Pricing Intellectual Property in Defense Competitions
Toward Theoretical and Practical Advice for
Government Officials and Government Contractors

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SUMMARY

The ownership of the intellectual property (IP) underlying the design of complex weapon systems has been an issue—between governments and their contractors—for over a century. In the United States, federal policy has directed several cycles of attention, both positive and negative, on the relative need to acquire these IP rights. The most recent cycle of attention began under the Obama Administration in 2010, and has continued with nuanced guidance under the Trump Administration. One of the more notable changes in this policy is the recommendation to acquire only what IP is needed, and at a fair price.

Fair is a challenging word to define economically, but mutually beneficial is more tractable. To find the negotiating space over IP rights to complex weapon systems, I devise a model of a defense procurement competition with one buyer and two potential sellers, in which the weapon and its IP are priced separately. I find that the room for a deal depends strongly on the difference between the government and the respective contractors’ avowed discount rates. Deals may generally be possible because a government’s rate is arguably much lower than that of any business.

NEXT STEPS

To test this model, and its potential to systematize the exchange of IP rights between contractor and government, I propose specifying a hierarchical linear model of US military truck procurement since the end of the Cold War, grouping programs by whether IP rights were purchased or not, and incorporating the observed discount rates of government and the truck-building industry. Statistical differences in the trajectories of prices for vehicles and possibly spares should indicate the ex ante value of having traded the IP rights.

BACKGROUND

In September 2010, Under Secretary of Defense Ashton Carter issued the first version of the Obama Administration’s Better Buying Power (BBP) memorandum, as a “quiet rallying cry for better performance in the business of defense.”

One of BBP 1.0’s twenty-three initiatives instructed that

At Milestone B . . . a business case analysis be conducted in concert with the engineering trades analysis that would outline an approach for using open systems architectures and acquiring technical data rights (TDRs) to ensure sustained consideration of competition in the acquisition of weapon systems.

The initial implementation of the memorandum attracted criticism for attempts at uniform implementation, with procurement bureaucrats presuming that the Secretary had just directed them to buy whatever IP they could, whenever possible. Revised guidance from Carter’s successor, Under Secretary Frank Kendall, discouraged this over-enthusiasm, but some goodwill was lost with industry. The Obama Administration would depart office six years later; the Trump Administration would quietly drop talk of BBP, but not of the importance of those TDRs, an element of the IP underpinning those systems.


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Thus, in December 2018, Army Assistant Secretary Bruce Jette would issue a memorandum entirely on the question of IP in Army procurements. His policy discoursed a one-size-fits-all attitude and requires that we consider the unique needs of each weapon system and its components as we develop the IP strategy.

Similarly, in October 2019, Under Secretary of Defense for Acquisition Ellen Lord issued her memorandum on the same question, but for the entire Defense Department. Therein, she directed her immediate subordinate, the Assistant Secretary for Acquisition Kevin Fahey, to improve the quality and consistency of financial analysis and valuation for determining fair and reasonable prices and appropriate needs for IP and IP rights in order to develop program budgets and evaluate proposals.

So would continue another round of a century-long effort to grapple with the question of just who owns, and should own, the rights to the designs of the weapons that contractors build and the military buys. In waves of policy changes over that time, officials have addressed the importance of IP with occasional efforts to buy that IP whenever possible, or only when necessary. However, neither Jette nor Lord provided in their policies the same critical element that Carter omitted as well: none provided any insight into just what government actually should pay for IP, or at what price industry might sell.

In an earlier work, I developed a simple model describing whether government officials should buy or not buy the IP underpinning the designs to complex systems, especially armaments, in public procurement auctions. This model described a two-round auction with fixed margins by contractors, varying costs, invariant quality, and a hard budget constraint. Prospective contractors were thus competing on quantity, offering to build as much as possible for a war effort. In this paper, I develop a model more useful in peacetime, with Bayesian-optimal margins, varying costs and quality, soft budget constraints, and invariant quantities set by stated military requirements. I conclude by offering some sample figures to characterize the size of the negotiating space.

