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Evaluating Consolidation and the Threat of Monopolies Within Industrial Sectors

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Abstract

Economics scholars and policy-makers in recent years have rung alarm bells about the increasing threat of consolidation and concentration within industrial sectors. This paper examines the importance of industrial consolidation in two ways: first, as a direct relationship between concentration and performance outcomes; and second, as an indirect relationship, where concentration influences performance through reduced competition for government contract business. The paper finds that both increasing consolidation and decreasing competition are associated with an increase in contract cost ceiling breaches but also lower rates of termination. Subsequent stages of research will examine the interrelation of consolidation and competition.

Introduction

Project Motivation—Monopoly, Consolidation, and Implications for Performance

In recent years, economists, policy-makers, and other observers have expressed growing concerns over industrial concentration and the threat of monopolies in the U.S. economy.[1] Data on revenue concentration, for example, show that the largest firms in a number of U.S. industries are accruing an increasing percentage of their respective industry's market share. The 50-firm concentration ratio (CR_{50})—which measures the proportion of an industry's revenue accruing to its 50 largest firms—has grown by 10% or

[1] For a recent summary and synthesis of current views regarding industrial consolidation, monopoly, and their implications for policy, see Shapiro (n.d.).

more over the last 15 years (1997–2012, based on the latest available information) in industries ranging from transportation and warehousing to retail trade to finance and insurance (White House Council of Economic Advisers, 2016). For example, in the case of finance and insurance, the latest available data (as of 2012) shows the 50 largest firms account for nearly half (48.5%) of all revenue in the industry. This figure is even higher elsewhere. In utilities, for instance, the CR_{50} stands at 69.1% (White House Council of Economic Advisers, 2016).

These trends may reflect an actual decline in competition, but it is important to note they could also stem from superior economic performance among firms that may have driven their competitors out of the market. Moreover, production in many industries (like utilities) is subject to at least some degree of economies of scale—where per unit costs fall as production increases, and an industry's total output can be produced more efficiently by fewer, rather than more, firms—making those industries more concentrated to begin with. Finally, while the data reflect what is happening nationally, the actual effects of concentration tend to play out on a lower geographical scale (such that the issue is not strictly one of growing concentration nation-wide but one that affects regional and local markets in particular). Acknowledging these caveats (and their implications for whether increasing concentration warrants one or another type of public policy response), the increasingly concentrated nature of many industries in the U.S. remains a noteworthy economic development.

Concerns over industrial concentration and potential monopolies also extend to the U.S. defense industry. Maintaining a vibrant, dynamic defense industrial base with vendors that compete vigorously to win contracts and provide the government with products and services is critical to U.S. national security. Indeed, while historically the government has relied on mobilizing a mix of federally-funded arsenals and civilian contractors during wartime to meet its military needs, following WWII, these needs have been met principally by a permanent private defense establishment.

This research project seeks to evaluate the urgency of these concerns by examining the connection between industrial consolidation and contract outcomes. It examines the relationship in two ways: first, directly—through the influence of consolidation in the contract's sector on performance, and second—indirectly, through the effects of competition on contract performance. Future stages of this paper will combine both of these examinations into a single model.

Literature Review

As the primary buyer of the defense industry's goods and services, the U.S. government can play a significant role in shaping the industry's size, composition, and economic viability. As a result, the defense industrial organization has evolved (at least in part) in accordance with military spending. Since WWII, the defense budget has cycled between a series of peaks and troughs, generating significant expansions in industrial capacity followed by more modest declines. This pattern resulted in a particularly acute case of capacity overhang following the end of the Cold War, because during the war, contractors had invested heavily in plants, equipment, and other assets that were no longer needed following the war's end (and the subsequent drop in defense expenditures). To eliminate inefficiencies stemming from excess capacity, the Department of Defense (DoD) explicitly encouraged its contractors to merge, and offered to share in savings generated from consolidations. Merger activity in the defense industry increased dramatically. Between 1993 and 2000, the number of major prime contractors fell from 50 to six (Gansler, 2011). However, it is still an open question whether and to what extent these mergers actually

generated savings—or even stemmed as much from the DoD's pro-consolidation policy and post–Cold War budget cuts as they did from economy-wide trends that also drove mergers in non-defense industries.[2]

Defense budgets reversed following 9/11, and grew at rapid double-digit rates for nearly a decade. However, spending reductions mandated by the Budget Control Act (BCA) of 2011 and the cuts to Overseas Contingency Operations (OCO) funding around that time—policies collectively referred to as "the drawdown"—have significantly impacted the defense industry. Across individual product and service platforms, a recent analysis showed declines in defense contract obligations from 16% for Ships and Submarines to as high as 56% for Land Vehicles (McCormick, Hunter, & Sanders, 2017). Declines in other portfolios varied, according to the analysis, from 19% for Aircraft, to 20% for Ordinance and Missiles, to 32% for Space Systems (McCormick et al., 2017). Obligations for products, services, and R&D activities not falling under one of these specific platform categories fell by 30%, 28%, and 19% respectively (McCormick et al., 2017). Within product, service, and R&D categories, the analysis showed shares of obligations going to small businesses tended to grow or remain steady, but tended to fall for the Big 5 (Lockheed Martin, Boeing, Raytheon, Northrop Grumman, and General Dynamics) and especially for large- and medium-size vendors (McCormick et al., 2017). Across categories and vendor sizes, the analysis found that the number of vendors receiving prime contracts from the Department of Defense (DoD) dropped in all by 17,000, or nearly 20% over the drawdown period (McCormick et al., 2017).

Whether these vendors fully exited the defense marketplace or remained (e.g., as subcontractors) cannot be definitively established. Nonetheless, existing evidence suggests the U.S. defense industry is in the process of another significant episode of transformation, and officials from both the previous and current administrations have signaled worries over the industry's health and competitiveness. As far back as 2011, Ash Carter, then Under Secretary of Defense for Acquisition, Technology, and Logistics (USD[AT&L]) and later Secretary of Defense, stressed the importance of avoiding excessive consolidation among large prime contractors (Weisberger, 2015). His successor as USD(AT&L), Frank Kendall, took the same view, calling Lockheed Martin's proposed and subsequently executed acquisition of rotary-wing aircraft manufacturer Sikorsky "the most significant change to the defense industry since the general consolidation that followed the Cold War" (Weisberger, 2015). Kendall warned more generally that continued consolidation, particularly of large prime contractors, could diminish competition and the number of suppliers available to the military, erect barriers to entry, and hinder innovation that is key to sustaining U.S. technological superiority (Weisberger, 2015). Around the same time, the U.S. Department of Justice (DoJ) and the Federal Trade Commission (FTC) issued a joint statement saying "many sectors of the defense industry are already highly concentrated [and others] appear to be on a similar trajectory" and reiterated their commitment to take action against mergers that would dampen innovation and competitive forces (DoJ & FTC, n.d.). More recently, under Executive Order 13806 (2017), President Trump directed a sweeping review of the industrial base with the aim of determining if its broad composition, capacity, and resiliency can meet a growing set of security threats through having a robust base of capable

[2] For a review of competing explanations of post–Cold War U.S. defense industry consolidation, see Brady (2009).

suppliers. Questions of industrial concentration and monopoly power, as well as their implications for competition and performance, relate importantly to these issues.

