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Competition and Bidding Data as an Indicator of the Health of the U.S. Defense Industrial Base

Andrew Hunter, CSIS
Gregory Sanders, CSIS
Jesse Ellman, CSIS

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Competition and Bidding Data as an Indicator of the Health of the U.S. Defense Industrial Base

Andrew Hunter—is a Senior Fellow in the International Security Program and Director of the Defense-Industrial Initiatives Group at the Center for Strategic and International Studies (CSIS). From 2011 to 2014, he served as a senior executive in the Department of Defense, serving first as Chief of Staff to Under Secretaries of Defense (AT&L) Ashton B. Carter and Frank Kendall, before directing the Joint Rapid Acquisition Cell. From 2005 to 2011, Hunter served as a professional staff member of the House Armed Services Committee. Hunter holds an MA in applied economics from the Johns Hopkins University and a BA in social studies from Harvard University. [ahunter@csis.org]

Gregory Sanders—is a Fellow with the Defense-Industrial Initiatives Group at CSIS, where he manages a team that analyzes U.S. defense acquisition issues. Utilizing data visualization and other methods, his research focuses on extrapolating trends within government contracting. This requires innovative management of millions of unique data from a variety of databases, most notably the Federal Procurement Database System, and extensive cross-referencing of multiple budget data sources. Sanders holds an MA in international studies from the University of Denver and a BA in government and politics, as well as a BS in computer science, from the University of Maryland. [gsanders@csis.org]

Jesse Ellman—is a Research Associate with the Defense-Industrial Initiatives Group (DIIG) at CSIS. He specializes in U.S. defense acquisition policy, with a particular focus on Department of Defense, Department of Homeland Security, and government-wide services contracting trends; sourcing policy and cost estimation methodologies; and recent U.S. Army modernization efforts. Ellman holds a BA in political science from Stony Brook University and an MA with honors in security studies, with a concentration in military operations, from Georgetown University. [jellman@csis.org]

Abstract

Promoting competition in contracting has been a focus of Department of Defense (DoD) efforts for many years, but this focus has heightened in recent years as defense budgets have declined dramatically. Though there has been much written about the results of these efforts, most of the literature has focused on rates of competition for the DoD overall. In previous work on DoD contracting, however, the Center for Strategic and International Studies (CSIS) has found that competition rates vary not just on what is being purchased, but by who in the DoD is doing the purchasing.

This research effort builds upon previous CSIS work on defense contracting, using publicly available data from the Federal Procurement Data System. The study team has undertaken to build a predictive model of defense contracting, identifying factors that correlate with higher or lower rates of effective competition, and using data from past years to generate an "expected" rate of competition. With this model, CSIS digs a step deeper by examining trends in competition by Place of Performance (states) and by Major Contracting Command. The findings from this analysis are used to generate an improved predictive model, which is previewed in this report

Introduction[1]

The Defense-Industrial Initiatives Group at the Center for Strategic and International Studies (CSIS) has completed the work detailed in this paper as an intermediate effort for a larger study being conducted for the Naval Postgraduate School. The following paper details the structure of the team's efforts to create a predictive model of the degree of effective competition in defense contracting. Our team defines *effective competition* as all contracts that solicit two or more bids. CSIS believes that effective competition is the best metric to measure whether the DoD is successfully promoting competition, as it excludes competitively-sourced contracts that receive only one offer. The final product of this research effort will delve deeper into the issue of single-offer competition, but the study team believes that many cases of single-offer competition never had a chance of getting more than one offer.

The purpose of the model described in this paper is to better understand the extent to which different factors in defense contracting influence effective competition in the bidding process. This effort is an important addition to the literature on defense competition, as it quantifies the correlative effects of different factors through a statistically rigorous analysis. Numerous statements from officials inside the DoD and throughout the federal government have emphasized the importance of promoting competition, particularly in a difficult budget environment, as a way to improve quality and reduce cost.

The larger study analyzes competition via a range of approaches. Earlier, under this research effort, the study team reported on levels of effective competition for the military departments and then disaggregated the effective competition rates for products, services, and R&D.[2] This approach allows for trend analysis to see whether rates are improving or degrading under Better Buying Power and during sequestration. That paper found that while recent reports from the Government Accountability Office found reduced competition, effective competition rates have held steady in aggregate despite the pressures of sequestration. The paper also found that while rates of effective competition for products, services, and R&D have been remarkably consistent over time for the DoD as a whole, those rates differ significantly between major DoD components. In particular, there are notable differences between the major DoD components in rates of effective competition for similar categories of products, services, and R&D, which is an issue that the study team intends to delve into further in the next stages of this study.

The primary focus of this study is one level deeper: Major Contracting Commands and U.S. states. By aggregating the data at this level, the study team can look for signs of weakness in the industrial base on a geographical and a functional basis. The utility of this study is to go beyond obvious findings, such as low levels of competition for complex defense specific systems, to instead look at which states and Major Commands are over- or underperforming expectations. To do that, it was first necessary for CSIS to set a baseline of what to expect.

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[1] CSIS does not take specific policy positions; accordingly, all views expressed in this presentation should be understood to be solely those of the author(s).
[2] Available at http://csis.org/publication/quality-competition-defense-contracts-under-better-buying-power

To set that baseline, the first phase of this study analyzed, in isolation, the relationship between a variety of contract characteristics and the level of competition through the number of offers. The evaluated characteristics include the following:

- **Type of Good Procured:** Products, Services, and Research & Development (R&D)
- **Platform Portfolios:** Land, Air, Vessel, Missiles and Space, Electronics & Communications, and Weapons and Ammunition
- **Contracting Methods:** Contract Pricing, Contract Size, and Contract Vehicle

Due to the large number of commands and U.S. states, the results from that first phase are available at the Competition repository of the CSIS defense GitHub account.[3] This collection includes scatter plots for each study variable as well as the annual competition rates for each major command and U.S. state.

