Washington State Military & Defense Contracts Economic Modeling Tool—Technical Appendix

INTRODUCTION

This report was prepared under contract with the Washington State Department of Commerce, with financial support from the Office of Economic Adjustment, Department of Defense. The content reflects the views of the Washington State Department of Commerce and does not necessarily reflect the views of the Office of Economic Adjustment or the Department of Defense.

The methodology required to produce economic impact results of defense contract spending in Washington state involves multiple steps. The sections below detail this modeling process, including background information on data sources, adjustments to the raw data obtained through USASpending.gov, and modeling efforts.

DEFINING DEFENSE PROCUREMENT IN WASHINGTON

Procurement in this analysis refers to both contracts and grants. For the remaining of this technical appendix, "contracts" will refer to both contracts and grants. Contracts includes purchases of goods and services, while "grants" take into account grants for defense-related research, most notably Defense Advanced Research Projects Agency (DARPA), of which a large amount is directed to universities and laboratories in Washington.

Throughout this analysis, defense contracts and grants were defined as those originating from either the Department of Defense (DOD) or the Department of Homeland Security (DHS) that were purposed to fund military and related activities. All contracts and grants with the Department of Defense were included, while only Coast Guard activities were included among Department of Homeland Security contracts and grants.

Data Sources

Federal Sources

Contracts and Grants Data. The primary data sources used for this analysis are DOD and DHS contract and grants data from the Office of Management and Budget (OMB) made available via USASpending.gov. This data includes all prime contracts greater than $3,000 and all subcontracts greater than $25,000 except in special cases. All single-year awards and assistance transactions are reported at the contract level and multi-year contracts are reported at the transaction level. Further information is available at: https://www.usaspending.gov/about/Pages/TheData.aspx

Contracts and Grants News Releases. The DOD publishes news releases on contracts valued at $7 million or more each business day at 5 PM eastern time. These releases include more detailed work plan data than is available in the OMB contract data—such as rough contract value by site, for some contracts with multiple work sites. News releases are available at: https://www.defense.gov/News/Contracts/

Military Personnel. The DOD publishes public information on enlisted and civilian personnel, facility size, and base replacement value annually in base structure reports. Reports are available at: http://www.acq.osd.mil/ie/ie_library.shtml#rpts

Industry Employment and Wages. The Bureau of Labor Statistics regularly publishes detailed employment and wage data for covered employees (those protected by state unemployment insurance; this does not include partnerships or sole proprietorships) through the Quarterly Census of Employment and Wages (QCEW). Data is organized according to the North American Industry Classification System (NAICS), which assigns industry codes from two to six digits that describe a business's primary activity. QCEW data is available at: http://www.bls.gov/cew/datatoc.htm

Occupational Employment. The Bureau of Labor Statistics also publishes a detailed national table of occupations by industry. This data illustrates how different industries employ different combinations of occupations, based on survey data gathered from across the nation. The National Industry-Occupational matrix is available at: http://www.bls.gov/emp/ep_table_109.htm

U.S. Input-Output Table. The Bureau of Economic Analysis produces a national benchmark input-output table that describes transactions between and within the industries nationally. This data also includes purchases by private households, government, and investment by industry. Benchmark input-output data is available at: http://www.bea.gov/industry/io_benchmark.htm

Inflation Adjustments. Implicit price deflators and the consumer price index, published by the U.S. Bureau of Economic Analysis and U.S. Bureau of Labor Statistics, were used to adjust transactions and wages.

State and Other Sources

Boeing Activities. Boeing, as a publicly traded company, regularly publishes key performance and activity indicators. Among these are orders and deliveries by model number, annual revenue by company division, and other financial information. Boeing delivery data is available at: http://www.boeing.com/commercial/#/orders-deliveries

Gross Business Income. The Washington State Department of Revenue reports gross business income data on the state's registered businesses. This information is presented from the two- to the six-digit NAICS level and can be accessed at: http://dor.wa.gov/content/aboutus/statisticsandreports/TID/StatisticsReports.aspx?query=gbinaics

Washington State Input-Output Model. The Washington State Office of Financial Management publishes a state-level input-output model similar to that produced by the U.S. Bureau of Economic Analysis, but with custom representation of industries and activities in Washington. The 2007 and 2002 editions of the model are available at: http://www.ofm.wa.gov/economy/io/

State and County-Level Industry-Occupational Matrices. The Washington State Employment Security Department also provides information on the state's occupational-industry composition. Data is drawn from the same survey data as the table published nationally by the Bureau of Labor Statistics. Data is available at: https://fortress.wa.gov/esd/employmentdata/reports-publications/industry-reports/employment-projections

MODEL COMPONENTS

Assigning Final Firm Names and Revenue

Final Firm Names

Each transaction recorded in the OMB data lists the name of the contractor who is assigned to perform that work. However, in many cases, those names do not match up for the same organization. Boeing, for example, is called "The Boeing Company", "Boeing Company, The", and "BOEING", among others.