Industrial Concentration—Definition and Measurement

Industrial concentration refers to the degree to which a smaller versus a larger number of firms account for production or other measures of market share (e.g., revenue) in some part of the economy.

Taking this idea as a point of departure, a large discourse in the literature has developed around alternative approaches to measuring concentration in practice.[3] One approach is to use concentration ratios, which add shares (whether of production, revenue, or some other activity) of a pre-determined number of firms in a particular market. Commonly used numbers include the top 4, 8, 20, or 50 firms in the market of interest. These ratios are relatively simple to calculate and, compared to other metrics—such as the Herfindahl–Hirschman Index (HHI)—do not impose as large a challenge with data collection because they do not require data on the shares of every firm in the relevant market place. By contrast, to calculate the standard HHI requires data on the shares of every firm in the relevant market place and entails squaring each individual share before adding them (so as to weight the index more strongly toward larger companies). The upsides of this approach include counting shares of every applicable firm and weighting firms with larger shares more heavily in the calculation. Whereas concentration ratios are expressed in percentage terms (with a 100% maximum), the HHI varies between a minimum of 0 and a maximum of 10,000 (where one firm accounts for 100% of the market and $100^2 = 10{,}000$). For purposes of evaluating mergers and their antitrust implications, the DoJ deems HH indices of 2,500 or higher to be significantly concentrated.[4]

As noted, both concentration ratios and the HHI continue to be used in practice, with the choice of one versus the other depending principally upon data availability and the objectives of the analysis. Common challenges that must be addressed in using either measure include identifying and collecting reliable data on market shares and, more fundamentally, defining the scope of the marketplace in which concentration will be analyzed. As noted above, concentration metrics are often calculated and presented on nation-wide basis, whereas evaluating the implications of concentration for competition, consumer welfare, and public policy often requires examining trends at a less aggregated level. Moreover, concentration measures can be sensitive to the specificity with which products are defined and categorized. With all else equal, defining a particular class of product more broadly—and thereby including more firms—will tend to reduce concentration levels, whereas a more precise definition will raise them.

Causes of Industrial Concentration and Monopolies

Variation in levels of industrial concentration—from very low to monopoly levels where one firm accounts for all of an industry's production, revenue, sales, or other economic activity—stems from several sources. Differences across industries or within a given industry over time may reflect an underlying decline in competition and attendant increases in market power for leading firms—a common interpretation of recent trends in the

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[3] See Curry and George (1983) for a commonly-cited review of the literature.
[4] See DoJ (2015).

U.S.[5]—although one of at least four other forces may also be at play (and, depending on which, may suggest alternate explanations for changes in concentration levels).

First, higher industrial concentration may stem from *economies of scale,* a technological feature of production that leads per unit production costs to fall as output rises. The upshot of this dynamic is that an industry's aggregate output can be most efficiently produced by a smaller, rather than a larger, number of firms (Carleton & Perloff, 2015). Accordingly, in a case like this, the industry actually operates most efficiently and can charge lower prices for its output with less as opposed to more firms in operation. The number of firms may fall due to some firms exiting the marketplace, or through mergers and acquisitions. In extreme cases, economies of scale are so high as to make it most efficient for a single firm to produce all of an industry's output, a situation referred to as a *natural monopoly*. Unlike (as discussed below) situations where monopoly power derives from purposefully erected barriers to entry (e.g., government conferring operating privileges exclusively to a single company), natural monopolies arise due to the underlying technology for production of a good or service.[6] Commonly-cited natural monopolies include utilities, where entry of additional firms would entail highly inefficient (and arguably infeasible) recreation of distribution infrastructure like pipes or power lines that one firm has already incurred the costs to build (Kunneke, 1999).

Second, and similarly, production may be subject to *learning curves*, where (however high or low scale economies may be) per unit costs fall as firms discover more efficient ways to produce output. According to learning curve theory, through repeated production, firms accumulate knowledge and experience that can be used for purposes of process improvement, efficiency enhancements, and lower per-unit pricing, which may make them more competitive relative to their peers and lead them to capture higher market share (Brady & Greenfield, 2009). Manufacture of large capital assets like ships, planes, or construction equipment, which may initially entail high costs for design and early unit production but entail lower costs as production expands, are often suggested to benefit from the learning curve dynamic.

Third, firms may create barriers to entry or force competitors out through strategic behavior like predatory pricing, hostile takeovers, or alternative forms of vertical acquisition where an incumbent firm acquires lower-level suppliers (thus eliminating potential sources of productive inputs that new entrants need in order to operate). Incumbent firms may act alone to create entry barriers, or they might potentially collude with one another for this purpose. A commonly cited example of collusion to prevent competition involves incumbent firms dividing up customers in lieu of vying with each other to capture as much business as possible. The firms may divide up sales territories, for example, and work together to prevent competitors from entering. Such conduct has been suspected or documented to have happened in industries as diverse as health insurance and chemicals.[7]

Finally, in some instances governments purposefully erect structural barriers to entry that may limit competition that is otherwise likely to arise (e.g., in cases where scale economies do not operate at high levels and concentrate production in a few firms).

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[5] See Shapiro (n.d.).
[6] For an early overview of natural monopoly, see Posner (1969).
[7] For further explanation and specific examples, see FTC (n.d.).

Governments may create entry barriers through extending protections for intellectual property and innovation (e.g., through patents), through establishing legal and regulatory requirements that must be fulfilled in order to do business in a particular area, or by granting only one or a few firms permission to do a form of business (thereby foreclosing competitors from entering the market). Sufficiently high entry barriers can create monopolies in cases where the underlying technology of production implies strong efficiency gains from having one or only a few producers. Taxis are an often-cited example of a monopoly that city governments have created through regulations, such as requiring the purchase of a medallion to drive a cab.