After examining the influence of contract characteristics in isolation, CSIS proceeded to study their interaction on two separate but mutually reinforcing tracks. The first track was to develop a regression model which used the same units of analyses as the first phase: major commands and states. For each geographical and organizational unit, the study team calculated the percentage of obligations that aligned with each contract characteristic using a denominator of constant obligations from fiscal year (FY)2000 to FY2013. As is discussed below, not every characteristic could be included, because of correlation. Products and services inversely correlate with one another while Missiles and Space correlates positively with R&D, but the team chose those contract traits which had the highest explanatory value and a clear causal mechanism.

On a parallel track, the team took advantage of a Bayesian model developed for a separate research project on fixed price contracting. That model uses individual contracts, rather than major commands or U.S. states as the unit of analysis and allows for use of the entire dataset of publicly reported DoD contracts completed between FY2007 and FY2013. This larger sample approach can yield more statistical power and is well suited to examining the causal connections between variables in addition to looking at how those connections influence the outcome.

In addition to studying and putting in place enhanced statistical methods, the CSIS team has been working to ensure that our work will be fully reproducible by future researchers who seek to cross-validate and build upon our results. This goes beyond the aforementioned publishing of the competition data for each U.S. state and major command and work that was completed in the fall of 2014 comparing the level of effective competition for each individual variable. The study team has also published the lookup tables used to classify the Federal Procurement Data System (FPDS) competition data, the regression model building process, and the Bayesian model and analysis.

This paper outlines our efforts in four parts:

- **Modeling DoD Effective Competition Rates Using Regression**, wherein we detail our model and its variables;

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[3] Available at http://github.com/CSiSdefense/competition

- **Examination of Outlier Major Commands and U.S. states**, which demonstrates the capabilities of the CSIS model by comparing the actual effective rate of competition with the predicted rate of competition on a select group of major commands and states of interest;
- **Tracing the Influence of Study Variables at the Contract Level**, which takes a closer look at the independent variables included in the regression model and analyzes how they influence competition with assistance from a Bayesian network that uses contracts as a unit of analysis; and
- **Initial Results and Planned Next Steps.**

Modeling DoD Effective Competition Rates Using Regression

In order to evaluate trends in effective competition in DoD contracting, CSIS has divided up DoD contracting activity in two ways:

- Place of Performance: This breakdown examines in which state a contract is to be performed. This is done by using each state as an observation and aggregating the data from each state for each variable over the time period from 2000 to 2013. This can provide indications of the vibrancy of the industrial base available to perform contracts activity that takes place within a particular state.[4]
- Major Contracting Command (MCC): Going a level below the usual analytic level of "component," this breakdown allows for analysis of how successful different major contracting commands have been in promoting effective competition relative to the goods or services for which they are contracting and the types of contracts for which they are responsible. This is done by using each MCC as an observation and aggregating the data from each MCC for each variable over the time period from 2000 to 2013.

For these two data groups, CSIS has built a linear regression model in order to generate an "estimated" rate of effective competition for each state and MCC, along with a confidence interval. This model uses data from FY2000 to 2013 to generate a prediction of 2014 effective competition rates, based on a number of variables (described in the introduction, and explained in detail in a later section), and what types of contracts are used. Each of these variables has been tested and validated as having a statistically significant correlation to either increasing or decreasing rates of effective competition.

The "estimated" rate of effective competition is then compared to the actual rate of effective competition for FY2014. At this point, this predictive model is not intended to evaluate performance in promoting effective competition—the regression model is only capable of explaining about half of the variance in effective competition rates, and the confidence intervals for estimates were sufficiently wide as to include the vast majority of actual values for both models. CSIS is currently refining the model and considering

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[4] Because the issues involved with competition for contracts performed overseas and/or in contingency environments are notably different than those for most domestically-performed contracts, contracts whose place of performance is outside the United States are excluded from the "place of performance" analysis. CSIS will consider whether and how foreign countries should be included for future iterations.

increasing the sample size by separating out the MCC and state entries by year. For the purposes of this analysis, results from the regression model are used to identify states/MCCs where the difference between "estimated" and actual effective competition rates is notable enough to warrant deeper investigation.

Because there is some difference in the variables used to evaluate states versus those used for MCCs, the following discussion is divided into two sections, highlighting a selection of states/MCCs that the model suggests are worthy of further study.

Major Command Regression

The following variables have been evaluated as being part of a statistically significant causal model for competition in MCCs; however, significance varies across variables.

```
lm(formula = pEffectiveComp ~ pService:pProduct + pAir + pMnS +
    pwnA + pEnC + pIDV + pService + pService:pIDV + pProduct:pService:pIDV,
    data = MCClist)

Residuals:
     Min       1Q   Median       3Q      Max
-0.36330 -0.08168  0.02227  0.07601  0.27716

Coefficients:
                        Estimate Std. Error t value Pr(>|t|)
(Intercept)              0.7161     0.1029    6.962 5.19e-09 ***
pAir                    -0.4776     0.1458   -3.276 0.001861 **
pMnS                    -0.1763     0.1449   -1.217 0.228995
pwnA                    -0.5896     0.7871   -0.749 0.457136
pEnC                    -0.3050     0.1153   -2.646 0.010684 *
pIDV                     0.1038     0.1384    0.750 0.456538
pService                 0.2678     0.1659    1.614 0.112547
pService:pProduct       -2.8542     0.6788   -4.205 0.000101 ***
pService:pIDV           -0.4570     0.2320   -1.970 0.054064 .
pService:pProduct:pIDV   3.5275     1.0235    3.447 0.001119 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.1394 on 53 degrees of freedom
Multiple R-squared:  0.5987,   Adjusted R-squared:  0.5305
F-statistic: 8.784 on 9 and 53 DF, p-value: 6.159e-08
```

