel, capital equipment, and a fully developed infrastructure. A resource rich company is better placed to obtain future programs. Revenue growth relates to job security. This is especially important if revenues are declining in other areas; revenue growth can save jobs. Higher revenues suggest the possibility of raises for incumbents. Increased revenues also correlate to higher dollar profits. This occurs because a profit percentage which varies little (and is uncorrelated with price) is applied to a larger base.

COST IMPACT OF COMPETITION

Competition both costs money and saves money, when compared to reliance upon a single source.

Factors leading to higher costs are both non-recurring and recurring. Non-recurring factors include the cost of financing two companies through development, and purchasing two sets of production tooling. Technology transfer costs and other costs involved in coordination between two companies can be both non-recurring and recurring. A recurring cost of competition is movement down two learning curves rather than one.

However in many cases these extra costs are more than offset by the fact that competition is a powerful force which reduces recurring production cost.

This cost reduction has been expressed and measured as: a) percentage savings from competition, and, b) steeper learning curves under competition. The second approach has empirical support, harmonizes with weapon system costing procedures, and is consistent with competition as an enduring force.

Why are learning curves often steeper when there is competition? The answer is that the price elasticity of demand is greater when you have competition. A reduction in price can result in a large increase in quantity at the expense of the competition.

TWO SOURCES IN PRODUCTION

The way this is usually practiced in DoD is through yearly competitions. The low bidder receives the higher portion of a year's buy. The remainder goes to the high bidder. The percentage split is usually determined in advance. Common percentages are 60/40 and 75/25. The government has the option of giving the entire quantity to the low bidder, if prices diverge dramatically.

How do we describe the demand curve under dual-source split-award competition? What is its price elasticity? Our discussion will differentiate between the short run and the long run.

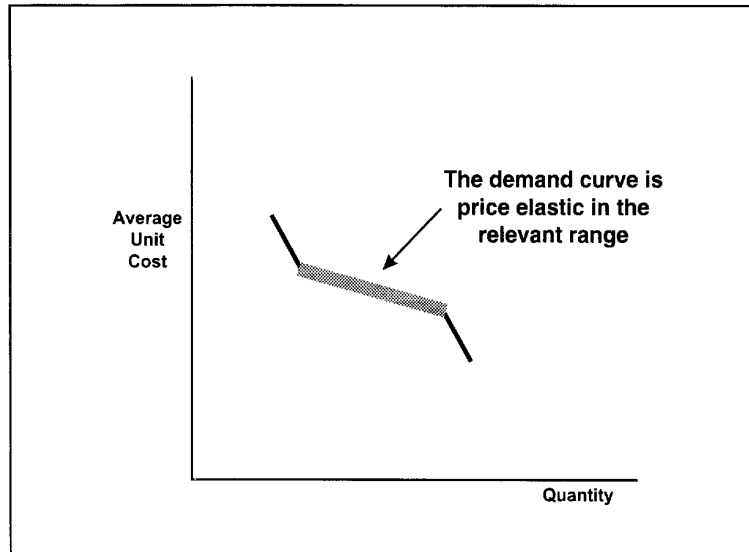


Figure 2. Price Elasticity Dual Source Split-Award Competition

COMPETITION, THE SHORT RUN

In this context, the short run corresponds to an individual contract. The demand curve is shown in Figure 2. The firm's production quantity is dependant upon the price it bids. Within a competitive region, a small change in price can lead to a large change in quantity.

Let's assume a 60/40 split. A small change in price, say -10 percent can lead to a large change in quantity, 50 percent (going from 40 to 60 percent). The price elasticity of demand is 5, the absolute value of 50 percent/-10 percent.

If the ground rules specify a 75/25 percent split then the elasticity is even greater. An increase from 25 to 75 percent is a 200 percent increase. If this results from a 10 percent reduction in price, then the price elasticity of demand computes to a value of 20. I'll use this value as an upper bound.

The demand curve is not known with certainty. The relatively flat portion of the curve is in a probabilistic haze. A price reduction of 8 percent might have the same impact as a reduction of 10 percent. However, the probability of becoming the low bidder is greater with a 10 percent reduction. To summarize competitive production in the short run, $1 < E < 20$.

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COMPETITION, THE LONG RUN

The long run is between more than one contract, and the entire program. In the long run, a firm can expect higher program quantities and revenues if it aggressively reduces cost and price. The reasons are that the firm can reasonably hope for the larger portion of a majority of the buys, the firm will not be cut out of the competition, and the other firm may be cut out of the competition. The long-run demand curve is elastic: $E > 1$.