MODEL

Consider a market with one buyer and two potential sellers. The buyer is the government (G), which seeks to procure a new complex weapon (e.g., an armored vehicle, warship, aircraft, or space satellite). The government can also be substantially a monopsonist, in that the sellers have limited potential for selling their goods or services to others, at least not without the buyer’s permission. At the same time, the bidders (A, B) are effectively oligopolists. The technical complexity and capital requirements of their industry render entry challenging in the long run, and perhaps prohibitively so in the short run.

The government proposes a procurement auction with one or two stages, soliciting suitably complex bids through a request for proposals (RFP). Quantities are fixed by the military’s beliefs about its requirements, so bidders compete and set prices based on the cost, quality, and their perceptions of the customer’s willingness to pay. The RFP demands that each bidder open its books, subject to audit, so that the government can observe the difference between cost and margin (the requested profits $\pi_A, \pi_B$) in each bidder’s proposed price. The government then assigns to each bid an effective cost ($C_A, C_B$) which incorporates the long-term differences in quality, including maintainability, disposability, and other factors not fully captured by the price.

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5. For the origins of the issue, see Katherine C. Epstein, Torpedo: Inventing the Military-Industrial Complex in the United States and Great Britain, Harvard University Press, 2014.
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Each bidder responds. While the government clearly holds the balance of negotiating and legal power in the relationship, the competition is but one round in a multi-stage game of particularly long duration. The government also depends on the industry’s products for its security, or at least its perceptions thereof. While exit would be difficult for the sellers, firms have departed the arms industries at some pace for decades. Because the government has a strong aversion to dealing with the problems of double monopoly, it thus has a sustained incentive to offer consolation prizes to unsuccessful bidders. With that in mind, the bidders propose margins above their long-term average costs.

The government expects to have sustained, long-term demand for the weapon, which may actually exceed the cost-effective lifespan of any individual unit produced. This will necessarily require a second round of production. This could also entail a second formal procurement, which could be awarded on a sole-source basis, without extensive engineering changes to the system, so as to maintain a relatively common fleet as early units wear out faster than latter ones. However, the government imagines that the winner of the first round need not be the winner of the second, and contemplates holding a future re-competition. For two reasons, this may have value. To begin, technological advancements could warrant a modest reconsideration of the design, in which selected injections of new subsystems into an otherwise commonly adopted product may be economical.8

But further, procurement of a complex product from a single source can transform a bidder into an effective monopolist, with many of the challenges of managing a double-monopoly relationship.9 We should not expect that B would provide A’s product at a lower effective price than A, even with a full set of blueprints, as the incumbent has little incentive to make available any of the tacit know-how needed to cost-effectively build its system (see below). However, such build-to-print awards have been made to challengers. One of the better known examples in recent history was that of the 2009 re-competition of the Family of Medium Tactical Vehicles (FMTV) truck contract. The Army solicited build-to-print bids, and three firms responded credibly: incumbent BAE Systems, Navistar, and the ultimately successful firm Oshkosh, which underbid the incumbent by nine percent. As BAE Systems’ truck-building division was effectively a one-product business, Oshkosh’s win induced exit.10

Thus, the stakes may be high for business, and the value significant for the government. To model this problem conveniently, we posit that, after considering the effective overall prices (C_A + π_A, C_B + π_B), the government awards the business to bidder A in the opening round. If we suppose that government will later require a second procurement, of equal quantity, then the full cost of both, awarded non-competitively, would be

\[ C_A + \pi_A + \sum G (\lambda C_A + \pi_A) \]

At this point, some explanation of notation is in order. C_A is the effective cost to A of producing its own product. π_A is the profit that A requests and is awarded, in competition with B, in the first round. π_B is the profit that A negotiates with the government, in only the shadow of future competition, in the sole-source second round. \( \sum G \) is the government’s inter-temporal discount rate between the first and second procurements. \( \lambda \) is the learning effect that A experiences between rounds, reducing it effective cost of producing its own system.