The monopsony of the market can also be a barrier. The defense industry sells its products principally to a single buyer: the U.S. government (from which decisions about policy, budgets, and procurement priorities can significantly impact defense industry structure). In addition, concentration in different sectors of the defense industry may stem at least partially from underlying scale economies, learning curve dynamics, and government-imposed regulations, which are often cited as a barrier to further entry by commercial firms. Scale economies and learning curves are fundamental to the production of large, complex assets such as fighter jets and ships, leading to high concentration in these sectors (U.S. aircraft carriers, for example, are built exclusively in one shipyard, operated by Newport News Shipbuilding). And, in both of these sectors (and all others from which government purchases products, services, and R&D support) rules and regulations that firms must adhere to for purposes of bidding on contracts and winning business may constitute a substantial barrier to further competition—particularly for nontraditional firms that could be significant sources of innovation. Experiments with alternative acquisition models and partnerships, such as the Defense Innovation Unit Experimental (DIU_x)—the DoD's Silicon Valley–based unit focused on identifying and acquiring cutting-edge commercial technology solutions for the U.S. military, are ongoing, but large-scale entry of commercial players into the defense marketplace (and attendant growth in competition) remains to be seen.

Concentration, Competition, and Performance

To the extent it stems from factors such as reductions in competition and barriers to entry (whatever their source), rather than economies of scale, learning effects, or other forces that reflect firms actively searching for ways to enhance efficiency, industrial concentration is concerning because it can reduce economic welfare and generate market power firms that may use to extract rents in the form of higher prices to consumers (Carleton & Perloff, 2015).

Empirically, there is a large and now decades-old body of evidence relating increasing concentration to elevated prices and profits for firms.[8] Whether these relationships reflect firms exercising market power to charge excessively high prices and make additional profits is less clear, however. Some research, for example, attributes the observed link between concentration and profits to efficiency gains stemming from learning and harnessing scale economies. These arguments suggest that efficiency-enhancing concentration generates reductions in both prices and costs, but greater reductions in the latter than the former (leading, on average, to higher observed profitability as price-cost

[8] Literature reviews date back as far as the 1970s, with one review (Weiss, 1974) cataloging the results of 40 preexisting studies.

differentials grow; Peltzman, 1977). This finding is supported by other research demonstrating that, after controlling for firm size, the relationship between concentration and profitability is less strong—suggesting profit growth comes from efficiencies brought about by increasing the scale of production, of which increased concentration is just a byproduct (Brozen, 1982). More recent research comes to the opposite conclusion, finding robust connections between growing concentration, profits from both ongoing business as well as from mergers and acquisitions, and higher stock prices. Rather than reflecting operational efficiency and declining costs, however, this analysis suggests higher profitability is a function of increased market power (Grullon, Larkin, & Michaely, 2017).

Compared to research on relationships between concentration, competition, and firm- performance outcomes like profitability, there has been less research conducted on the implications of concentration for other measures of performance. While, as noted, higher profitability from increasing concentration may reflect stronger operational efficiency, there are other possible sources that do not imply better performance. As a result, this still leaves open the problem of explicitly examining links between concentration and firm performance along nonfinancial dimensions.

Moreover, compared to research on the private sector, very little work has been done to examine the implications of industrial concentration for government, specifically in the context of procurement and contracting. Competition is deemed a fundamental source of value in public procurement and is argued to provide higher quality products at lower prices, along with ancillary benefits such as accountability, fraud prevention, and better stewardship of taxpayer resources (Manuel, 2011). In buying simple goods and services for which many suppliers already exist, the benefits of competition can be powerful. For more complex products—whether inputs into government's provision of public services (e.g., fighter jets for national defense) or public services delivered by nongovernmental actors (e.g., social services provided by a nonprofit organization)—markets may be thinner and competition less viable (Kettl, 1993). However, in these cases too, the focus has been on examining the relationships between the quality of products and services on the one hand and competition on the other. Moreover, this work has often been done in the context of one or a few different product types.

Research that independently (or through competition as a mediating channel) explores the link between program level outcomes and concentration, competition, and contractor performance appears to be mostly absent from the existing literature and would be considerable value-added to the literature. In particular, there's an absence of work that uses large amounts of data to look across numerous product and service categories. Example studies explicitly assessing the link between industrial concentration and performance outcomes in the U.S. defense arena appear to be very few. One example is an analysis finding a positive relationship between concentration and firm profitability in the aerospace industry (Davis, 2006). Another analysis, more closely related to the research presented in this paper, finds evidence that some defense industry mergers generated cost savings in Major Defense Acquisition Programs (MDAPs) but also found that mergers do not categorically generate program-level savings (Hoff, 2007). Unlike the present study, however, this analysis is focused on financial dimensions of performance at the program level. This study extends the literature by looking at both financial and nonfinancial dimensions of performance and considers outcomes at the contract, rather than the program, level.

Conceptual Framework and Hypotheses

This paper posits and tests a conceptual argument linking industrial concentration and contract performance in two ways: first, as a direct relationship between concentration and performance outcomes; and second, as an indirect relationship, where concentration influences performance through reducing competition for government contract business. Specified in this manner, the argument broadens the approach to observing the relationship between concentration and contract performance, accounting for multiple ways the two variables may be connected.

Industrial Concentration and Contract Performance—Direct Relationship

The most straightforward way that industrial concentration impacts different markers of contract performance is through a direct relationship between the two variables. That is, changes in the level of industrial concentration are associated with an observable variation in alternative performance benchmarks, including (as considered in this paper) terminations and breaches of cost ceilings.

While arguments about concentration and contract performance may suggest the two are negatively related, with higher concentration leading to poorer performance, these arguments usually imply the presence of a mediating variable. Competition, as discussed previously, is one such variable. Economies of scale is another, which is often cited when arguing that concentration and performance may instead be positively related. In this case, rather than decreasing competition (and the attendant accumulation of market power a vendor may wield over the government), increasing concentration leads to positive performance, as it reflects efficiency gains from one or more vendors consolidating to operate at a larger scale of production.

Arguments that do not imply or explicitly reference a mediating variable—but instead posit a direct concentration–performance link—are agnostic with respect to whether growing concentration levels foster better or worse performance. For hypothesis testing purposes, the study team therefore does not suggest the direct relationship between concentration and contract performance is positive or negative. Instead, we simply hypothesize that the former may have a direct influence on the latter:

$\underline{H_1}$: Industrial concentration leads to changes in contract performance.

Industrial Concentration and Contract Performance—Mediating Role of Competition

While concentration and contract performance may be directly related, one common argument is that higher concentration negatively impacts performance by hindering competition that would otherwise act to discipline incumbent vendors. With all else equal, greater competition gives the government greater control in their relationship with vendors, providing them with multiple options while forcing vendors to perform well as they are considered more replaceable.