SOLE SOURCE, THE SHORT RUN

The short-run demand curve and its price elasticity are dependent upon administrative procedures. The government decides how much to spend through the budget, appropriation and authorization processes. After deciding the level of expenditures (revenues from the perspective of industry), the government commences contract negotiations¹. Quantity varies through the negotiation process. One could say that industry (prime contractor and subcontractors) selects a point from the government's demand curve². This demand curve is an implicit curve. Its elasticity is equal to one: $E = 1$.

SOLE SOURCE, THE LONG RUN

Given our definition of the long run as a period including more than a single contract, it is likely that demand will be affected by factors other than price. In economic theory the effect of these factors is referred to as a change in demand. They cause a shift of the demand curve. This is often contrasted with a movement along the demand curve, referred to as a change in the quantity demanded.

A change in the perceived threat causes a change in demand (shift of the curve). So does a change in the perceived effectiveness of a system. The Stinger surface to air missile provides an example of a change in perceived effectiveness. Stinger was receiving bad press as being too difficult to operate. Press reports changed dramatically when Stinger was used successfully in the Soviet-Afghanistan war.

Despite occasional changes in demand, it is still appropriate to discuss

1 This is contrary to most business or individual practice where expenditures are a function of price. It may be that the government voluntarily surrenders its option of "walking away from a bad deal."

2 In many cases contractors can go straight to budget documents and see what dollars have been appropriated. However, even when the contractor does not know how much the government has decided to spend, it knows the decision has been made. The government's expenditure decision does not correlate in any way to the contractor's (subsequent) pricing decision.

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and even quantify the long run price elasticity of demand for a weapon system. I know of one major weapon system which was viewed within part of the Army as being overpriced. A decision was made at high levels to put a cap (a ceiling) on spending over the life of the program and to accept quantity shortfalls. This decision equates to a long-run price elasticity of demand of one. At the request of the prime contractor, Congress removed the cap and authorized additional spending. This implies a price elasticity of demand of less than one.

Weapon system acquisition is based upon requirements (need), and this implies an inelastic demand curve. If one takes requirements logic to its extreme, it results in a vertical demand curve with elasticity of zero. For example: we require a quantity of x , more is unnecessary, less is unacceptable and price is no object. In fact, however, more is better, less can be tolerated, affordability is a real driver, and elasticity is greater than zero. To summarize, the long run demand curve has an elasticity greater than zero, and less than or equal to one: $0 < E \leq 1$.

REVENUE = UNIT PRICE X QUANTITY

Observation: unit price falls more quickly in competitive environments than in sole source environments. How do we explain this? Hypothesis: this can be explained by the government's price elasticity of demand and the assumption of revenue (profit) maximizing behavior on the part of firms.

In the competitive split-award dual source environment, the demand curve has an elasticity greater than one in both the short and the long run. Price reductions are more than offset by increases in quantity; reducing price increases revenue. Reducing unit price directly increases employment and profit dollars. Employees, management and stockholders all benefit.

In the sole source environment, the demand curve has an elasticity equal to one in the short run. This means that price reductions are just offset by an increase in quantity. Reducing price leaves revenue unchanged. In the long run the demand curve has an elasticity that is less than or equal to one. A lower unit price results in equal or declining revenues. There is no clear benefit to reducing unit price. One can expect relatively flat learning curves.

ACQUISITION STRATEGIES AND THE PRICE ELASTICITY OF DEMAND

Sole- and dual-source production have been examined in both the short and the long run. Firms perceive a demand for their product that is related to many variables including price. The relationship between unit

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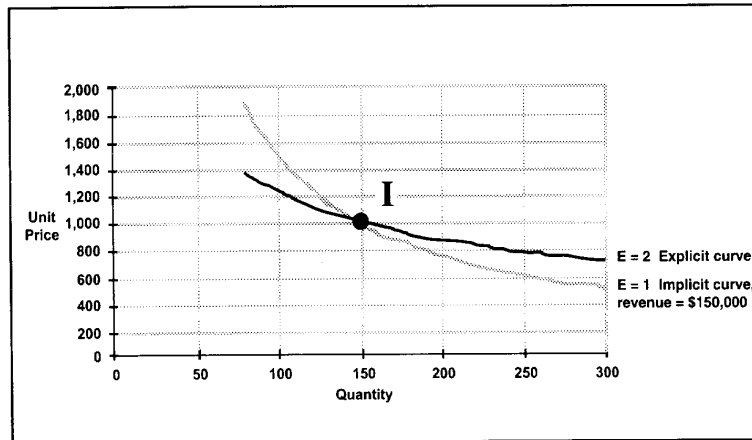


Figure 3. Standard and Modified Sole Source Procurement

price and quantity demanded relates mathematically to the shape of the demand curve, revenue, and price elasticity. (See the Mathematics of Explicit Demand Curves sidebar).

