TECHNICAL Data Packages: When Can They **Reduce Costs** for the Department of Defense?

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This article presents an economic model analyzing the impact of research and development (R & D) costs, production costs, and quantity requirements on the price of a Technical Development Package (TDP). It compares payoffs in a game involving a duopoly of defense firms and the government to analyze potential cost savings to the government by purchasing a TDP. It concludes that the price of a TDP depends primarily on rival firms' R&D as well as production costs. The government is most likely to achieve cost savings in the case where a rival firm has lower production costs, but would lose a competitive bid without a TDP. However, a TDP does not automatically lead to competition-based savings. The author then discusses the implications of relaxing key assumptions of the model.

Keywords: *national defense economics, competitive procurement, competition-based savings, data rights, technology transfer*

In the acquisition of many weapon systems, the Department of Defense (DoD) must decide whether to buy a Technical Data Package (TDP), which contains the information needed to produce them. The government faces a tradeoff: pay for a TDP and try to save money by competing production and sustainment, or decline to purchase a TDP and possibly pay much more for new systems, spares, and repairs. This article examines this tradeoff by comparing payoffs in a game of a duopoly of defense contractors. While it focuses on the role of TDPs, competition, and the procurement of systems, there are naturally other important uses of TDPs such as allowing the government to conduct better engineering and logistics analysis. The model suggests that the price of a TDP depends on the cost to replicate it via an independent research and development (R&D) effort, relative production costs between firms, and the quantity of systems procured. It further discusses implications of relaxing key assumptions of the model.

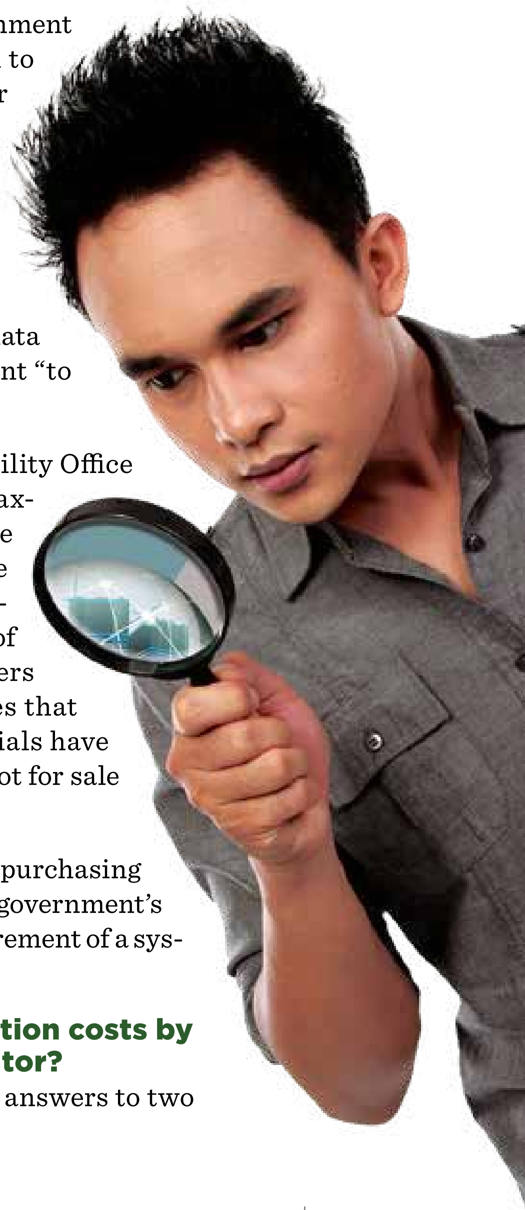
Background

Economists and policy analysts disagree about the role of competition in the procurement of defense systems. They can be grouped into two broad opposing groups. One group believes that setting up a competition between multiple prime contractors leads to lower costs for the government. The other group contends that using multiple prime contractors reflects political realities or industrial base concerns, and does not provide efficiency gains through competition.

In the first group, Lyon (2006) concludes in an analysis of missile production, "dual sourcing appears to produce procurement cost savings" (p. 248). Gansler, Lucyshyn, and Arendt (2009) argue that employing competition reduces costs by stressing that competition provides strong incentives for contractors to reduce costs while providing high-quality products. Kovacic and Smallwood (1994) stress the role of competition in promoting innovation by contractors, but recognize cost savings as a secondary benefit. Driessnack and King (2007) argue that the use of subcontractors by prime contractors has several benefits, including "decreasing costs by increasing the level of competition and innovation in the defense industry through increased outsourcing" (p. 64).