If the government can secure the design of the weapon and the rights thereto from A, then a competitive second round is a possibility. In the parlance of the US Defense Department, this is buying the technical data package (TDP, effectively a robust set of blueprints) and the technical data rights (TDRs), respectively. This technical delineation of the difference may be more useful than the broader term intellectual property, in that it clearly covers only codified knowledge, excluding the tacit know-how that remains important, even critical, to manufacturing and servicing a complex product. In this case, the cost to the government, excluding the cost of the TDP and TDRs, would be

\[ \min \{ C_A + \pi_A + \sum G (\lambda C_A + \pi_A), C_B + \pi_B \} \]

Here, \( C_B \) is the effective cost of B's

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building A’s system, and \( \pi_{B2,C} \) is the margin that B will seek in a competitive second round. Thus, the first half of the expression describes the cost of awards in the first and second rounds to A, so that the margins awarded in both rounds are now a competitive matter. The second half of the expression describes the cost of an award to A in the first round, but an award to B in the second. In this case, there is no learning effect to B’s building A’s system, but there is at least a competitively-awarded margin.

So what should the government pay for the option of holding that second round? And for how much should a contractor sell, if the firm is so inclined? In our model, we exclude from consideration strategic effects, such as the military benefit of holding more fulsome knowledge of one’s own weapons. For simplicity, we further exclude the possibility that A could be driven to greater factor efficiency (lower \( \lambda \)) in the production of its system in the follow-on procurement. We consider the problem from the vantage point of an incumbent A, which as noted above, is eventually awarded the business in the second round as well. In that case, the decrease in effective price should be no less than the time-discounted difference between the negotiated and competitive prices expected of a second round. If B simply serves as a stalking horse for A’s preferred bid, this difference will be the net financial benefit of procuring the TDP and TDRs: the development of a credible threat for an honestly competitive procurement. With some simple algebra, we can find that figure to be

\[
Y_G (\pi_{A2,N} - \pi_{A2,C})
\]

This presumes, of course, that the negotiated margin will be no less than the competitive margin. Even if competitive procurements are not always preferred, and for sound economic reasons, the narrow judgment about margins seems reasonable. We should note, however, that this is nearly a zero-sum outcome for the government and A. After all, A is unlikely to part with that difference in margins for anything less than the difference in margins.

If there is a difference, it is found in differing discount rates and impressions of the likelihood of success in the second round. The government, with its very long time horizons for decision-making, and nearly risk-free cost of borrowing, almost certainly has a lower discount rate than either bidder (\( Y_G < Y_A \)). At the same time, the government, firm A, and firm B all have imperfect knowledge of the firms’ future capabilities, motivations, and bidding strategies. We will assume for simplicity that the government’s motivations, source selection criteria, and bureaucratic behaviors do not change. In this case, we say that A can expect to be awarded the business in the second round with probability

\[
P_{\text{win}A2} = P[\lambda C_{BA} + \pi_{A2,C} \leq C_{BA} - \pi_{B2,C}]
\]

Here, we assume that in the event of a tie in effective prices, the business will remain with the incumbent. We can further state that A’s expected, time-discounted payoff in a second round, from the vantage point of the first round, is

\[
P_{\text{win}A2} Y_A (\pi_{A2,C})
\]

The difference in outcomes between a negotiated and a competitive second round is thus

\[
Y_A (\pi_{A2,N} - P_{\text{win}A2} \pi_{A2,C})
\]

The value to A of avoiding the transfer of TDP and TDRs is this expected pay-off. In this case, the government and A could transact for the TDP and TDRs at a price not to exceed the product of the difference in valuations of time and the expected difference in negotiated and competitive margins:

\[
( Y_A - Y_G ) (\pi_{A2,N} - P_{\text{win}A2} \pi_{A2,C})
\]