Through reducing the number of vendors from which government can select for awarding a contract, the argument is that concentration effectively reduces competitive forces. In addition, this would reduce the incumbent vendor's incentive to perform effectively, as the prospect of being replaced is now lower. The incumbent may therefore be less motivated to innovate, control costs, or otherwise ensure its product meets or exceeds the government's requirements. Consequently, the risk of termination or a cost ceiling breach may be elevated.

This line of reasoning points to two hypotheses. First, the logic that concentration as influencing performance through a competition channel implies a relationship between concentration and competition per se. Put simply, as concentration increases, competition

decreases. Second, it implies a link between competition and performance outcomes, where reduced competition makes poorer performance more likely. In other words,

> H_2: Increasing (decreasing) industrial concentration leads to decreasing (increasing) competition.
>
> H_3: Decreasing (increasing) competition makes poor contract performance more (less) likely.

Data and Methods

Data Sources and Structure

Data Sources

The study team's primary source of data for this study is the Federal Procurement Data System (FPDS), which tracks all prime federal contract transactions worth $3,500 or more, conducted by most U.S. government department and agencies.[9] CSIS has created its own copy of this database, using data downloaded from USAspending.gov and supplemented at times with the FPDS-NG ad hoc search webtool.[10] During the period of this study, USAspending.gov underwent a major update that CSIS is still incorporating into the study team's analysis.

Data Structure

The unit of analysis for the dataset is prime contracts and task orders. Each contract entry has a unique procurement identifier and each task order entry has a unique combination of a parent award identifier and procurement identifier. The dataset includes all completed DoD contracts and task orders initiated between fiscal years 2007 and 2015 that were completed by the end of fiscal year 2015.[11] For task orders, the dates of inclusion and completion are based on each specific task order, not the date of the larger parent. The data set contains over 8.8 million entries, of which 12.6% were removed due to missing data, primarily with reference to undefinitized contract awards. These removed entries accounted for about 13.5% of obligations in the original dataset. For computational efficiency purposes, the study team has limited the analysis to a random sample of 250,000 to 1,000,000 contracts and task orders from the filtered dataset.

The study team has created the contract dataset from FPDS, which expands and updates a dataset used in previous CSIS reports on fixed-price (Hunter et al., 2015) and crisis contracting (Sanders & Hunter, 2017). To create this dataset, the study team decided how to handle contradictory information within the same field and how to consolidate large numbers of categories in the raw data to the more manageable number used in the regression to mitigate contradictions and to emphasize information available at the time a

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[9] Prominent exceptions include classified contracts, which excludes the entirety of the CIA and some DoD contracts, most prominently in the U.S. Air Force. Other parts of the government are not required to report, such as the Defense Commissary Agency or the U.S. Postal Service.

[10] The study team is exploring additional sources, such as economics statistics broken down by NAICS category report by the U.S. Census and Bureau of Labor Statistics. However, they have not been incorporated into the dataset at this stage of the project.

[11] Completion is measured by having surpassed the current completion date of the contract or task order by at least one year or by contract closeout or a partial or complete contract termination.

contract is awarded. As a general principle, the most weight is given to a contract or task orders' initial unmodified transaction. The primary addition to the datasets used in previous reports relates to the North American Industrial Classification System (NAICS). First, the study team calculated the top 6-digit NAICS codes for each contract in the dataset. Second, the study team added a measure for consolidation, calculated at the NAICS sectoral-level.[12]

In addition to the contract dataset, the measures of consolidation also relied on past and updated work by the study team to consolidate large vendors who may be represented by multiple DUNSnumbers, the primary unique identifier for vendors within FPDS. The study team uses an obligation-weighted approach to choose identifiers for manual classification that have received more than $1 billion in obligations from 2000 to 2017 or $250 million in any year, in constant 2017 dollars. Those identifiers which the study team has not manually classified are instead handled via parent codes provided by the database. One disadvantage to this approach is that merger and acquisition activity is sometimes backdated to years before the merger occurred. However, the value weighted approach applied by the study team is appropriate for the consolidation measures described in the literature review because the largest firms in a sector are disproportionately important to calculating the HHI.

Measures of Dependent and Independent Variables

This section introduces the variables used in our regression model. For consistency and ease of data replication, the shortened name of the variable is included in parentheses after the full name. This shorthand name is also used in the definition of the equation and the results.[13]

Dependent Variables

Partial or Complete Terminations (b_Term) measures whether contracts and task orders experience a partial or complete termination, which yields a value of 1, while contracts with no terminations are given the value 0 for this variable. FPDS does not differentiate between complete and partial terminations, so this can include both a cancelled program and a contract that was completed after being initially protested and reassigned. 1.2% of contracts and task orders have experienced at least one partial or complete termination, and those records account for about 5.6% of obligations in the dataset.

Ceiling Breaches (b_CRai) tracks whether the contract had to be changed in a means that risked significant cost increases. To measure this, the study team observes transactions that are contract change orders and considers a ceiling breach to have occurred (assigning a value of 1) if any of these modifications also increased the contract or task order's cost ceiling, and assigning 0 otherwise. While only 1.2% of contracts and task orders have experienced a ceiling breach, the total obligations of those entries account for

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[12] CSIS has made this dataset publicly available through our github repository (https://github.com/CSISdefense/Vendor/) to other researchers to be used with attribution.

[13] Some of the variables were transformed from categorical variables to the mathematical formats used in the dataset. For example, Term has a value of "Terminated" or "Not Terminated" while b_Term has a value of 0 or 1. Different prefixes are used depending on data type: "b_" refers to binary variables, "n_" refers to numerical variables, "l_" refers to variables that have undergone a logarithmic transformation, and "c_" labels to variables that were center (and thus "cl_" is a centered logarithmically transformed variable).

over 21% of obligations in the dataset. In addition, a slim fraction of terminations overlaps with ceiling breaches, despite both accounting for a similar percentage of contracts and task orders.

Study Independent Variables

Study Variables

Effective Competition (n_EffComp) is a numerical variable with three values:

- 1 for contracts competed with multiple offers (54% of contracts and task orders).
- 0.5 for contracts competed receiving only 1 offer (13% of contracts and task orders).
- 0 for non-competed contracts (33% of contracts and task orders).

The term "effective competition" is used by the DoD when monitoring their own competition rates.[14] The study team draws on multiple variables in FPDS to make this determination, with some contracts and task orders relying on the extent of the competitive field and others relying on the fair opportunity field. The study team considered other variations on the measure for competition, including the possibility of increasing gradations for competition with 2+ offers, before settling on effective competition as the best measure. However, effective competition has limitations, one being that the number of offers for competitive contracts and task orders is not always reported. Effective competition information is missing for 1.8% of contracts and task orders, and less than 0.8% of obligated dollars in the dataset.