In their analysis of rising ship costs for the U.S. Navy over the last half century, Arena, Blickstein, Younossi, and Grammich (2006) argue a contrasting perspective: "The reality is that using multiple producers can make a program more politically palatable" (p. 46). They go on to state, "Although competition might help reduce prices, there is also little evidence … that current 'allocation' processes gain the benefits of competition" (p. 65). In a similar study comparing the production of the F/A-22 and the F/A-18 aircraft, Younossi, Stem, Lorell, and Lussier (2005) note that the "artificial distribution of work" among several major contractors helps explain in part the higher costs of the F/A-22 when compared to the F/A-18, which used a single prime contractor (p. xviii).

This debate is not merely academic: the U.S. Government has taken an active interest in using competition to reduce the costs of weapon procurements. An Under Secretary of Defense for Acquisition, Technology, and Logistics memorandum states, "competition is the most effective tool we have to control cost" (Kendall, 2015, p. 23). Guidelines produced by this office claim, "competition . . . is the most effective motivator for industry to reduce costs and improve performance" (DoD, 2014a, p. 1). It also suggests, "data deliverables and rights" are a necessary component "to realize the full benefits of competition" (p. 2).



On defense contracts, the Government Accountability Office (GAO, 2013) reports competition "can help save taxpayer money, conserve scarce resources, improve contractor performance, curb fraud, and promote accountability for results" (p. 1). In a study on competition in contracting, GAO has observed, "lack of access to technical data as one of the main barriers to competition" (GAO, 2010). However, GAO notes that when several program offices or contracting officials have attempted to obtain technical data, it "is [either] not for sale or purchase of it would be cost-prohibitive" (p. 19).

This article takes a narrow focus on the tradeoff of purchasing technical data. The focus here is specifically on the government's purchase of TDPs that facilitate competitive procurement of a system. It seeks to answer the following question:

Can the government realize lower production costs by purchasing a TDP to provide to a competitor?

To do that, the government needs to weigh the answers to two specific questions:

1. What is the price of the TDP?
2. Under what conditions can ownership of a TDP reduce the price the government pays for production?

To answer these questions, this article presents a simplified model, which explores the behavior of the economic agents involved and the implications if one relaxes the major assumptions.

> ***The government should not assume it can achieve competition-based savings by purchasing a TDP.***

Based on this analysis, one should view a TDP not as based on the costs to make it, but rather as based on a strategic decision by a firm responding to economic incentives. The price of the TDP depends on:

1. The R&D costs to replicate the information in the TDP. R&D costs are the costs incurred to develop a system prior to production.
2. The relative production costs between rival firms.
3. The quantity of systems procured.

Based on this price, the government should purchase a TDP when savings on the reduced production price are greater than the price of the TDP. The government should not assume it can achieve competition-based savings by purchasing a TDP. In cases where rival firms have higher production costs than the incumbent, the purchasing of a TDP will likely not lead to savings for the government. Conversely, in cases where rivals have lower costs of production, but R&D costs act as a high barrier to entry, the government may achieve savings through a TDP.

Analytical Framework

The government needs to understand the economic behavior of the defense contractors involved when deciding to purchase a TDP. To understand the nature of this tradeoff, this article employs a model of a game of two firms based on several key assumptions.

Assumptions for TDPs

1. **The government does not already own the data rights to the system.** In obtaining a TDP, the government is purchasing the rights to the system design in addition to information on how to produce it. In instances where the government funded R&D efforts, it would typically own the data rights and would not need to purchase them (although even here there may be some minor delivery costs).

2. **The model assumes that a TDP eliminates R&D costs for rival firms.** A TDP reduces barriers to entry in competition by allowing rival firms to compete with an incumbent by not having to conduct their own R&D effort. Importantly, rival firms can still compete without a TDP, but need to have their own R&D effort to enter production.

3. **There is no cost for producing a TDP.** The model excludes the cost of producing a TDP for simplicity. While depending on the system, TDPs would likely cost in the hundreds of thousands or very low millions, which is often minor in the context of defense procurements in the hundreds of millions or billions of dollars.

Assumptions for Firms

1. **The model is based on a duopoly.** This is a realistic assumption because DoD work is highly specialized. Only a few firms are able to produce hardware for major DoD procurements. For clarity in analysis, these are called:

   - Firm One: Incumbent that has completed an R&D effort under a previous effort.

   - Firm Two: Rival that needs to complete a separate R&D effort or receive a TDP to compete in the new contract.

For several possible reasons, Firm One may have already completed the R&D effort. The government may have previously planned to procure sole-source before deciding to compete the procurement. Firm One could have been the original producer for an item requiring a mid-service upgrade or a new contractor for sustainment.

2. **Both firms behave as profit maximizers.** Firm One will only sell a TDP if that sale increases Firm One's profit. Neither firm will bid for less than zero profit.

3. **Firms have perfect information on their own production costs, their rival's production costs, and Firm Two's R&D costs.** Both firms have enough information to accurately predict their rival's production costs (and in the case of Firm Two, R&D costs too), and hence their rival's price during the bidding process. The analytical framework presented in this section involves Firm One identifying Firm Two's price as a step in its strategy. In reality, Firm One would likely be trying to estimate Firm Two's costs, though it would not have perfect information to determine the exact costs. Additionally, both firms have enough information to accurately predict their own production costs.