Variables that correlate with a lower rate of effective competition:

- Greater percentage of contract obligations related to Aircraft & Drone programs (pAir); Missiles and Space programs (pMnS); Weapons and Ammunition programs (pWnA); and Electronics & Communications programs (pEnC).
- Greater mix of contract obligations for products and services (pService:pProduct). As the contracting portfolio becomes more mixed, rates of effective competition decrease.
- Percentage of contract obligations for services and awarded under IDV contract types (pService:pIDV). Competition decreases when both increase.

Variables that correlate with a higher rate of effective competition:

- Greater percentage of contract obligations awarded under Indefinite Delivery Vehicle (IDV) contract types (pIDV).
- Greater percentage of contract obligations awarded for services (pService).

- Greater mix of contracting obligations for products and services, along with greater percentage of contracts awarded under IDV contract types (pService:pProduct:pIDV).

U.S. State Regression

The following variables have been evaluated as being part of a statistically significant causal model for competition in U.S. states; however, significance varies across variables.

```
lm(formula = pEffectiveComp ~ pAir + pMnS + pEnC + pIDV + pVessel +
    pProduct + pEnC:pProduct, data = ShortStateList)

Residuals:
      Min       1Q    Median       3Q       Max
-0.158476 -0.069727 -0.000495  0.058374  0.284960

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)    0.78557    0.08173   9.611 1.77e-12 ***
pAir          -0.43742    0.11976  -3.652 0.000675 ***
pMnS          -0.05380    0.25996  -0.207 0.836991
pEnC          -1.40027    0.39122  -3.579 0.000840 ***
pIDV           0.30292    0.14010   2.162 0.035957 *
pVessel        0.06109    0.15245   0.401 0.690506
pProduct      -0.60550    0.11802  -5.131 5.95e-06 ***
pEnC:pProduct  1.80070    0.67749   2.658 0.010846 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.09905 on 45 degrees of freedom
Multiple R-squared:  0.7023,   Adjusted R-squared:  0.656
F-statistic: 15.17 on 7 and 45 DF,  p-value: 5.431e-10
```

Variables that correlate with a lower rate of effective competition:

- Greater percentage of contract obligations awarded for products (pProduct)
- Greater percentage of contract obligations related to Aircraft & Drone programs (pAir); Missiles & Space programs (pMnS); Ships programs (pVessel); and Electronics & Communications (E&C) programs (pEnC)[5]

Variables that correlate with a greater rate of effective competition:

- Greater percentage of contract obligations awarded under Indefinite Delivery Vehicle (IDV) contract types
- Greater percentage of contract obligations awarded for both products and Electronics & Communications (pProducts:pEnC; competition increases when both increase)

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[5] These groupings include all product, service, and R&D contracts associated with a particular class of platforms or programs. Where relevant, this analysis also references specific categories of products or services, but those categories are specifically noted to be only products or services when mentioned.

Examination of Outlier Major Commands and U.S. States

After having created the predictive regression model and analyzed the causal roots of the variables that drive the model, the study team put these tools into practice to study FY2014 contracting. By applying the regression derived from FY2000 to FY2013 data to the FY2014 inputs, the study team estimated effective competition rates for each of the states and major commands in the sample for FY2014, and then compared the predicted value to the actual effective competition rate for each state or major command in FY2014. The intent of this process was to identify the organizational and geographical units that exemplify or defy DoD-wide patterns.

At this stage of the research effort, the limits of the predictive strength of the model means that the following analysis is not intended to "grade" MCCs and states on their competition performance. Rather, the following sections are intended as a proof of concept for the study methodology, demonstrating the ability of the CSIS model to identify "outliers" among the MCCs and states. The drivers of the differences between actual and "estimated" effective competition rates for the identified states and MCCs will be used to improve future iterations of the CSIS predictive model.

Major Contracting Commands[6]

The following section describes five MCCs, four with significant levels of contract obligations that show notable differences between "estimated" effective competition rates and actual rates in 2014 and one MCC where "estimated" and actual rates are nearly identical.

Defense Logistics Agency (DLA) Energy

- Total 2014 Contract Obligations: $8.4 billion
- "Estimated" 2014 Effective Competition Rate: 83%
- Actual 2014 Effective Competition Rate: 94%

DLA Energy exceeded its "estimated" competition rate in 2014 in part due to the unique mix of goods and services it contracts for, as well as higher than average effective competition rates for significant parts of its contracting portfolio.

As would be expected, the vast majority of contract obligations by DLA Energy are for fuels. Approximately 96% of fuels contract obligations by DLA Energy are awarded after effective competition in 2014, right in line with the overall DoD rate of 95%. DLA Energy also handles significant contract obligations for facilities-related services and construction (FRS&C; primarily for lease and operation of fuel supply facilities, as well as utilities), and 88% of those contract obligations were awarded after effective competition. By comparison, the rate of effective competition for overall DoD FRS&C contract obligations is 70%. Over 92% of DLA Energy contract obligations are awarded under IDV contract types, which are associated with higher rates of effective competition. Most of the other correlative variables do not apply to DLA Energy, which may explain the gap between the "estimated" and actual effective competition rates.

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[6] Because the 95% confidence intervals for the MCC model are so wide, no MCCs fell outside of their intervals. CSIS sees this not as a sign of the predictive power of the model, but rather a limitation to be addressed in future iterations.