Herfindahl-Hirschman Index (c_HHI_lag1) is a measure of consolidation in the defense industrial base. It is broken down into sectors as defined by six-digit NAICS codes. As described in the literature review, the HHI is calculated by squaring the market share of each participant in a sector. For the purposes of this study, market share refers to the percentage of prime obligations within a given fiscal year, which has the notable drawback of not capturing subcontracting activity. In the dataset this measure is lagged by one year, so for a contract signed in 2009, the consolidation measure of industry in 2008 is used. The variable is centered,[15] by subtracting its mean (2,056) and dividing by its standard deviation (1,867). The mean of this variable is roughly in the center of the DoJ's moderately consolidated category, which ranges from an HHI of 1500 to 2500. Data is missing for less than 0.1% of records and obligated dollars.

[14] See, for example, DoD (2015).

[15] Centering a variable is a way of making sure the different variables in a regression model are operating on the same scale, which makes it easier to compare coefficients across different variables. Mathematically to center x means c_x = (x –average of x) / (standard deviation of x).

Other Independent Variables

Initial Contract Scope

Initial Cost Ceiling (cl_Ceil) is the natural log of the initial contract cost ceiling as reported by the base and all options field, in then-year dollars.[16] The variable is centered, by subtracting its mean (9.12) and dividing by its standard deviation (2.26). Values of -1; 0; 1; and 2 correspond to $952; $9,121; $87,359; and $836,709 dollars respectively. Data is missing for less than 0.24% of contracts and transactions, which accounts for just over 0.3% of obligated dollars in the dataset.

Initial Duration (cl_Days) is the natural log of the initial maximum duration of the contract in days. The maximum duration is determined by comparing the contract effective date to the current completion date. The variable is centered, by subtracting its mean (3.05) and dividing by its standard deviation (1.92). Values of -1, 0, 1, and 2 correspond to 3.1 days, 21 days, 143 days, and 974 days respectively. Data is missing for just under 1% of contracts and transactions, which represents a miniscule percent of dataset obligations.

Contract Vehicle

Contracts and task orders come in a variety of types, some of which are simple purchase orders, others are complex but single use contract awards, and yet others are task orders that are a specific instance of an overarching indirect delivery vehicle. These types are explained below and help define the nature of the contractor/customer relationship.[17] The dataset uses dummy variables for four different types of indirect delivery vehicles:

- **SIDC** is 1 if the vehicle is a single-award indefinite delivery contract and 0 otherwise. These contracts may be initially awarded via competition, but afterwards are only used for task orders to a single vendor. They constitute over 58% of all contracts and task orders.
- **MIDC** is 1 if the vehicle is a multiple-award indefinite delivery contract and 0 otherwise. These vehicles have a pool of potential vendors that can receive task orders and make up 3.6% of contracts and task orders.
- **FSSGWAC** is 1 if the vehicle is a Federal Supply Schedule or Government-Wide Acquisition Contract and 0 otherwise. These two consistently multiple-award indirect delivery vehicles constitute 5.3% of task orders and contracts.
- **BPABOA** is 1 if the vehicle is a Blank Purchase Agreement or Basic Ordering Agreement and 0 otherwise. These indirect vehicles can be either single-award or multi-award, but taken together, only constitute 1.8% of task orders and contracts.
- The remaining types, definitive contracts and purchase orders, are intentionally left out.

---

[16] Constant dollars are not to allow for comparability between the contract ceiling and contract's actual expenditures in multiyear contracts. The base and all options ceiling of the contract is in nominal dollars but does not break out the cost ceiling for each individual year of a contract's life. As a result, the ceiling in constant dollars could be approximated, for example, by assuming that the ceiling will be split evenly over the life of a contract but cannot be calculated with any certainty.

[17] For more detail on contract vehicle types, see the glossary at USAspending.gov.

The remaining 31% of contracts and task orders are contract awards and purchase orders with no parent contract. This is the baseline for the regression model, true when all four dummy variables are zero. Vehicle classifications are missing for less than 0.1% of contracts and task orders and for a similarly small percentage of dataset obligations.

Contract Pricing

Fixed-Price (n_Fixed) is a numeric variable based on contract pricing. It has a value of 0 for cost-based (3.5% of records), 0.5 for "combination or other" (0.1% of records), and 1 for any fixed price (97% of records). While the overwhelming percentage of contracts and task orders are fixed price, nearly 29% of obligations go to cost-based contracts. Slightly more than 0.1% of contracts and task orders are unlabeled, along with a miniscule proportion of obligations. The study team is experimenting with including fee type as well but has not been able to replicate results by other researchers on the benefits of incentive fee contracts. This may be explained by the rarity of that fee type and the range of potential confounds. The study team intends to return to this question in later stages of the research.

Undefinitized Contract Action (b_UCA) is a binary variable with a value of 1 for contracts and task orders that begin as letter contracts or undefinitized contract awards (UCA) and a value of 0 otherwise. They account for a miniscule proportion (less than 0.01%) of contracts and task orders and only 3.4% of obligations, but do significantly correlate with a greater risk of terminations and ceiling breaches. Unfortunately, due to a reporting error in recent years on the now retired version of USAspending.gov, UCA classification is missing for nearly 10% of records and over 12% of obligations in the dataset. Nonetheless, the predictive power of this variable is sufficient, and, therefore, it is still included in the study.

Contract Location

Any International (b_Intl) is a binary variable with a value of 1 for contracts and task orders with any transactions performed internationally and a value of 0 otherwise. Nearly 10.5% of contracts and task orders had an international component as well as nearly 15% of obligations. Only a miniscule portion of records were unlabeled.

Contract Industrial Sector

NAICS represents the top North American Industrial Classification Code of each contract and is measured by obligated amount. This paper uses a multilevel model that allows for setting a different intercept for each industrial sector, discussed in greater detail in the next section. Due to computational limitations, the level of detail varies between models and is shown by the number at the end of the code (e.g., NAICS6 is the full six-digit NAICS code while NAICS2 is the minimal two-digit version). Less than 0.1% of contracts and task orders have no NAICS labeling whatsoever.