4. **Zero transaction costs in the bidding process.** While transaction costs and rent seeking are important components of analyzing government behavior, the model excludes transaction costs of bidding for clarity in analysis. This article discusses the implications of relaxing these assumptions under the section Additional Complexities.

Assumptions for the Government

1. **The government sets the procurement quantity exogenously based on operational requirements.** This means firms will decide their bidding price, but not quantity. However, this quantity is large enough that marginal revenue will be greater than or equal to marginal cost for the winning firm.

2. **The government behaves as a cost minimizer when evaluating bid prices.** As a cost minimizer, the government selects the firm with the lowest price.

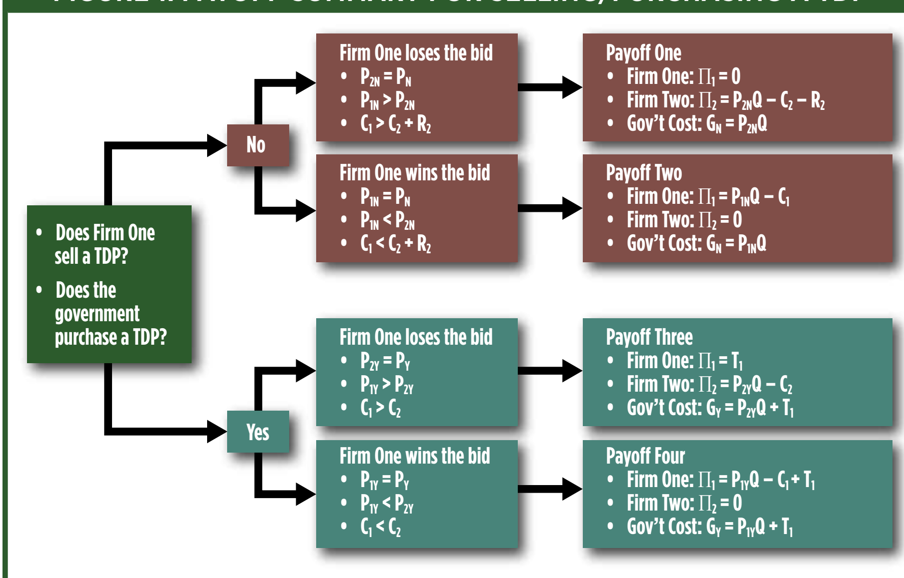
3. **The competition is a one-off and winner takes-all.** This means only one of the two firms will win the bid and be able to complete the work. This is not true for all DoD competitive procurements (e.g., continuous competition where firms compete multiple times for the share of the work).

4. **From the government's perspective, both firms produce an equally acceptable product (e.g., schedule, quality).** This is an important assumption because in some cases the government will face a tradeoff between quality and price.

Model Summary

Given these assumptions, one can summarize the payoffs for a duopoly of defense contractors and the cost implications for the government. Figure 1 summarizes these payoffs.

FIGURE 1. PAYOFF SUMMARY FOR SELLING/PURCHASING A TDP



Where:

Π = profit

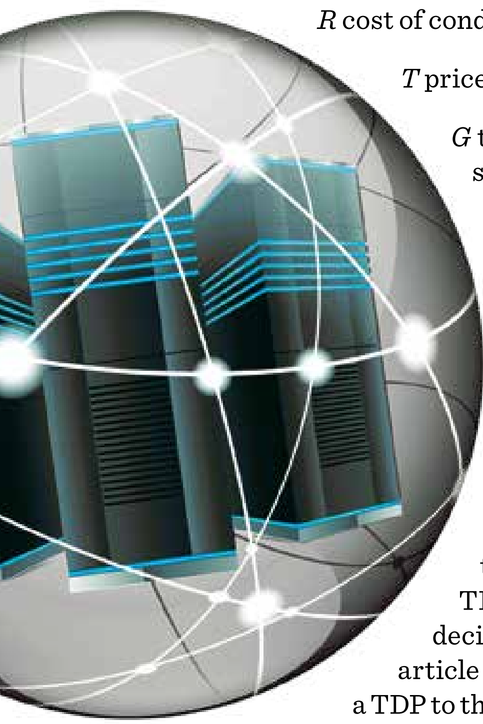
P_N = unit price if Firm One does not sell a TDP

P_Y unit price if Firm One does sell a TDP

Q number of systems procured

C total cost for a firm

- Includes fixed and variable cost of production
- Increases linearly as quantity increases (assuming no learning in the production process)



R cost of conducting R&D prior to production

T price the government pays for TDP

G the cost incurred by the government for procuring the system.

All independent variables are greater than or equal to zero. Subscripts in Figure 1 refer to Firm One and Firm Two (1, 2), and whether or not there is a TDP (Y, N).