In order to deal with this, CAI developed a simple protocol to assign cleaned firm names to the raw data. First CAI assembled a list of unique firm names for contractors (both prime and sub) who worked in Washington. Then, CAI assessed each individual firm name and assigned a final name. This process involved searching the list of unique names for duplicates, checking individual firm name DUNS numbers to see if multiple names were recorded for the same DUNS, and searching company websites for information on business subsidiaries or other 'doing business as' names. This analysis resulted in a final match between raw firm names from the transaction data and final firm names for use in the model.

Final Firm Revenue

Similar to the problem of single firms being recorded under multiple names, CAI found that single firms had multiple reported revenue numbers for the

same year. In order to estimate firm revenue dependency, CAI needed a single revenue number for each firm in each year.

TO accomplish this, CAI developed a protocol to choose a single revenue value for firms with multiple reported values. First, CAI created a list of unique firm revenues for each firm in each year. Next, CAI assessed each individual revenue. If the revenue value was less than $10,000 or lower than the sum of DOD contracts for that firm, then CAI assumed the revenue was an error and removed that revenue from the analysis.

For the remaining revenue values, if each firm's revenue within a single year was within 20% of the average of those revenues, CAI chose to use the average of those revenues. If the revenues were too spread out, CAI looked to other years with valid revenue values. If all valid years of revenue were within 15% of the average of those values, then CAI used the average of those values. Finally, CAI assessed the top contractors individually, looking at company financial reports and online records to determine if any modeled revenue outcomes were erroneous.

Lockheed Martin Adjustments

Lockheed Martin has received several large contracts that involve a small portion of work done in Washington. Because both the primary location of Lockheed Martin and the primary location of the work performed are outside of Washington, this value is not captured in the raw OMB data.

As a result, CAI investigated alternative sources to find information on detailed contract place of performance. In particular, CAI relied on DO press releases that indicate how large contract work will be split across multiple sites. These new releases are more detailed than the data that goes into USASpending.gov. CAI used this information for Lockheed Martin to estimate total contract value at Lockheed Martin's Kitsap site. This data was then inserted into the raw OMB data.

Strategic Initiatives

Strategic initiatives refer to the DOD's high-level, long-term priorities. According to CAI research, several of these are relevant to Washington contractors, including:

- Air platforms
    - P-8
    - KC-46
- Unmanned/Autonomous Vehicles
    - Air
    - Underwater
- Foreign Military Sales
- Small Naval Craft

- Cybersecurity
- Energy Efficiency/Energy Storage

CAI determined methods to link individual contracts to one or more of the above strategic initiatives. These methods rely on contractor names, contract descriptions, contract system equipment codes (SEC), contract product service (PSC) codes, and contractor NAICS codes, along with supporting news materials. For example, determining which contracts were in the P-8 program involved looking at SEC codes and project descriptions for the phrase "P-8" or "Poseidon."

Smoothing

While contracts are reported for one point in time, the actual work undertaken for those contracts occurs over a period of time. In some cases, that period of time spans multiple fiscal years. To properly estimate how contracts are completed over time, CAI smoothed contract value over each year that the contract record indicated performance in.

For example, a $300,000 contract with an effective date of 12/1/2015 and an ultimate completion date of 1/1/2017 spans three fiscal years: FY 2015, FY 2016, FY 2017. In this case, CAI spreads the contract value evenly over the three years, so that $100,000 occurs in FY 2015, $100,000 occurs in FY 2016, and $100,000 occurs in FY 2017.

Adjustments to Transactions

Adjustments to obligated funds and scheduling of payments. Transactions in the OMB data refer to when contracts are amended; the fiscal year assigned to each transaction therefore does not necessarily reflect the timing of actual payments, which may extend over multiple years. The raw data was thus adjusted to present a more accurate rendering of capital inflows into Washington state.

Obligated funds per transaction were divided by the duration of a contract, calculated as the difference between the effective date of the contract and the current completion date (anticipated), yielding an average payment per year for each contract. For transactions with between 0 and 1 year in duration, the entirety of the contract was assigned to the year of the transaction. For contracts extending for 2 or more years, each year into the future was assigned a share of the total contract equal to the average value of obligated funds per year.

For a given fiscal year, total payments across all contracts thus equal first year estimated payments among transactions from the given year, plus estimated second year payments from the year prior, plus estimated third year payments from two years prior, and so on.