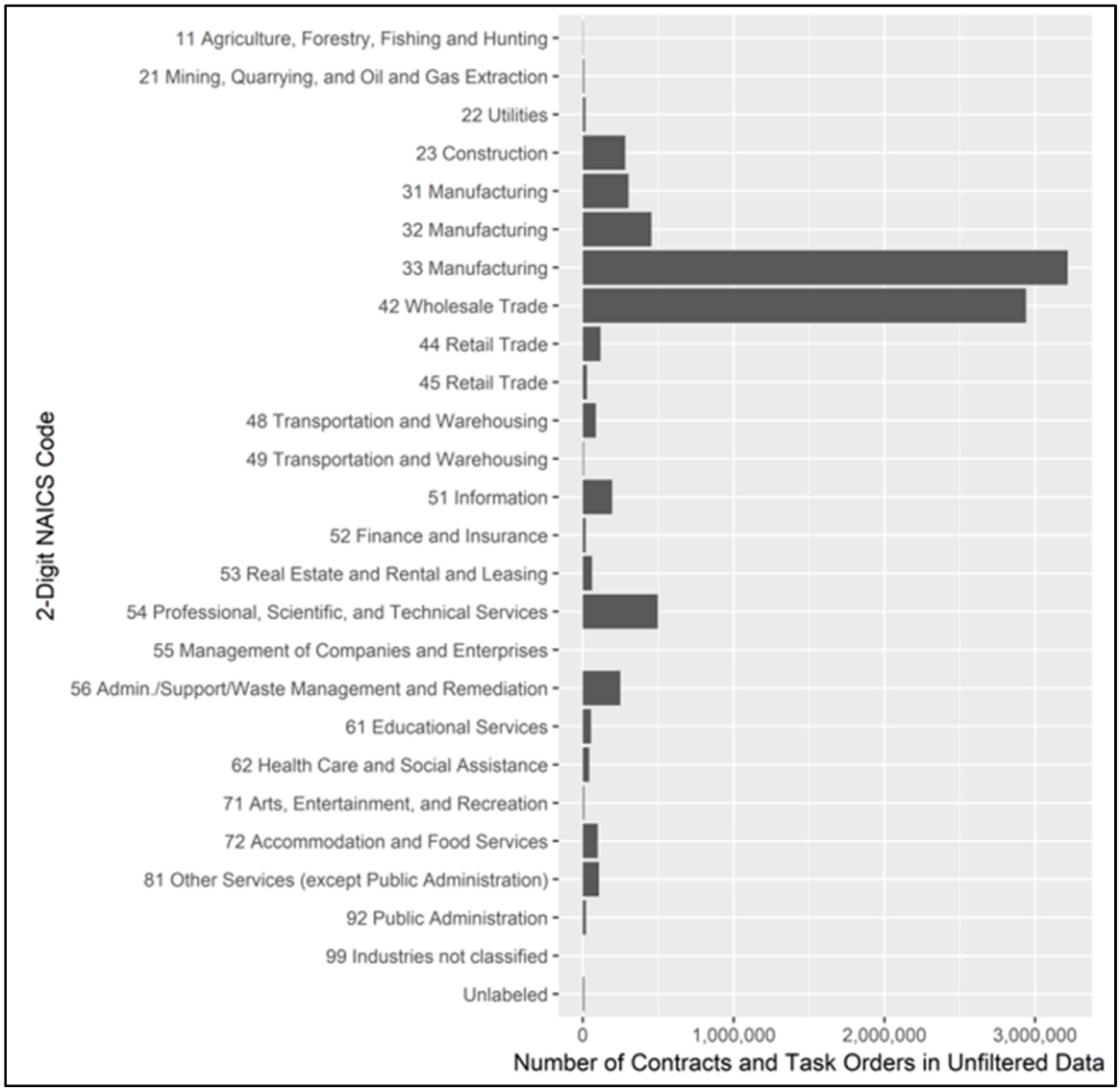

Figure 1. Distribution of Contract Obligations by NAICS 2-Digit Code

As shown in Figure 1, the distribution of DoD contract obligations is focused in a subset of the 24 NAICS 2-digit codes. Manufacturing (31–33) particularly stands out, as that category (Manufacturing), like Transportation and Warehousing (48–49), as well as Retail Trade (44–45), spills over into multiple 2-digit codes. In dollar terms, Professional, Scientific, and Technical Services (54) and Construction (23) are the second and third most prevalent industrial sectors; however, they are less significant in terms of the number of contracts and task orders because those sectors have higher value contracts. At the other end of the scale, Wholesale Trade (42) has lower obligations contracts, with less dollars obligated in that sector than either Construction or Professional, Scientific, and Technical Services.

Empirical Approach

At this stage of the project, the study team has four working models evaluating all combinations of the study and mediating variables: competition and consolidation respectively, with the two contract outcome variables, terminations and ceiling breaches. These initial models allow the study team to study H_1 and H_3, but leave H_2, the connection between consolidation and competition, to a later stage of the research.

Choice of Econometric Model

The study team uses a maximum likelihood logit analysis to analyze both termination and ceiling breaches. Logit is suited to dependent variables which can be true or false, 1 or 0, but not values outside of that range. This approach does not allow for evaluation of the size of a ceiling breach or variations of partial or complete terminations. However, less than 5% of contracts or task orders ever experience ceiling breaches or termination, therefore, the study team is only focusing on when these events occur and not differences between these cases.

In addition, when examining competition, the study team employs multilevel modeling techniques to capture the differences in expected outcomes between industrial sectors as categorized by NAICS codes. Each contract is assigned to a 2-digit NAICS sector based on the NAICS code that received the most overall obligations over the contract's lifespan. The equations below use a varying intercept model, which is to say that each of the 24 2-digit NAICS codes has a constant term added to the equation based on the termination or ceiling breach rate within that sector. Multilevel modeling techniques are a means to balance between two extremes when considering how to combine data from different groups. The first technique is complete pooling, which means there would be no varying intercept and no differentiation based on a contract's NAICS sector. The second technique is no pooling, which means there is a separate model for each NAICS sector. Multilevel modeling uses "soft constraints," which are covered in more detail in the next section.

Presentation of Estimating Equation

For competition as a mediating variable when estimating the probability of termination, the study team used the following model (subscript i refers to the individual contract or task order, while subscript j refers to the NAICS sector):

Consolidation Equations

$$
\begin{aligned}
&Probability\ of\ Termination\ (y_i = 1\ ) \\
&\quad = Logit^{-1}\big(\alpha + \alpha_{k[i]}^{NAICS} + \beta_1 c\_HHI\_lag1_{\ i} + \beta_2 cl\_Ceil + \beta_3 cl\_Days_i + \beta_4 SIDV_i \\
&\quad + \beta_5 MIDV_i + \beta_6 FSS\text{-}GWAC_i + \beta_7 BPA\text{-}BOA_i + \beta_8 n\_Fixed_i + \beta_9 b\_UCA_i \\
&\quad + \beta_{10} c\_HHI\_lag1_i \cdot SIDV_i + \beta_{12}\, c\_HHI\_lag1_i \cdot MIDV_i \\
&\quad + \beta_{13} c\_HHI\_lag1 \cdot FSS\text{-}GWAC_i + \beta_{14}\, c\_HHI\_lag1_i \cdot BPA\text{-}BOA_i \\
&\quad + \beta_{15} c\_HHI\_lag1_i \cdot b\_UCA_i + \epsilon_i\big), for\ i = 1\ to\ 1{,}000{,}000 \\
&\qquad \alpha_j^{NAIC} \sim N(\mu_\alpha, \sigma_\alpha^2), for\ j = 1\ to\ 24
\end{aligned}
$$