In this model, Firm One must decide whether to sell a TDP. Once Firm One makes this decision, both firms provide bids to the government. Given this scenario, Firm One should make its decision based on backward deduction of its payoffs. If Firm One decides to sell, the government must decide if it wants to buy the TDP. As with Firm One, the government should make its decision based on backward deduction of its payoffs. This article first examines a scenario where Firm One does not sell a TDP to the government. Thereafter, it examines a scenario where Firm One sells a TDP to the government.

Firm One Does Not Sell a TDP

Firm One starts by comparing its profit if it wins the bid (summarized in Equation 1) to the profit Firm Two obtains if it wins the bid (summarized in Equation 2).

$$\Pi_1 = P_1 * Q - C_1 \quad (1)$$

$$\Pi_2 = P_2 * Q - C_2 - R_2 \quad (2)$$

Firm One knows that Firm Two will not offer a bid where $\Pi_2 < 0$ and that Firm One will win the bid if $P_1 < P_2$. Firm One will identify Firm Two's P_2 and set P_1 at the highest level it can below P_2. Firm One's bidding price will be such that $P_1 * Q \geq C_1$.

Since Firm One will set P_1 below P_2, one can arrive at Firm Two's price. The lowest amount Firm Two will bid is $\Pi_2 = 0$, and the following two equations illustrate solving for P_2 at this point.

$$0 = P_2 * Q - C_2 - R_2 \tag{3}$$

$$P_2 = \frac{C_2 + R_2}{Q} \tag{4}$$

At $P_1 = P_2$, the following equation summarizes what Firm One's profit function becomes:

$$\Pi_1 = P_1 * Q - C_1 = \frac{C_2 + R_2}{Q} * Q - C_1 = C_2 + R_2 - C_1 \tag{5}$$

If Firms One and Two have identical cost functions, $\Pi_1 = R_2$ at $P_1 = P_2$ and $\Pi_1 < R_2$ at $P_1 < P_2$.

Several major takeaways emerge from this analysis. A major implication of Equation 5 is that Firm One's profit can be directly impacted by its rival's R&D costs. The major implications of Equation 4 when $P_1 < P_2$ (i.e., Firm One won the bid) are twofold. First, Firm One's price decreases as Firm Two's cost decreases (assuming $C_1 \leq C_2$). Second, Firm One's price increases as Firm Two's R&D costs increase. Finally, when comparing Firm Two's price (Equation 4) with Firm One's minimum-bid price in Equation 6, several implications are surmised.

$$P_1 = \frac{C_1}{Q} \tag{6}$$

Each firm's minimum bid (i.e., P_1 and P_2) increases when quantity decreases (i.e., when the government changes its quantity requirements) and/or costs increase. Firm Two can only underbid Firm One when its total costs are low enough, such that $C_2 + R_2 < C_1$.

The upshot of this analysis where Firm One does not sell a TDP are that if firms have equivalent costs, Firm One will undercut Firm Two by the amount approximately equal to the R&D costs. Firm One will earn a profit equal to price times quantity minus its costs. Firm One's revenue will be greater than its costs by an amount slightly less (because Firm One's price needs to be less than Firm Two's) than the R&D costs Firm Two would have to incur. For Firm Two to win the bid, it must have significantly lower costs to offset the fact that it must pay for its R&D effort.

Firm One Does Sell a TDP

If Firm One does sell a TDP, both firms' profit equations change. Equation 7 summarizes Firm One's profit if it wins the bid, while Equation 8 summarizes Firm One's profit if it loses the bid.

$$\Pi_1 = P_1 * Q - C_1 + T_1 \tag{7}$$

$$\Pi_1 = T_1 \tag{8}$$

Notice that now Firm One earns revenue based on what it gains from selling the TDP to the government (as mentioned previously, assuming Firm One's R&D work occurred under a previous effort). Equation 9 summarizes Firm Two's profit if it wins the bid. Notice that it now excludes R&D costs because Firm Two now has access to a TDP.

$$\Pi_2 = P_2 * Q - C_2 \tag{9}$$

As it would have done had it not sold a TDP, Firm One compares the profit equations and identifies Firm Two's P_2. Firm One will set P_1 at the highest level it can below P_2 to win the bid. Firm One should not use the TDP to subsidize its production costs because Firm One's assumed goal is to maximize profits and not market share.

As described earlier, since Firm One will set P_1 below P_2 , one can arrive at Firm Two's price. The lowest amount Firm Two will bid is $\Pi_2 = 0$, and the following two equations illustrate solving for P_2 at this point.

$$0 = P_2 * Q - C_2 \tag{10}$$

$$P_2 = \frac{C_2}{Q} \tag{11}$$

At $P_1 = P_2$, the following equation summarizes what Firm One's profit function becomes:

$$\Pi_1 = P_1 * Q - C_1 + T_1 = \frac{C_2}{Q} * Q - C_1 + T_1 = C_2 - C_1 + T_1 \tag{12}$$

If Firms One and Two have identical cost functions, $\Pi_1 = T_1$ at $P_1 = P_2$ and $\Pi_1 < T_1$ at $P_1 < P_2$.