DLA Aviation

- Total 2014 Contract Obligations: $4.3 billion
- "Estimated" 2014 Effective Competition Rate: 42%
- Actual 2014 Effective Competition Rate: 20%

DLA Aviation significantly underperformed its "estimated" effective competition rate in 2014, due to lower than average rates of effective competition for Electronics & Communications, Facilities & Construction, and products categorized as "Engines & Power Plants."

Unsurprisingly, the majority of DLA Aviation contract obligations are for Aircraft & Drones, with a significant share also going for Electronics & Communications; both correlate to lower rates of effective competition. The DLA Aviation rate of effective competition for Aircraft & Drones contract obligations was low in 2014 (17%), but that is only slightly lower than the rate for Aircraft & Drones contracts in the DoD overall (21%). (Within Aircraft & Drones, only 12% of DLA Aviation contract obligations for products categorized as "Engines & Power Plants" were awarded after effective competition, compared to 37% for the DoD overall.) By contrast, the rate of effective competition for Electronics & Communications within DLA Aviation (22%) is significantly lower than the rate for the DoD overall (35%).

Interestingly, while 73% of overall DoD contract obligations for products and services categorized as "Facilities & Construction" (F&C) are awarded after effective competition, that rate is only 36% for F&C contract obligations within DLA Aviation.

Army Materiel Command (AMC)

- Total 2014 Contract Obligations: $43.6 billion
- "Estimated" 2014 Effective Competition Rate: 34%
- Actual 2014 Effective Competition Rate: 46%

The main driver of AMC's higher-than-"estimated" rate of effective competition in 2014 is the unusually high rate of effective competition for one category of its services contracts portfolio.

Based solely on the correlative variables for AMC, AMC's effective competition rates being higher than "estimated" in 2014 seems unusual: a nearly even mix of products and services, as well as higher-than-average shares of obligations going to Aircraft & Drones and Electronics & Communications, correlate with lower rates of competition. The main driver of the higher-than-"estimated" rate of effective competition for AMC seems to be in the rate of effective competition for professional, administrative, and management support services (PAMS): PAMS account for nearly a quarter of AMC's contract portfolio, and 66% were awarded after effective competition, compared to 36% for the DoD overall.

Naval Supply Systems Command (NAVSUP)

- Total 2014 Contract Obligations: $7.1 billion
- "Estimated" 2014 Effective Competition Rate: 52%
- Actual 2014 Effective Competition Rate: 33%

The main drivers of the lower-than-predicted rate of effective competition are twofold. First, only 3% of NAVSUP contract obligations for Aircraft & Drones in 2014 were awarded after effective competition, compared to 21% for the DoD overall. Secondly, only 23% of NAVSUP contract obligations for Electronics & Communications were awarded after effective competition, compared to 45% for the DoD overall.

The relevant correlative variables for NAVSUP are a mixed bag: a relatively even mix of products and services, along with slightly higher-than-average shares of obligations going to Aircraft & Drones and Electronics & Communications, correlate with lower rates of effective competition. Meanwhile, higher-than-average usage of IDV contract types, especially alongside the aforementioned even mix of products and services, correlate with higher rates of effective competition.

Air Force Materiel Command (AFMC)

- Total 2014 Contract Obligations: $36.7 billion
- "Estimated" 2014 Effective Competition Rate: 30%
- Actual 2014 Effective Competition Rate: 30%

Unlike the previous four examples, where particular categories of contracts have significantly higher/lower rates of effective competition than the DoD overall in one direction, there are notable differences in both directions for AFMC.

AFMC has a high percentage of contract obligations going to Aircraft & Drones (though, at 38%, not as high as one might assume), which correlates with lower rates of effective competition. AFMC also has a relatively even mix of products and services in its contracting portfolio, which similarly correlates with lower competition rates. Only 26% of AFMC contract obligations for PAMS in 2014 were awarded after effective competition, compared to 36% overall. By contrast, for AFMC equipment-related services (ERS), 33% of contract obligations were awarded after effective competition, compared to 26% overall. This lack of unidirectional deviations from "estimated" rates of competition is likely a significant factor enabling the predictive model to accurately estimate 2014 effective competition rates.

Place of Performance—States

The following sections describe four states with significant levels of contract obligations that show notable differences between "estimated" effective competition rates and actual rates in 2014, along with one state where "estimated" and actual rates are nearly identical.

Minnesota

- Total 2014 Contract Obligations: $3.9 billion
- "Estimated" 2014 Effective Competition Rate: 65%
- Actual 2014 Effective Competition Rate: 89*% (Upper limit of 95% confidence interval: 89%)*

DoD contract obligations performed in Minnesota significantly over-performed their "estimated" effective competition rates, due to higher than average rates of effective competition for medical services.

Only 19% of contract obligations for contracts performed in Minnesota were for products in 2014, compared to 45% for the DoD overall, which would correlate with higher rates of effective competition. At the same time, only 11% of contract obligations were awarded under IDV contract types, less than a quarter of the rate for the overall DoD, which would correlate with lower competition. Nearly 80% of obligations for contracts performed in Minnesota were for medical services, specifically "General Health Care Services." Interestingly, nearly all of those medical services contract obligations were awarded after receiving only two offers; while the overall rate of competition is exceptional, this is not

necessarily indicative of a highly competitive marketplace. For overall DoD medical services contracting in 2014, approximately 75% of contract obligations were awarded after effective competition, with the vast majority of those receiving five or more offers.