Consideration of price elasticity suggests a new acquisition strategy. This strategy relies upon a single source but offers some of the unit price reducing benefits associated with competition.

A NEW STRATEGY-EXPLICIT DEMAND CURVES

Suppose we are in a sole source environment in the purchase of a particular weapon system. It has been in production for many years. The configuration is stable. We would start with an initial cost, quantity point (see Figure 3). The quantity would be next year's planned quantity. The cost would be this year's unit price adjusted for inflation and learning. Around this point one would construct an elastic demand curve. Perhaps we would set the elasticity to 2. This would be the government's explicit demand curve. The contractor would select a price/quantity point from the curve.

The advantage of this strategy is that the contractor has an incentive to lower unit cost, much as he does in a competitive environment. By reducing unit cost he obtains an increase in quantity, revenue, employment, and profit dollars. There would be increased job security and the possibility of raises.

VARIATION ON A THEME

A variant of this approach is shown below. Here the elasticity of de-

MATHEMATICS OF EXPLICIT DEMAND CURVES

A demand schedule of constant elasticity is a curve. Its equation is $P = A Q^b$. P is price. Q is quantity. And $b = -1/E$, where E is the price elasticity of demand¹. The curves shown below have constant elasticity throughout their range. Each rectangular block is worth ten thousand dollars² in revenue.

Curves with higher elasticities are flatter. This translates into a greater quantity change in response to a given change in price. The greater quantity change in turn yields a greater change in revenue.

Point I is common to all curves. Unit price is \$1,000, quantity is 150, and revenue is \$150,000 (15 \$10,000 blocks). When price falls to \$800, the steep E1 curve yields a quantity demanded of 188, producing revenue of \$150,000. The flatter E2 curve results in a higher quantity, 234, and higher revenue, \$187,200. The E5 curve results in the highest quantity and revenue, 459 and \$367,200 respectively.

- 1 E is a point elasticity (See table 1). A is a constant that differs for each curve and equals the price implied by a curve for an annual quantity of one. It is a mathematical convenience with no real meaning.
- 2 Each block corresponds to a \$200 change in price and change in quantity of 50: $\$200 = \$10,000$.

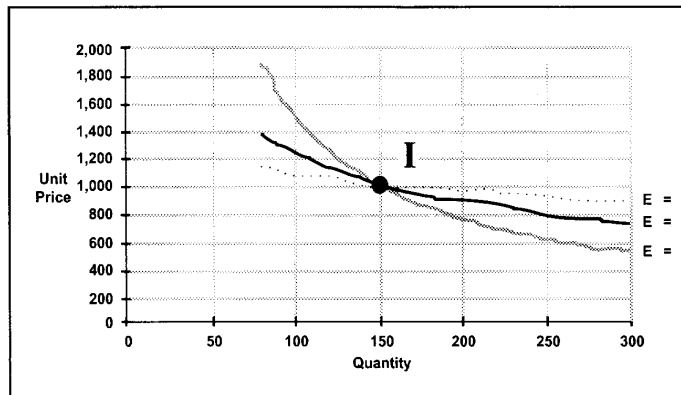


Figure 4. Demand Curves of Varying Price Elasticities

**MATHEMATICS OF EXPLICIT
DEMAND CURVES (continued)**

In the case of a price increase, the higher elasticity curves once again result in greater quantity and revenue changes. A unit price increase to \$1,200, yields a quantity reduction from 150 to 125 on the E1 curve. Revenue remains \$150,000. Using a curve with an elasticity of 2, quantity falls to 104 and revenue falls to \$124,800. The E5 curve results in a quantity of 60 and revenue of \$72,000.

From the government's perspective, quantity purchased is a function of price; $Q = F(P)$. Using our equation for a demand curve of constant elasticity ($P = AQ^b$ where $b = -1/E$), we obtain the equation $Q = (P/A)^{-E}$.

Contractor revenues are a function of price; $R = F(P)$. When we use an explicit demand curve the equation for total revenue is: $R = PQ = P(P/A)^{-E}$. (When using these equations, remember to round the quantity variable to an integer value.)

By means of explicit demand curves, the Government can choose and communicate a value for E. A higher value for E provides a greater incentive for the contractor to reduce unit price.