The upshot for the government of having a TDP is that the lowest cost producer will win the bid in this game. Because Firm One has the profit $\Pi_1 = T_1$, if it loses the bid and $\Pi_1 < T_1$ at $P_1 < P_2$ if it wins the bid, Firm One will bid only if $C_1 < C_2$ so that $P_1 < P_2$ and $\Pi_1 > T_1$. To have the lowest winning price, the winning firm must have the lowest costs. Previously without a TDP, Firm Two, as a profit maximizer, had to have its production costs significantly lower to offset its R&D effort.

The Price of a TDP

Having worked through the implications of Firm One either not selling or selling a TDP, one must consider the price of a TDP. One can arrive at the bounds of the TDP's price by analyzing the conflicting cost-minimizing behavior of the government and the profit-maximizing behavior of Firm One. Table 1 summarizes the analysis presented in this section.

TABLE 1. LOW AND HIGH BOUNDS FOR THE TDP'S PRICE

Relative Costs of Firm One and Firm Two	Firm One's Minimum Price	The Government's Maximum Price	Winner with TDP	Winner w/o TDP
$C_2 + R_2 < C_1$	0	$Q * (P_N - P_Y)$	Firm Two	Firm Two
$C_2 + R_2 > C_1$ & $C_2 < C_1$	$P_{1N}\,Q - C_1$	$Q * (P_N - P_Y)$	Firm Two	Firm One
$C_2 + R_2 > C_1$ & $C_2 > C_1$	$Q * (P_{1N} - P_{1Y})$	$Q * (P_N - P_Y)$	Firm One	Firm One

At What Price Does Firm One Sell a TDP?

Firm One sets the price to maximize profits based on expectations from Firm Two and the government. As an upper bound, Firm One's TDP price should never exceed the government's cost savings for purchasing a TDP, $Q *$ $(P_N - P_Y)$ (see following section on When Should the Government Purchase a TDP?). For prices greater than this point, Firm One, though naturally desiring an infinitely positive payoff, realizes that it is cheaper for the government to contract Firm Two to develop and produce the system. Firm One would receive a payoff of zero.

As a lower bound, Firm One's TDP price depends on Firm Two's production costs. When $C_2 + R_2 > C_1$ but $C_2 < C_1$, Firm One should set the price of the TDP such that:

$$T_1 > P_{1N}\,Q_1 - C_1 \qquad (13)$$

This price ensures that Firm One's payoff of the TDP is greater than the payoff lost from not producing systems. When $C_2 > C_1$, Firm One should set the price of the TDP such that:

$$T_1 > Q * (P_{1N} - P_{1Y}) \quad (14)$$

This TDP price ensures that Firm One's payoff from the TDP more than compensates for its lower production price.

Finally, if $C_2 + R_2 < C_1$, Firm One knows it will lose the bid, and should be willing to sell a TDP for any price the government would be willing to accept, which would fall in the range where $0 < T_1 < R_2$ (this assumes that Firm Two passes cost savings from having a TDP on to the government).

When Should the Government Purchase a TDP?

Similar to how Firm One made its decision, the government should work through backward induction to examine the payoffs (i.e., its costs) and select the cost-minimizing option. Importantly, even if Firm One would like to sell a TDP, it does not necessarily make sense for the government to purchase it.

Since the government finds either firm's product equally acceptable and makes its decision based on price, one can summarize the government's decision to purchase a TDP as depicted in Equations 15 and 16:

$$P_Y * Q + T_1 \leq P_N * Q \quad (15)$$

$$T_1 \leq Q * (P_N - P_Y) \quad (16)$$

Equation 15 is the cost to the government of the two options for procuring the system: price times quantity plus the TDP if it purchases one compared to a presumably higher price times quantity without purchasing a TDP. Equation 16 means that the government should never pay more for a TDP than the cost savings it obtains by paying P_Y instead of P_N. The upshot from Equation 16 is that as quantity increases, the maximally acceptable price of the TDP can increase as well.

The government, as a cost minimizer, should apply the decision rule in Equation 16 to its four distinct payoffs as shown in Figure 1. The most important aspect of this is using a TDP to go from Payoff Two ($G_N = P_{1N}Q$) to Payoff Three ($G_Y = P_{2Y}Q + T_1$) because in this case, the government can successfully utilize a TDP to move production to a lower cost producer.

Payoffs One and Four are less important because the TDP does not cause the production to switch from one firm to another. In Payoff One ($G_N = P_{2N}Q$), Firm Two's production and R&D costs are low enough to underbid Firm One. The government should purchase a TDP in this instance only if $T_1 < R_2$ and Firm Two is willing to pass these savings on to the government.