This presumes, of course, that the government and A have identical views of those expected margins. On the other hand, if B could actually win the second round, by offering a lower effective price (such that \( C_{BA} + \pi_{B2,C} < \lambda C_{BA} + \pi_{A2,C} \)), then the value of the acquiring the TDP and TDRs, assuming that the business will necessarily be awarded to B, would be no less than

\[
Y_G (\lambda C_{BA} - C_{BA} + \pi_{A2,N} - \pi_{B2,C})
\]

This expression is the sum of the aforementioned time-discounted difference between the expected negotiated and competitive prices in the second round, and the time-discounted difference between the attainable effective costs as well. This situation obtains with the probability of a contract award to B, which is the inverse of the probability of a contract award to A:

\[
P_{\text{win}B2} = P[\lambda C_{BA} + \pi_{A2,C} > C_{BA} - \pi_{B2,C}]
\]

Here, we assume that in the event of a tie in effective prices, the business will remain with the incumbent. We can further state that A’s expected, time-discounted payoff in a second round, from the vantage point of the first round, is

\[
P_{\text{win}B2} Y_A (\pi_{A2,C})
\]

By bringing B into a second round of bidding, the government thus expects the time-discounted better value

\[
(1 - P_{\text{win}A2}) Y_G (\lambda C_{BA} - C_{BA} + \pi_{A2,N} - \pi_{B2,C})
\]

assuming that this value is positive, which obtains with probability \( 1 - P_{\text{win}A2} \). This figure is thus the government’s factored, time-discounted reservation price for obtaining the TDP and TDRs. Even if the government and A have identical beliefs about A’s chances in the second round, they may then transact over the TDP and the TDRs if
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\[(1 - P_{\text{win}A2}) Y_G (\lambda C_{AA} - C_{BA} + \pi_{ALN} - \pi_{RLC}) > Y_A (\pi_{ALN} - P_{\text{win}A2} \pi_{RLC})\]

In plain language, there is a deal to be made, even if A knows that it may lose the future business, if the government has a remarkably lower discount rate, or expects a factored effective price difference that substantially outweighs what A could obtain in a competitive margin. Firm A could be a better design agent than producer, but with less-than-patient investors, and may realize this. At that point, with these parameters in mind, the government and the firm may have a negotiation in which to engage.

INTERIM OBSERVATIONS

Thus the theory, but what of practical application? Many of these figures are readily estimated. In the United States, not all federal agencies have official views about discount rates (the Treasury Department is a clear exception). In that case, at worst, \(Y_G = 1\). Almost all large defense contractors have official views of their own discount rates, drawn up by their finance departments (whether they are well-founded is another question). Both government and the firm have an expectation of how much time will transpire between procurement rounds. Learning curves are neither easily estimated \textit{ex ante} nor stable \textit{ex post}, but estimating them over time is a common exercise for manufacturers. Firm A can estimate its own costs (\(C_{AA}\)) with some accuracy; if it lacks its own competitive estimating group, it can hire business consultants to estimate others (\(C_{BA}\)). The Defense Department maintains staffs of cost estimators for considering the future efforts of multiple possible contractors.

This leaves two remaining undressed factors in the inequality above: the probability of A’s winning the business (\(P_{\text{win}A2}\)) and the requested margins (\(\pi_{ALN}, \pi_{RLC}\)) on which they will depend. The final formula above has a serious problem with endogeneity, but this is easily resolved with Monte Carlo simulation. Of course, firm A presumably has a view on its own profit policy, and may choose to set it based on an explicit objective function. If the management of A are acting purely in the interests of highly diversified shareholders, they will seek to maximize the expected time-discounted payoff. If they care about their own employment, or that of their people, they may seek to maximize \(P_{\text{win}A2}\) subject to an acceptable \(\pi_{RLC}\). Firm A may then examine its options under a reverse Bayesian-optimal pricing, treating \(\pi_{ALN}\) and \(\pi_{RLC}\) as random variables.