We have been surprised on occasion by the large price reduction resulting from competition. This may indicate that where incentives provide a will, the defense industry will find a way. A real incentive to reduce unit price will change priorities. This in turn should harness the ingenuity of individuals toward unit price reducing (revenue enhancing) pursuits.

Care should be taken not to set too high a value for E. Higher values for E create greater expenditure uncertainty. Also it may be possible to overly incentivize price reduction efforts.

mand is two for quantities between 100 and 225. Before and after these points, the elasticity is one. This limits the potential swing in budget dollars while giving industry an incentive to lower cost and price in a 50 percent quantity range about the planned quantity of 150.

REDUCED THREAT ENVIRONMENT

The acquisition strategy of using an explicit demand curve has relevance in a variety of settings, including today's environment of reduced threat

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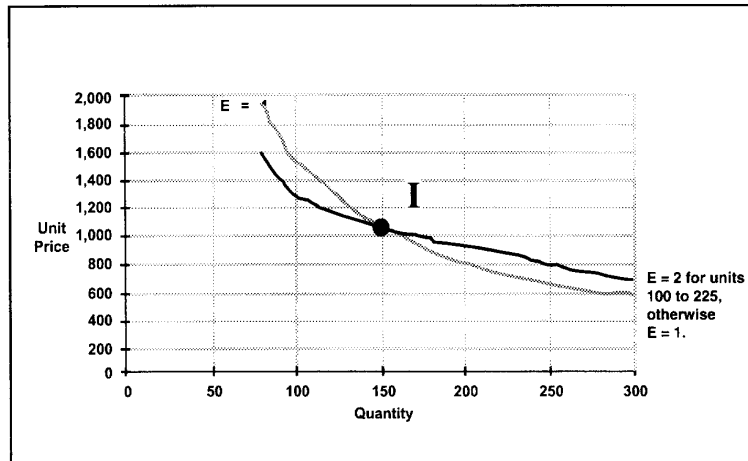


Figure 5. Variation on a Theme

and downward budget pressures. Consider two scenarios:

Scenario 1. A sole source program faces reduced annual production. Normally this could be modeled by shifting the implicit demand curve ($E = 1$) to the left. Why not shift an explicit demand curve ($E = 2$) to the left? This would give the contractor an incentive to regain lost revenues and employment by energetic actions to reduce unit cost.

Scenario 2. A major weapon system relied upon two sources in production. However because of the reduced threat, quantity has been reduced and the decision has been made to go sole source. An explicit demand curve, $E = 2$, would provide continued incentive to lower unit costs.

LONG RUN CONSIDERATIONS

The explicit demand curves that we have considered are short run curves. A long-run strategy which links reduced unit price to increased program quantities and revenues would provide a long run demand curve with an elasticity greater than one.

One way to do this would be to take the change in a year's quantity, and add it to the total program quantity. Suppose that in a given year the contractor reduces unit price and sells 200 units instead of the planned 150. In this case, the total program quantity would be increased by 50.

This kind of approach may not always be necessary. In some cases there is so much uncertainty about the long run that it will be ignored in decision making. What we want to avoid however is the situation where

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lower unit costs and higher annual production rates raise the specter of early program completion and unemployment³.

ADMINISTRATION

There are many ways to administer the strategy of using explicit demand curves. They all entail a change in the way we do business.

One method would be to send the explicit demand curve to Congress for approval prior to sending it to the contractor. However, in this case Congress would not know the resultant level of expenditures.

Another procedure would be to go through an iteration prior to obtaining final Congressional approval. In this case Congress would bless an explicit demand curve. This would be submitted to the Contractor who would select a cost/quantity point from the curve. This would then be submitted to Congress for final approval. This approach has the advantage that Congress would know expenditure level, unit cost and quantity. Currently the level of expenditures is given but Congress does not know the resulting unit cost or quantity.

Yet another way is for Congress to grant the latitude to use explicit demand curves subject to some higher level spending constraint. The constraint could be applied at either the Service Secretary, Acquisition Executive, or Program Executive Officer level. Congress would approve an explicit demand curve for a particular weapon system. The contractor would select a cost/quantity point. Other programs would be either increased or diminished to maintain overall spending under (at) the agreed upon ceiling.

³ Along the same lines, it has been suggested that nuclear plant construction in the United States has suffered from "last plant syndrome." Once a plant is complete, workers are laid off. There is little incentive to complete the plant. Furthermore, deficiencies that require rework can extend employment.