Payoff Four is likely a case where the government should be indifferent whether it purchases a TDP. In this instance, Firm One's minimum price equals the government's maximum price. This implies that any savings the government achieves from lower production costs would be negated by the price it pays for the TDP.

Additional Complexities

The focus of the model presented in the preceding section is to illustrate the fundamental strategic options and behavior of Firm One as well as the government and Firm Two. However, this model is a simplification of reality. This section discusses various complexities of the model, including a TDP as a substitute for R&D, the behavior of the government, and behavior of firms.

Research and Development and a Technical Data Package

For simplicity, the analytical framework presented earlier in this article relies on the assumption that a TDP is a perfect substitute for a firm's own R&D effort. However, this is not entirely accurate, in part because a TDP does not communicate all production knowledge. At the very least, a firm would need to expend some R&D effort to customize the information in a TDP to its own production facility. This could include items such as production set up, accuracy of machines, training personnel, and obtaining relevant certifications. Some projects require much more than a TDP. For instance, in the late 1970s Williams Research Corporation designed the F107 cruise missile engine that the U.S. Air Force wanted to be coproduced with Teledyne Continental Aircraft Engines (CAE). The Air Force required Williams "to provide Teledyne CAE with all of the knowhow necessary to produce the engine" (Leyes & Fleming, 1999, p. 414), which was beyond the scope of a TDP. Additionally, third-party firms provide a service of deriving information from a TDP. One such company states on its Web site that they "support the process [of] taking engineering designs and technical data packages (TDPs) to optimize the manufacturing/production of a part/component/system" (Strata, n.d.).

Further, the firm selling the TDP has a large degree of control over its format and content. This firm, seeking to maximize profits, has an incentive to make the TDP as useless to a rival as possible. These and similar considerations should lead the government to ensure that the TDP content and format are carefully specified so that the TDP will serve its intended purpose of transferring relevant data to the other firm.

However, the basic dynamic behind the model remains the same, although now the TDP serves to reduce rather than eliminate a rival's R&D costs. Firm Two would have to incur some R&D costs even with a TDP. Firm One would be able to undercut Firm Two by approximately this amount provided their production costs are equal.

The model presented in the previous section assumes that the government does not own the data rights and it obtains these when it purchases the TDP. In some cases, the government may already own the data rights (e.g., it may have paid for the development effort) even though it has not purchased a TDP. For more information, see Defense Federal Acquisition Regulation Supplement (DFARS) 252.227-7013 and DFARS 252.227-7015 (DoD, 2014b, 2014c).

However, some of the dynamics of the model remain relevant even if the government owns the rights. For instance, the firm producing the TDP could seek ways to increase the cost of the government's TDP purchase, such as proposing an excessive number of senior-level engineers to develop the package and make it more complex than required. While presumably not as large as the price for the data rights, this increase would be significant enough for the government to consider.

> ***During the sustainment phase of a program, the government may be able to reverse engineer an item (DoD, 2006) in some cases instead of purchasing a TDP.***

Another simplification is that the model relies on an assumption that Firm Two conducts its own independent R&D effort if it does not have a TDP. Alternatively, the government could pay a firm other than Firm One to develop a TDP, and provide this to Firm Two. From the government's perspective, this method would ensure the bidding process better reflects rival firms' production costs. In the context of the analytical framework presented earlier in this article, the lowest amount Firm Two can bid is no longer $C_2 + R_2$, but rather C_2. The government could also pay less for this option because a third-party firm, not bidding for production, does not have incentives to use a TDP as a means to increase its production price. The cost of research could be even lower than the original development, because the nature of the solution is now known.

During the sustainment phase of a program, the government may be able to reverse engineer an item (DoD, 2006) in some cases instead of purchasing a TDP. It could do this either through one of its depots or through a contractor with the Replenishment Parts Purchase or Borrow Program (Defense Logistics Agency, n. d.). Using a depot would be analogous to the government paying a third-party firm as described previously. Using a contractor would be similar to retaining $C_2 + R_2$. This is because even though the contractor pays the cost to reverse engineer the item under this program, a profit-maximizing firm would presumably later recoup these costs in its sales to the government.

Government Behavior

Government is not a monolithic force. Rather, it is an organized collection of publically funded individuals who face externally imposed budget constraints and their own set of incentives, as a large body of public choice literature has pointed out (e.g., Buchanan & Tullock, 1962). For weapons procurement, the decision-making body is composed of individuals in acquisition program offices throughout DoD. These individuals face time constraints on when they receive funding from Congress via the DoD bureaucracy.

The analytical model presented earlier in this article does not consider time even though the program office's funding profile by fiscal year matters. For instance, program managers may believe that they have ample funding to purchase a TDP now, but believe they will have less funding in the future to procure production units. In this case, the program office may purchase a TDP when $P_Y Q < P_N Q$ but $P_Y Q + T_1 > P_N Q$ (i.e., paying more overall, but reducing future costs). Conversely, the program office could decline to purchase a TDP when $P_Y Q + T_1 < P_N Q$ for several possible reasons. The program office may face a budget constraint in which it lacks funds currently, but will have ample funding in future years.