Mississippi

- Total 2014 Contract Obligations: $2.3 billion
- "Estimated" 2014 Effective Competition Rate: 44%
- Actual 2014 Effective Competition Rate: 71% *(Upper limit of 95% confidence interval: 67%)*

DoD contract obligations performed in Mississippi significantly outperformed their "estimated" effective competition rates, due to higher than average rates of effective competition for contracts related to Aircraft and Ships programs.

A disproportionately large share (42%) of contract obligations performed in Mississippi in 2014 were related to Ships platforms, primarily related to construction of DDG-51 destroyers at Ingalls Shipbuilding in Pascagoula, MS, owned by Huntington Ingalls Industries. Nearly three-quarters of Ships obligations were awarded after effective competition, almost entirely with only two offers, which is largely a function of the limited industrial base for large combat ships. Approximately 30% of contract obligations performed in Mississippi were related to Aircraft programs, which generally have low levels of effective competition, due to the limited industrial base for aircraft platforms, the long-term nature of aircraft programs, and the tendency for maintenance contracts to be performed by the development/production vendor. But the contract obligations in Mississippi, mainly for "maintenance–repair of aircraft,"[7] were highly competitive, with nearly three-quarters awarded after effective competition, split relatively evenly between two offers and three or more offers.

Nevada

- Total 2014 Contract Obligations: $1.3 billion
- "Estimated" 2014 Effective Competition Rate: 69%
- Actual 2014 Effective Competition Rate: 41% *(Lower limit of 95% confidence interval: 47%)*

DoD contract obligations performed in Nevada notably underperformed their "estimated" effective competition rates, primarily due to a lower than average rate of effective competition for one category of services.

Contract obligations for contracts performed in Nevada are overwhelmingly IDV-type contracts (80%) in 2014, which correlate with higher levels of effective competition, and only 24% of contracts are for products, which is well below the levels for the overall DoD. Nonetheless, the rate of effective competition for contracts performed in Nevada in 2014 is well below the "estimated" rate produced by the regression model and significantly below the lower limit of the 95% confidence interval. The main source of this low rate of competition seems to be an 18% effective competition rate for PAMS performed in Nevada,

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[7] These obligations are likely related to Columbus Air Force Base, a major Air Force pilot training installation.

around half the rate seen for PAMS in the DoD overall; PAMS account for approximately 40% of contract obligations performed in Nevada. Most of the obligations under PAMS are for "logistics support services."

Washington

- Total 2014 Contract Obligations: $7.5 billion
- "Estimated" 2014 Effective Competition Rate: 13%
- Actual 2014 Effective Competition Rate: 45% *(Upper limit of 95% confidence interval: 37%)*

DoD contract obligations performed in Washington state significantly over-performed their "estimated" effective competition rates in 2014, primarily due to higher than average rates of effective competition for contracts related to Aircraft programs and contracts for facilities-related services & construction.

As would be expected from the home state of Boeing, a high share (66%) of obligations for contracts performed in Washington go to Aircraft & Drones programs, which are associated with lower rates of effective competition. A below-average share (26%) of Washington contract obligations are IDV-type contracts, which would also correlate with less competition. The source of the higher-than-"estimated" rate of competition for contracts performed in Washington appears to be a higher-than-average rate of competition for Aircraft-related products: While only 10% of contract obligations for the DoD overall were awarded after effective competition in 2014, 35% of those contracts performed in Washington were awarded after effective competition.[8]

FRS&C also makes up a significant share of contracts performed in Washington, and the data shows a highly competitive market: 88% of Washington FRS&C contract obligations were awarded after effective competition in 2014, compared to 70% for the DoD overall. And nearly 90% of the effectively competed FRS&C contracts performed in Washington received three or more offers.

Virginia

- Total 2014 Contract Obligations: $33.6 billion
- "Estimated" 2014 Effective Competition Rate: 54%
- Actual 2014 Effective Competition Rate: 55%

Despite a higher than average rate of effective competition for a category of services that makes up a significant share of contract obligations performed in Virginia, the predictive model was able to almost exactly predict Virginia's effective competition rate for 2014.

Only 32% of obligations for contracts performed in Virginia were for products, compared to 41% overall, which would tend to correlate with higher rates of effective competition. Similarly, 67% of Virginia's contract obligations were awarded under IDV contract types, notably higher than the rate for the DoD overall. As might be expected given

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[8] Due to poor data labeling, the competed portion of Washington's Aircraft contract obligations are labeled as being associated with the Shillelagh Missile, a 1970s Army anti-tank missile program. CSIS is engaging with experts to try to determine what program these contract obligations are actually associated with.

the volume of available vendors, the market for PAMS in Virginia is significantly more competitive than it is nationwide: 61% of PAMS contract obligations performed in Virginia were awarded after effective competition, compared to 36% nationwide.

It is also notable that, for R&D contract obligations performed in Virginia, 36% awarded after competitions received only a single offer—over twice the rate for R&D nationwide. As a result, the rate of effective competition for R&D contracts performed in Virginia was only 32% in 2014, compared to 46% nationwide. Given the heavy concentration of major R&D vendors in Virginia, this high rate of single-offer competition is likely masking contracts that would be more properly classified as noncompetitive.

Tracing the Influence of Study Variables Using a Bayesian Model

For predictive analysis via regression to be most effective, it is important to understand the causal mechanisms' underlying analysis. For this reason, the study team examined each of the variables used in the regression at the contract level. This is done using a smaller subset of the FPDS database, six million publicly reported DoD contracts that were completed between FY2007 and FY2013. While this population of contracts includes fewer years, because the unit of analysis is contracts rather than major commands or states, the number of observations is dramatically higher. For similar reasons, the effective competition rates are different when calculating by market share of obligations than when calculating by number of contracts.