The second half of the equation merits additional explanation. α_j^{NAICS} refers to the intercept, which in this and the subsequent equations will vary for each of the 24 2-digit NAICS codes. Gelman and Hill (2007) explain the concept in their introductory textbook:

In the multilevel model, a "soft constraint" is applied to the [α_j^{NAICS}]'s: they are assigned a probability distribution [see above], with their mean μ_α, and standard deviation σ_α^2 estimated from the data. The distribution has the effect of pulling the estimates of [α_j^{NAICS2}] toward the mean level μ_α, but not all the way. (p. 257)

$$Probability\ of\ Ceiling\ Breach\ (y_i = 1\ )$$
$$= Logit^{-1}\big(\alpha + \alpha_{k[i]}^{NAICS} + \beta_1 \text{c\_HHI\_lag1}_i + \beta_2 cl\_Ceil + \beta_3 cl\_Days_i + \beta_4 SIDV_i$$
$$+ \beta_5 MIDV_i + \beta_6 FSS\text{-}GWAC_i + \beta_7 BPA\text{-}BOA_i + \beta_8 n\_Fixed_i + \beta_9 b\_UCA_i$$
$$+ \beta_{10} c\_HHI\_lag1_i \cdot cl\_Ceil_i + \beta_{11}\, b\_Intl + \beta_{10} cl\_Ceil_i \cdot SIDV_i$$
$$+ \beta_{12}\, cl\_Ceil_i \cdot MIDV_i + \beta_{13} cl\_Ceil_i \cdot FSS\text{-}GWAC_i + \beta_{14}\, cl\_Ceil_i \cdot BPA\text{-}BOA_i$$
$$+ \beta_{15} cl\_Ceil_i \cdot b\_UCA_i + \beta_{16} c\_HHI\_lag1_i \cdot b\_UCA_i + \epsilon_i\big),$$
$$for\ i = 1\ to\ 1{,}000{,}000$$

$$\alpha_j^{NAICS2} \sim N(\mu_\alpha, \sigma_a^2), for\ j = 1\ to\ 24$$

Competition Equations

$$Probability\ of\ Termination\ (y_i = 1\ )$$
$$= Logit^{-1}\big(\alpha_0 + \alpha_{j[i]}^{NAICS2} + \beta_1 b\_Comp_i + \beta_2 cl\_Ceil_i + \beta_3 cl\_Days_i + \beta_4 SIDV_i$$
$$+ \beta_5 MIDV_i + \beta_6 FSS\text{-}GWAC_i + \beta_7 BPABOA_i + \beta_8 n\_Fixed_i + \beta_9 b\_UCA_i$$
$$+ \beta_{10} SIDV_i \cdot Comp_i + \beta_{11}\, MIDV_i \cdot Comp_i + \beta_{12} FSS\text{-}GWAC_i \cdot Comp_i$$
$$+ \beta_{13}\, BPABOA_i \cdot n\_Comp_i + \beta_{14} b\_UCA_i \cdot n\_Comp_i + \epsilon_i\big),$$
$$for\ i = 1\ to\ 1{,}000{,}000$$

$$\alpha_j^{NAICS} \sim N(\mu_\alpha, \sigma_a^2), \qquad for\ j = 1\ to\ 24$$

$$Probability\ of\ Ceiling\ Breach\ (y_i = 1\ )$$
$$= Logit^{-1}\big(\alpha + \alpha_{k[i]}^{NAICS} + \beta_1 n\_Comp_i + \beta_2 cl\_Ceil + \beta_3 cl\_Days_i + \beta_4 SIDV_i$$
$$+ \beta_5 MIDV_i + \beta_6 FSS\text{-}GWAC_i + \beta_7 BPA\text{-}BOA_i + \beta_8 n\_Fixed_i + \beta_9 b\_UCA_i$$
$$+ \beta_{10} n\_Comp \cdot cl\_Ceil + \beta_{11} b\_intl_i + \beta_{12} cl\_Ceil_i \cdot SIDV_i + \beta_{13}\, cl\_Ceil_i \cdot MIDV_i$$
$$+ \beta_{14} cl\_Ceil_i \cdot FSS\text{-}GWAC_i + \beta_{15}\, cl\_Ceil_i \cdot BPA\text{-}BOA_i + \beta_{16} cl\_Ceil_i \cdot b\_UCA_i$$
$$+ \beta_{17} n\_Comp_i \cdot b\_UCA_i + \epsilon_i\big), for\ i = 1\ to\ 1{,}000{,}000$$

$$\alpha_j^{NAIC} \sim N(\mu_\alpha, \sigma_a^2), for\ j = 1\ to\ 24$$

Results and Discussion

Consolidation and Performance—Direct Relationship

In keeping with H_1, consolidation significantly correlated with both outcome measures, which supports the hypothesis on the importance of industrial consolidation. Surprisingly, as the c_HHI_lag1 row in Table 1 shows, the relationships of consolidation to the two dependent variables are opposite. Supporting perceptions of the risk of industrial consolidation, more consolidation is associated with a greater prevalence of ceiling breaches. In addition, the increased likelihood of cost escalation also undercuts the explanation that the lower associated rate of terminations may simply be the result of consolidated sectors having superior economics of scale or efficiencies.

Table 1. Logit Model Results for Consolidation

	Complete and Partial Termination	Ceiling Breach
(Intercept)	-5.50 (0.16)*	-4.75 (0.21)*
c_HHI_lag1	-0.15 (0.02)*	0.28 (0.01)*
cl_Ceil	-0.02 (0.01)	0.64 (0.02)*
cl_Days	0.67 (0.02)*	0.19 (0.01)*
SIDV	-1.04 (0.03)*	-0.07 (0.03)*
MIDV	-0.22 (0.05)*	0.37 (0.05)*
FSSGWAC	-0.28 (0.05)*	0.16 (0.06)*
BPABOA	-0.45 (0.08)*	-0.01 (0.08)
n_Fixed	1.02 (0.09)*	0.30 (0.04)*
b_UCA	1.64 (0.07)*	2.01 (0.07)*
c_HHI_lag1:SIDV	-0.50 (0.04)*	
c_HHI_lag1:MIDV	0.18 (0.05)*	
c_HHI_lag1:FSSGWAC	0.21 (0.05)*	
c_HHI_lag1:BPABOA	-0.02 (0.11)	
c_HHI_lag1:b_UCA	0.37 (0.09)*	0.37 (0.07)*
b_Intl		-0.27 (0.03)*
c_HHI_lag1:cl_Ceil		-0.17 (0.01)*
cl_Ceil:SIDV		-0.14 (0.02)*
cl_Ceil:MIDV		-0.24 (0.03)*
cl_Ceil:FSSGWAC		0.04 (0.04)
cl_Ceil:BPABOA		-0.32 (0.08)*
cl_Ceil:b_UCA		-0.39 (0.05)*
AIC	112213.41	105872.70
BIC	112402.46	106097.20
Log Likelihood	-56090.70	-52917.35
Num. obs.	1000000	1000000
Num. groups: NAICS2	24	24
Var: NAICS2 (Intercept)	0.32	0.98