Another problem is a principal-agent problem, where the incentives of the program managers are not well aligned with those of taxpayers, or even DoD leadership. One possibility could be budget-maximizing bureaucrats (e.g., Niskanen, 1975). In this case, the program office could be attempting to increase its budget and hence the prestige of its members, thereby resulting in the program office deliberately increasing its budget by selecting a more costly option. Another example could be one of externalities leading to poor incentives to reduce costs. The responsible program manager could be anticipating leaving the program office before savings from a TDP are realized. If the program manager is not penalized in the present time by the future higher costs, the manager lacks good incentives to work for a TDP even though this would benefit DoD and potentially the taxpayer by saving funds.

Behavior by Firms

The analytical model presented earlier has three major underlying assumptions that impact the price that firms would bid: profit-maximizing behavior, zero transaction costs, and perfect information. Relaxing the profit-maximizing assumption may lead to a lower bid if firms seek to cover only variable costs as opposed to fixed costs. While defense firms should behave as profit maximizers in the long run across a portfolio of systems, they may not behave as profit maximizers for individual programs in the short run. For instance, a firm may have some large fixed costs, such as excess plant capacity or highly specialized staff, which are temporarily underutilized, but needed for long-term profitability. In cases like this, the firm may bid a price to cover only its variable costs, but not its fixed costs. A possible example of this is Boeing bidding very aggressively on the replacement of aerial tankers to exclude rival Airbus from one of its markets (Thompson, 2011).

The analytical framework assumes zero transaction costs in the bidding process. However, firms could engage in additional activities other than the bidding process to win. For example, this could include expending considerable resources on lobbying and/or contesting lost bids through political mechanisms. Economists Christopher Coyne and Thomas Duncan (2013) contend that in striving to win the competition to produce the F-35, "Boeing and Lockheed Martin engaged in rounds of mergers and acquisitions to expand their political base" (p. 426). Economist Gordon Tullock (1967) has pointed out that parties competing to be a monopolist can bid up expected profits, eliminating their consumer surplus. Since firms are profit maximizing and would exit the industry if their profits are less than zero, one would expect that these costs would eventually get passed on to the government, possibly through higher unit prices for the government. In the context of the model, one could even add a term for bidding costs—which means the losing firm would have a negative payoff, instead of zero.

> ***While defense firms should behave as profit maximizers in the long run across a portfolio of systems, they may not behave as profit maximizers for individual programs in the short run.***

While the model assumes perfect information, this is not always a realistic assumption (for instance, Hayek [1945] contains an argument on information contrary to neoclassical economics). In the context of DoD procurement, firms typically know only their costs, what government program offices are willing to share regarding the acquisition plan, and the quantity of systems desired. Knowing the acquisition plan and quantity of systems is imperative, because as the model suggests, the price of the TDP increases as the number of systems procured increases.

Imperfect information on a rival's costs would benefit the government if firms would offer lower bids than absolutely necessary. The purpose of these lower bids is to make sure the firm gives itself enough price margin to successfully undercut its competitor's bid. Conversely, relaxing the information assumption for a firm's own production costs (i.e., the firm is not sure of the accuracy of its own production costs) could lead firms to offer a higher bid. The purpose of this is for the firm to have a reserve to meet potential cost overruns during production.

Firms, realizing that the government does not have perfect information on contractors, could attempt postcontract opportunism. The bidding firms could provide low bids based on overly optimistic cost estimates. This could lead the government to pay more than it anticipated in production costs. One solution would be for the government to conduct independent cost studies on firms' bids for realism. However, because cost estimators also have limited information, this is not a perfect solution. Another solution, especially if the government lacks even enough information for independent studies, would be to ensure a credible threat of retaliation in the contract to incentivize firms to provide accurate bids. For instance, the government could maintain an industrial base with multiple firms, cancel the contract if costs went beyond a certain threshold, and then rebid the effort. This is one possible explanation for why DoD supports two independent shipyards to construct DDG-51 Arleigh Burke-class destroyers, awards contracts to small businesses, and prefers commercial off-the-shelf hardware to customized military versions.

Conclusions

The government should purchase a TDP if the price of the TDP is less than the savings resulting from a lower production price. It should tend not to purchase a TDP while blindly assuming it will minimize costs through competition. One can think of a TDP as a barrier to entry. A TDP has the most dramatic effect for the case in which it is very costly to replicate its information through an R&D effort, but a rival firm has significantly lower production costs. In this instance, making the TDP available to the rival firm serves to move production to lower cost producers. A TDP may be relevant in other cases as well. If a rival firm can undercut the incumbent even with its own R&D effort, providing that rival firm with a TDP may save the government funds if the rival firm is willing to pass on a sufficient portion of its savings by accepting a TDP from the government. While not necessarily cost-minimizing from the government's perspective, a TDP could benefit the government in cases where funding is readily available now, but less certain in the future. Finally, recognizing that firms may use a TDP as a barrier to limit competition, the government could have a third party, not involved in the production process, conduct R&D.