The process of gathering, cleaning, and organizing the data for the Bayesian network is described in greater detail in the CSIS report on fixed-price contracts that is also being presented at the 2015 Acquisition Research Symposium. In summary, the study team categorized and then collated FPDS data on a contract basis, a process which required significant error correction. The end product of this process is 11 evidence nodes, each having between two and eight distinct states. The study team then created the Bayesian network shown in Figure 1. In that model, an evidence node is a circle, and each arc indicates the direction that influence flows. The 11 nodes are described in the following section.[9]

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[9] See the Fixed Price repository under the CSISdefense GitHub account for the processing code used to create the model as well as the data itself. The nature of the Bayesian model is described in greater detail in the fixed-price report.
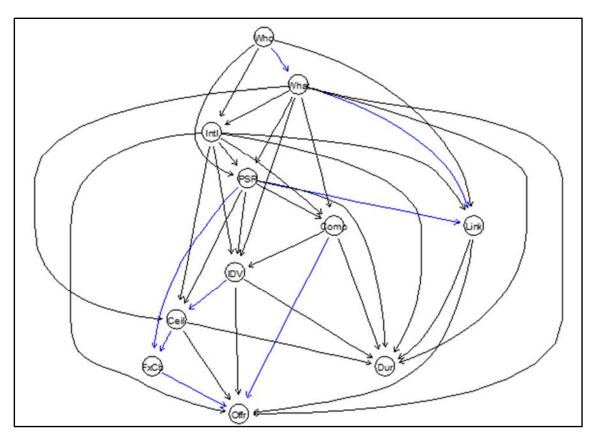
Figure 1. Competition Bayesian Network

Contract Fundamentals

These nodes of evidence include both the types of good procured and the platform portfolio. The methodological description is adapted from the fixed-price paper, which provides greater detail.

Who (Customer: Army/Navy/Air Force/Other DoD): Determined by the contracting office rather than the funding office.

What (Platform: Air/Land/Vessel/Electronics & Communications/Missiles and Space/Weapons and Ammunition/Facility Related Services & Construction/Other): Determined by the combination of the claimant program code for the platform when available and otherwise via the product or service code.

PSR (Product/Service/R&D): Determined by the product or service codes, with R&D management and support being treated as a service.

Intl (International: Just U.S./Some International): Based on the place of performance. Those contracts with any transactions in foreign countries are treated as having transactions with an international place of performance.

Link (# of linked contracts: none/1–749/750+): This calculated column is the study team's first effort to account for the possibility of problems cascading from other related

contracts. This is calculated by looking at contracts with the same equipment code or for contracts with the same platform portfolio (excluding the FRS&C and other platforms) and contracting office, with provisions to avoid double counting or counting contracts from different MDAPs. See the Fixed-price repository of the CSISdefense GitHub account for processing code used for this calculation.[10]

Contract Approach

These evidence nodes include the contracting methods discussed in earlier sections as well as scope-related parameters such as the contract ceiling and the initial duration. The regression did consider variables such as average contract size. However, the predictive value of contract size is notably more effective at the contract level than when aggregated at the state or major command level.

Comp (Competition: Comp./No Comp.): Is determined using the standard CSIS methodology with the critical exception that the numbers of offers received is treated as a separate piece of evidence.

Ceil (Ceiling: $15,000/$100,000/$1,000,000/$30,000,000): Refers to the initial ceiling on total potential contract obligations. Is set by the initial *base and all options value* for the contract. This value was chosen rather than the initial *base and exercised options value* because exercising options happens regularly during the course of an on-time and on-budget contract.

Dur (Duration: One Day to Two Months/Seven Months to a Year/More than a Year): Refers to the duration and is calculated using the number of days between the initial effective date and the current completion date for the contract. The ultimate completion date is also available but was regularly unlabeled.

FxCb (Fixed-price or Cost-based): Fixed-price includes all forms of fixed-price contracting except fixed-price level of effort. That comparatively rare form has been described in meetings with DoD officials as exhibiting more properties of cost-based contracts. Cost-based includes all forms of cost-plus contracts as well as time and materials and labor hours contracts.

Indefinite Delivery Vehicle (IDV): Indicates whether or not a contract is one of the many forms of Indefinite Delivery Vehicles (IDVs). This is a contracting approach in which a single-root contract is used as a basis for multiple other contracts.
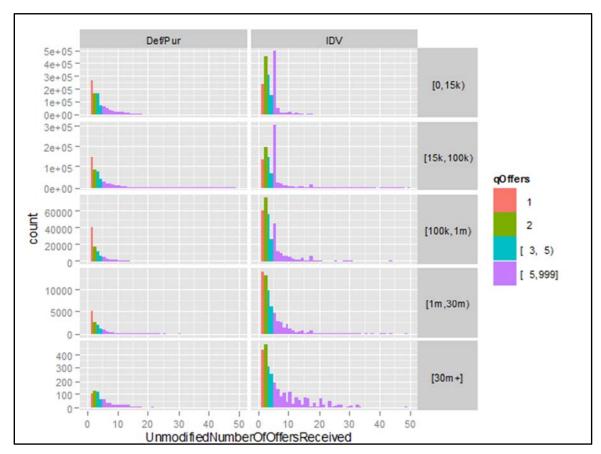
Contract Outcomes

Offr (Number of Offers Received: 1, 2, 3–4, 5+): This final evidence node is the one of most interest to this study. Cases with no competition are categorized as only one offer and further details of the calculation of this field are covered in the Fixed-price paper.