*p < 0.05

Statistical models

The interactions may merit further exploration in the future. In consolidated sectors, use of single-award IDCs are significantly correlated with a lower probability of terminations which may reflect an institutionalized partnership between government and industry. On the other hand, UCA contracts in a consolidated sector appear to magnify the already significant correlation with both terminations and ceiling breaches.

While the relationship is statistically significant, the coefficient for the HHI is not notably impressive. The range of industry that the DoJ considers to be moderately consolidated ranges from 1500 to 2500 on the HHI index or from 0.7 to 1.24 on the centered version of the variable used for this study. While there is significant variation between

sectors, few individual sectors are likely to change that rate of consolidation so much that they move by 1 point on this centered scale which corresponds to 1867 points on the HHI. The correlation with lower probability of ceiling breaches is also strongest for smaller contracts.

Role of Competition as a Mediating Variable

As shown in Table 2, competition correlates with terminations and ceiling breaches in the same direction as consolidation.

Table 2. Logit Model Results for Competition

	Complete or Partial Termination	Ceiling Breach
(Intercept)	-6.16 (0.10)*	-5.38 (0.05)*
n_Comp	0.58 (0.03)*	-0.25 (0.03)*
cl_Ceil	-0.04 (0.01)*	0.87 (0.02)*
cl_Days	0.83 (0.01)*	0.47 (0.01)*
SIDV	-0.58 (0.04)*	0.19 (0.03)*
MIDV	0.01 (0.07)	1.11 (0.05)*
FSSGWAC	-0.57 (0.07)*	0.24 (0.05)*
BPABOA	0.00 (0.09)	0.45 (0.08)*
n_Fixed	1.42 (0.09)*	0.38 (0.04)*
b_UCA	1.81 (0.06)*	1.94 (0.07)*
n_Comp:SIDV	-0.74 (0.05)*	
n_Comp:MIDV	-0.37 (0.09)*	
n_Comp:FSSGWAC	0.20 (0.09)*	
n_Comp:BPABOA	-0.74 (0.15)*	
n_Comp:b_UCA	-1.96 (0.27)*	-0.35 (0.14)*
b_Intl		0.13 (0.03)*
n_Comp:cl_Ceil		0.24 (0.02)*
cl_Ceil:SIDV		-0.33 (0.02)*
cl_Ceil:MIDV		-0.53 (0.03)*
cl_Ceil:FSSGWAC		-0.18 (0.04)*
cl_Ceil:BPABOA		-0.64 (0.08)*
cl_Ceil:b_UCA		-0.64 (0.06)*
AIC	115293.63	115669.09
BIC	115482.68	115893.58
Log Likelihood	-57630.81	-57815.54
Num. obs.	1000000	1000000
Num. groups: NAICS2	24	24
Var: NAICS2 (Intercept)	0.00	0.00

*$p < 0.05$

Statistical models

However, unlike consolidation, the literature suggests that competition should have a positive effect of performance. H_3 is only borne out in part. Competition is associated with a lower probability of ceiling breaches, in keeping with the hypothesis, but it is also correlated

with a higher probability of partial or complete terminations. Notably, the coefficient for terminations is more than twice that of the coefficient for ceiling breaches.

The correlation for more competition and a greater risk of termination, as with consolidation, has multiple straightforward explanations. Alternately, in the absence of any competition, the government may be locked-in to a given vendor. This explanation would assume that the cost and effort of termination is more appealing if another vendor waits in the wings. Another possible implication is that competition sometimes allows technically unqualified vendors or price-to-win bids to emerge victorious even if they are ultimately unable to deliver on the terms agreed. Finally bid-protests are one source of partial or complete terminations that are exclusive to competed contracts.

However, the interactions of competition with terminations complicate the story. When it comes to contract vehicles, single-award IDCs, blanket purchase agreements, basic ordering agreements, and, to a lesser extent, multiple-award IDCs are all less likely to be terminated when competed. Even more striking, the coefficient of the interaction of competition and UCAs is large enough to cancel out the greater probability of termination associated with that contracting method.

The support for H_3 comes from ceiling breaches, where competition is correlated with a lower probability of change orders raising the cost ceiling. One caveat to this finding, as with consolidation, is that the correlation of competition with a lower probability of ceiling breaches is strongest for smaller contracts and fades away as ceilings grow larger.

Other Noteworthy Results

Contract or task order vehicles and pricing wield a significant influence over contract outcomes. Fixed-price contracts were somewhat correlated with ceiling breaches but strongly correlated with terminations. The former result merits closer scrutiny as it runs against past findings by CSIS and outside research. Likewise, at this stage the study team was unable to replicate research on that and found that incentive fees are linked with lower costs, although ceiling breaches only capture the cost growth part of that equation. Finally, as covered under both consolidation and competition, UCAs have significant negative correlations with both terminations and ceiling breaches, justifying their classification as a high risk contract type.

Concluding Thoughts and Next Steps

The results at this stage of the research do support the idea that even in the sometime monopsony of DoD acquisition, competition and lower rates of consolidation do correlate with a lower risk of cost escalation. At the same time, the findings regarding terminations emphasize the complex interactions of acquisition policy decisions and the risk of unexpected results. On that same note, the significant explanatory power of contract vehicles and their varying situational relevance suggest that the choice of vehicles should perhaps be given additional attention as a factor influencing contract outcomes. As ever, these findings reinforce the judgment and human capital needed for successful acquisition policy and the absence of one-size fits all solutions, even for foundational approaches such as competition.

The next step for the study team will be to examine the direct relationship between consolidation and competition as well as to create models of contract performance that include both consolidation and competition. In addition, the study team will iterate the existing models by considering refinements of existing inputs as well as new inputs such as sector-level economic data for the defense-industrial base and for the U.S. economy as a whole.

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