The government should purchase a TDP if the price of the TDP is less than the savings resulting from a lower production price.

The key takeaway from the model presented in this article is that a profit-maximizing firm will price a TDP based on its production costs compared to its rivals, the cost to produce the content of a TDP through an independent R&D effort, and the number of systems procured subject to the considerations covered under the section Additional Complexities. The government should recognize that the price it pays for a TDP depends on these economic variables: a TDP's price is not simply the cost to produce the TDP.

References

Arena, M. V., Blickstein, I., Younossi, O., & Grammich, C. A. (2006). *Why has the cost of navy ships risen? A macroscopic examination of the trends in U.S. naval ship costs over the past several decades.* Santa Monica, CA: RAND.

Buchanan, J. M., & Tullock, G. (1962). *The calculus of consent: Logical foundations of constitutional democracy.* Retrieved from http://files.libertyfund.org/files/1063/Buchanan_0102-03_EBk_v6.0.pdf

Coyne, C. J., & Duncan, T. K. (2013). The overlooked costs of the permanent war economy: A market process approach. *The Review of Austrian Economics*, *26*(4), 413–431.

Defense Logistics Agency. (n.d.). *Replenishment parts purchase or borrow program (RPPOB)*. Retrieved from http://www.aviation.dla.mil/UserWeb/AviationEngineering/Engineering/valueengineering/RPPOB.asp

Department of Defense. (2006). *US Army reverse engineering handbook (guidelines and procedures)* (MIL-HDBK-115A[Army]). Retrieved from http://www.wbdg.org/ccb/ARMYCOE/COEMILHDBK/hdbk115a.pdf

Department of Defense. (2014a). *Guidelines for creating and maintaining a competitive environment for supplies and services in the Department of Defense.* Retrieved from http://bbp.dau.mil

Department of Defense. (2014b). *Rights in technical data–noncommercial items* (DFARS 252.227-7013). Retrieved from http://www.acq.osd.mil/dpap/dars/dfars/html/current/252227.htm#252.227-7013

Department of Defense. (2014c). *Technical data–commercial items* (DFARS 252.227-7015). Retrieved from http://www.acq.osd.mil/dpap/dars/dfars/html/current/252227.htm#252.227-7015

Driessnack, J., & King, D. (2007). Analysis of competition in the defense industrial base: An F/A-22 case study. *Contemporary Economic Policy, 25*(1), 57–66.

Gansler, J. S., Lucyshyn, W., & Arendt, M. (2009). *Competition in defense acquisitions.* College Park: University of Maryland, Center for Public Policy and Private Enterprise.

Government Accountability Office. (2010). *Federal contracting: Opportunities exist to increase competition and assess reasons when only one offer is received* (Report No. GAO-10-833). Washington, DC: Author.

Government Accountability Office. (2013). *Defense contracting: Actions needed to increase competition* (Report No. GAO-13-325). Washington, DC: Author.

Hayek, F. A. (1945). The use of knowledge in society. *American Economic Review*, *35*(4), 519–530.

Kendall, F. (2015). *Better buying power 3.0: Achieving dominant capabilities through technical excellence and innovation.* Retrieved from http://www.acq.osd.mil/fo/docs/betterBuyingPower3.0(9Apr15).pdf

Kovacic, W. E., & Smallwood, D. E. (1994). Competition policy, rivalries, and defense industry consolidation. *Journal of Economic Perspectives, 8*(4), 91–110.

Leyes, R. A., & Fleming, W. A. (1999). *The history of North American small gas turbine aircraft engines*. Reston, VA: The Smithsonian Institution.

Lyon, T. P. (2006). Does dual sourcing lower procurement costs? *The Journal of Industrial Economics, 54*(2), 223–252.

Niskanen, W. A. (1975). Bureaucrats and politicians. *Journal of Law and Economics*, *18*(3), 617–643.

Strata, G. (n. d.). *Engineering and design: Industrial engineering.* Retrieved from http://www.stratag-inc.com/ind_eng.html

Thompson, L. (2011). *How Boeing won the tanker war.* Retrieved from http://www.forbes.com/sites/beltway/2011/02/28/how-boeing-won-the-tanker-war/

Tullock, G. (1967). The welfare costs of tariffs, monopolies, and theft. *Western Economic Journal, 5*(3), 224–232.

Younossi, O., Stem, D. E., Lorell, M. A., & Lussier, F. M. (2005). *Lessons learned from the F/A-22 and F/A-18E/F development programs.* Santa Monica, CA: RAND.

Biography

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