Figure 2 shows the distribution of contracts by number of offers, faceted by the initial contract ceiling and use of an indefinite delivery vehicle (IDV). While all five categories show a similar broad curve, larger and smaller ceiled contracts do have clearly different patterns. There is a large spike at exactly five offers for those contracts with ceilings below $1 million. That spike is even more prominent for those with ceilings below $100 thousand. As is shown

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[10] Available at https://github.com/CSISdefense/Fixed-price

by comparing the left and right columns of Figure 2 this phenomenon is entirely driven by IDV contracts and given the immediate drop off from five to six contracts, this data would be consistent with a widespread coding quirk or a deliberate if not necessarily regulatory target for contracting officers dealing with smaller IDVs contracts.
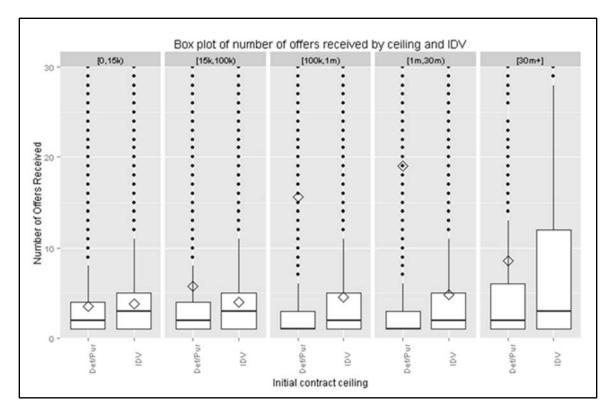

Note. Contracts with more than 50 offers are excluded from the graph. The data in this figure comes from FPDS, CSIS analysis.

Figure 2.   Number of Offers by Ceiling and Vehicle

By comparison, single-offer competition is prominent in all categories and exceeds two offers for contracts with ceilings between $100,000 and $30 million. As is shown in Figure 3, this phenomenon is driven first and foremost by definitive contracts and purchase orders, which below the $30 million dollar ceiling level consistently has more single-offer competition than any other number of offers. On the IDV side, this is only true for contracts with ceilings greater than or equal to $1 million. For both categories the median number of offers is lowest for contracts with ceilings between $100,000 and $30 million.

Note. Contracts with more than 30 offers are excluded from the graph. The mean number of offers for IDV contracts with ceilings of $30 million or higher is 33.4 and not depicted on this graph. The data in this figure comes from FPDS, CSIS analysis.

Figure 3. **Box Plot of Number of Offers Received by Ceiling and IDV**

However, above $30 million, single offer drops off as a proportion and upper quadrants of the box plot reach their highest values. As depicted on the graph, at least a quarter of these large contracts receive more than five offers regardless of vehicle. This would be consistent with middle tier contracts sometimes attracting fewer offers when they are unappealing or overly fitted for a single vendor. However, once the contracts get above the $30 million threshold, vendors appear to be generally more willing to bid even though the potential risks are greater in absolute terms.

As the above summary indicates, the number of offers received varies considerably depending on the characteristics of the contract. The patterns of lower competition for contracts between $100,000 and $1 million suggests that there is a middle tier of contracts which are not so small as to be easily pursued or so large as to be actively enticing to a large number of competitors. The strangest finding is the prevalence of five offer competition for IDVs, which merits further investigation.

Contract-Level Analysis of How the Study Variables Influence Effective Competition

Type of Good Procured (PSR)

Services

For MCCs, increasing contract obligations for services correlate with higher rates of effective competition. The correlative strength within the MCC model for services is weak-to-moderate (p = 0.112547), as is the degree of impact[11] (0.2678).

Overall, 55% of contracts for services in 2014 were awarded after effective competition. For Aircraft services, however, that rate was only 36%. By contrast, two of the other control variables are associated with significantly higher rates of effective competition for services: 66% of services contracts with a large contract ceiling were effective competed, while 61% of services contracts structured as IDVs were awarded after effective competition.

Products

The share of contract obligations for products correlates with lower rates of effective competition for states but, does not correlate within the model with rates of effective competition as strongly as does the share going to services for MCCs. The reverse was true for states. In each case the variable with higher correlation was used. The correlative strength within the states model for products is strong (p = 5.95e-06), and its degree of impact is moderate (-0.60550).

Overall, 67% of DoD contracts for products were awarded after effective competition in 2014.[12] A few of the control variables had notable effects on the rate of effective competition for products: only 47% of Aircraft products contracts were awarded after effective competition; for products contracts with a contract ceiling over $1 million, 58% of were awarded after effective competition; 74% of products contracts that were IDVs were awarded after effective competition; and only 42% of products contracts of long duration were awarded after effective competition.

Contracting Methods (IDV)

IDVs

Increasing shares of contract obligations awarded under IDV contract types correlate with increasing rates of effective competition, but the strength of those correlations is notably different between states and MCCs. For states, the correlative strength is strong (p = 0.035957), and the degree of impact within the model is mild (0. 30292). For MCCs, the correlative strength is significantly weaker (p = 0.456538), and the degree of impact is even lower (0.1038).

Overall, 71% of contracts awarded under IDV contract types in 2014 were effectively competed, but association with the control variables had significant effects on rates of

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[11] The study team uses "degree of impact" to describe the slope of the line resulting from the correlative analysis between the specified variable and rates of effective competition within the model.
[12] Note again that this refers to the share of contracts awarded after effective competition, not the share of contract obligations. By contract obligations, the rate of effective competition for DoD products is consistently well below the rate for services. By contracts, however, the sheer volume of smaller contracts for commercial-type products skews the results.

effective competition for IDVs. IDVs related to Aircraft (38%), IDVs with large contract ceilings (66%), IDVs with ceilings over $1 million (60%), and IDVs of long duration (48%) all showed lower rates of effective competition than overall IDVs.