To illustrate the range of possible outcome, we can outline a plausible scenario, and then describe the negotiating space available to the government and firm A. Consider a procurement competition for 100 units of a complex weapon, in which A’s cost of production is $100 million each (\(C_{AA} = $10 billion\)). Over the course of a second round, Firm A could produce its units for $85 million each (\(C_{AA} = $8 billion\)). Firm B is a production specialist, and can respond in a future round with unit costs of $80 million each (\(C_{BA} = $8 billion\)). The second round will be held five years in the future; over that time, the government has effectively no discount factor (\(Y_G = 1\)), but Firm A as 10 percent per annum (\(Y_G = 0.59\)). Firm A believes that it could negotiate a 10 percent margin in a second round, but anticipates that it would only bid 6 percent in a competitive situation. Firm A also has scant knowledge of B’s ability to cost-effectively produce A’s product.

This result, however, is highly sensitive to the difference the government and Firm A’s views of their respective discount rates (\(Y_G, Y_A\)), and secondarily to the government’s estimate (\(C_{BA}\)) of B’s ability to cost-effectively produce A’s product. Estimating the importance of these differences is the job of the government and the contractor’s business analysts. The point of the preceding discussion of the algebra and the underlying economics is to provide a quantified starting point for those discussions.

CASES FOR FURTHER STUDY

Of course, we should hope to do far better than a plausible illustration, by finding actual figures of funds expended when
TDRs were owned and not. As suggested above, with the case of the FMTV, military trucks may provide an excellent example of the dynamics between business and government, and between procuring and not procuring intellectual property in procurement auctions. This example is particularly useful for three reasons. First, the issue is important both to government policy and business strategy. The US Army and the US Marine Corps will continue to buy trucks, and those trucks will likely continue to be based substantially on technologies developed for commercial truck offerings. Second, we have a relatively rich set of cases to study, with the US Army and Marine Corps buying vehicles through at least a dozen programs since the end of the Cold War through the present. Third, those cases include differing treatments of the procurement question by the government: whether to buy TDRs or not when purchasing vehicles initially.\textsuperscript{11}

The time interval is important for two further reasons. To begin, since the First World War, military trucks have been substantially based on designs of heavy-duty commercial trucks.\textsuperscript{12} However, in the early 2000s, with the onset of the ground wars in Afghanistan and Iraq, designs began to diverge in electronic content and survivability needs. This means that truck manufacturing was certainly not a monopsony before the recent counter-insurgent campaigns. North American truck production is also globally competitive—in contrast, say, to North American shipbuilding. However, even though military truck manufacturing has become more specific to the relationship between government and (defense) contractor, the firms retain alternatives. Most of the technologies and engineering capabilities and practically all of the production capacities can also be used to produce commercial trucks. Second, after the end of the Cold War, the decrease in American military spending led the Army and Navy Departments to economize in the short run, less often purchasing TDRs. This contributed to the difference in treatments by governmental buyers.

The challenge lies in data collection and cleansing. In my next round of work, to test the value of procuring intellectual property in government procurement auctions, I will construct a hierarchical linear model of US military truck procurement from 1990 through 2019. I will group programs into those in which the government largely purchased the TDRs to the underlying designs of the vehicles its officials chose, and those in which it did not. I will then test for statistical differences in the trajectories of procurement costs in the ensuing years, to ascertain whether prices changes were materially different under the two treatments. Ideally, I would collect data on parts pricing as well, but these figures could be less available, less complete, and quite difficult to associate with particular truck programs.

\textsuperscript{11} These are some of the criteria cited as reasons for case selection in Steven Van Evera, Guide to Methods for Students of Political Science, Cornell University Press, 1997, 88.

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