Platform Portfolios (What)

Electronics & Communications

For both states and MCCs, increasing contract obligations related to Electronics & Communications (E&C) correlate with lower rates of effective competition, but the strength of that correlation differs for states and MCCs. The correlative strength within the model of E&C for states is high (p = 0.000840), and the degree of impact is the highest of any variable included (-1.40027). For MCCs, by contrast, the correlative strength within the model of E&C is relatively weak (p = 0.13066), and the degree of impact is similarly lower (-0.123549). This difference between states and MCCs may have two causes. First, if a wider number of states do E&C work, that would make the model less dependent on any given outlier. Second, for states an interaction variable was included. Electronics and communications products were an exception to the negative trend and correlated with greater levels of effective competition (p=0.010846), with a high degree of impact (1.80070) perhaps because services in electronics and communications are much more technically involved.

Overall, 55% of contracts (not contract obligations) for E&C were awarded after effective competition in 2014. Looking at the control variables to see which had a significant effect on effective competition rates for E&C, contract ceiling and whether the contract was an IDV had virtually no effect. But contracts for E&C of long duration at contract start had an effective competition rate of only 46%, likely reflecting contracts with greater complexity that fewer companies were willing or able to bid on.

Aircraft

The share of contract obligations related to Aircraft strongly correlates with lower rates of effective competition for both states and MCCs. For MCCs, the correlative strength is high (p = 0.001861), and the degree of impact within the model was moderately high (-0.4776). For states, the correlative strength was even higher (p = 0.000675), and the degree of impact within the model was slightly smaller (-0. 43742).

In 2014, 46% of contracts related to Aircraft were awarded after effective competition. In three cases, the control variables were associated with lower rates of effective competition for Aircraft. For Aircraft contracts with a contract ceiling of greater than $1 million, the rate of effective competition was only 36%. For Aircraft contracts structured as IDVs, only 38% were effectively competed. And for Aircraft contracts of long duration, only 34% were awarded after effective competition.

Missiles and Space

The share of contract obligations related to Missiles and Space (M&S) is weakly-to-moderately correlated with lower rates of effective competition for both states and MCCs. The correlative strengths were superior for MCCs (p = 0. 836991 for states; p = 0.228995 for MCCs) and in the same manner the degree of impact higher for MCCs (-0.1763) than states (-0. 05380).

Overall, 49% of contracts related to M&S in 2014 were awarded after effective competition. Looking at the interaction between M&S and the control variables, only 40% of M&S contracts with large contract ceilings were awarded after effective competition. By contrast, 54% of M&S contracts of long duration were awarded after effective competition.

Ships

The share of contract obligations related to Ships did not notably correlate with rates of effective competition for MCCs and showed a weak-to-moderate correlation with lower rates of effective competition for states. The correlative strength of Ships for ships (0.690506) is slightly higher than for M&S, although the degree of impact within the model (0.06109) is minimal. Due to the surprising sign of the correlation and the weak significance, this variable may not merit inclusion in future iterations of the model.

Overall, 46% of contracts related to Ships were awarded after effective competition in 2014. Several of the control variables are associated with notably different rates of effective competition for Ships. 69% of Ships contracts with large ($30 million or higher) contract ceilings were awarded after effective competition. Meanwhile, 53% of Ships contracts with a contract ceiling over $1 million saw effective competition. Similarly, 52% of Ships contracts awarded under IDVs were awarded after effective competition. By contrast, only 26% of Ships contracts of long duration were effectively competed.

Weapons and Ammunition

The share of contract obligations related to Weapons and Ammunition (W&A) showed weak with lower shares of effective competition for MCCs. For MCCs, the correlative strength was notably weaker (p = 0.457136), but the degree of impact within the model was the highest of any single variable (-0.5896).

Overall, 57% of contracts related to W&A were awarded after effective competition in 2014. The only control variable that had a significant impact in association with W&A was long duration—W&A contracts of long duration were effectively competed only 52% of the time.

Initial Results and Next Steps

Due to the previously-mentioned limitations inherent in this iteration of the model, it bears repeating that these initial results from the predictive model are not intended to be used to "grade" states and MCCs on their performance in promoting effective competition. The study team suspects that the relatively small amount of obligations in some of these states and MCCs may result in one or two large contracts skewing effective competition rates. Nonetheless, the initial results validate the ability of the model to identify states/MCCs where rates of effective competition for a segment of the contracting portfolio differ significantly from the rates for the overall DoD. In addition there are a number of interesting results, such as MCCs with a mix of product and service contracts having lower effective competition rates and states with a focus in products and electronics having higher rates.

This is particularly important given how stable rates of effective competition have been for the DoD overall, and for DoD products/services/R&D, respectively. If gains are to be made in promoting effective competition, it will have to be at a more granular level, taking examples from states/MCCs that have shown better than "estimated" rates of effective competition and trying to apply lessons learned to those with lower than "estimated" rates of competition. If nothing else, the study team hopes to provide policy-makers with a road map that will enable them to identify which states and MCCs warrant deeper analysis and to determine if their competition performance is an artifact of a few big contracts skewing results, or rather a systemic characteristic that should either be studied and emulated or studied and improved.

In an effort to both explain a greater amount of the noted variance and to reduce the size of the 95% confidence interval that we obtain, the CSIS study team is presently experimenting with ways to improve both the statistical foundations and the robustness of

the predictive model. The results of these explorations will also enable the study team to determine if additional variables will be incorporated into the model. Based on the output from the current version of the model, the study team has already determined to include a more detailed breakdown of services; this will help account for the states and MCCs that show large discrepancies between "estimated" and actual effective competition rates due to higher/lower rates for particular types of services.

Acknowledgments