Adjustments to Boeing Transactions. Within the raw data, all Boeing transactions for defense activities are originally listed as being assigned to Seattle, despite the majority of defense work—notably the KC-46 and P-8 programs—being performed in other locations across Puget Sound. The KC-46, for example, is built on a Boeing 767 platform, which is manufactured in Everett, while the P8—based on Boeing 737 platform—has its own production line in Renton.

To correct for these transaction location assignments, CAI integrated data from past analyses on the aerospace industry for the Boeing 767 and 737; tax preference disclosure data on employment for Boeing Commercial sites in Washington; and interview feedback to reallocate these transactions based on the actual location of production.

To correct for inconsistencies in product industry codes across Boeing transactions, the industry codes for all such transactions were re-assigned the NAICS code for aerospace, which is 3364.

Employment and Wages

Assigning Employment and Wages

Jobs Directly Supported by Defense Contracts. Ratios of revenues-to-worker and average wages by industry were used to estimate how DOD and DHS contracts support jobs and wages in Washington state.

For each transaction, an algorithm was developed to assign an appropriate ratio of revenues-to-worker for subsequent modeling. The default ratio was statewide gross business income (GBI) per worker at the four-digit NAICS level, while the alternative measure was the estimated inflation-adjusted output-per-worker.

For all transactions in retail and wholesale—Washington State Input-Output (I-O) sectors 29, 30, 31—the I-O output-per-worker ratio was used. This is because revenue for these sectors in the input-output model is reported as gross margins, so using GBI per worker would vastly underestimate jobs.

In other instances, GBI significantly understates the amount of business revenues generated by an industry due to reporting requirements within Washington's state tax structure. When GBI-per-worker fell within 20% of the associated I-O output-to-worker ratio, GBI-per-worker was used as the assigned ratio. When it fell outside this range, the I-O alternative ratio was used instead.

Jobs directly supported by defense contracts were then calculated by dividing the value of each transaction by the attached, industry-specific revenues-to-worker ratio.

Wages Directly Associated with Defense Contracts. Wages were assigned according to a two-step process. First, for transactions that used GBI-per-worker to estimate employment, average wage per worker according to the QCEW was used. If the resulting share of wages out of total transaction revenue was greater than the share of total value added out of total revenue (as reported in the Washington State Input-Output model), then wages were controlled down to equal the share of total value added out of total revenue. This prevented unrealistically deflating inter-industry purchases made by companies to fulfill contracts, by ensuring that wages were not unrealistically high. Wages for transactions that used output-per-worker were determined by using inflation-adjusted wages per worker reported in the Washington State Input-Output Model.

Estimated are then scaled to benefits, using the ratio of total wages (including benefits) in the Washington State Input-Output Model to raw wages from the QCEW for the benchmark year of 2007. This ratio is then applied to raw estimated wages by industry to produce full wage disbursements supported directly by defense contracts.

Redistribution of Contracts and Associated Jobs and Wages by Place of Performance

In addition to contract spending with Washington-based firms for performance in Washington, two other spending patterns need to be considered. In some cases, non-Washington firms perform work in Washington, such as construction projects and ship maintenance work. These activities bring additional benefits to the state through local hires and supply chain purchases.

Conversely, Washington-based firms may receive contracts for work outside of Washington, in some cases resulting in a share of this work (and contract value) accruing to regions outside the state. Interview feedback indicated that contractors among some industries will hire locally, at the place of performance, thus a certain proportion of wages, employment and contract revenue accrue to the place of performance rather than just the location of the contractor.

To provide a more accurate rendering of the value accrued to Washington state, defense spending, contract revenue, wages and employment need to be redistributed between the headquarters location and the place of performance location. The proportion of contract value, associated employment and wages accruing either to the place of performance or the headquarters location depends significantly on the industry of the contractor. For example, a construction vendor does a significant amount of their work on-site, at the place of performance, while an engineering firm may do a larger proportion of their work off-site (at the contractor location).

Jobs assigned to the place of performance, when different from the vendor location, can be thought of as "local hires." The allocation of wages distributed to the place of performance is therefore a function of the employment assigned to the off-site location. This allocation informs the distribution of direct purchases made by the vendor.

To determine the proportion of work done on-site versus off-site by transaction, an occupation-to-industry match is employed. Interview feedback and existing literature helped inform modeling segmentations between on-site and off-site workers. This segmentation was then applied to the national industry-occupation matrix to determine the proportion of jobs and wages performed on-site and off-site. These national proportions were then applied to the defense transactions in Washington (among vendors based in Washington and/or work performed in Washington).

Redistributing contract revenue. According to input-output industry accounting, total output (revenue) equals total input (costs), which is the sum of goods and services purchased, labor income, and other value added (e.g., dividends, profits). It is assumed all other value added accrues to the location of the contractor, while proportions of purchases and labor cost disbursements are made on-site and off-site.

Wages are distributed using previously calculated proportions, however, purchases must also be reallocated by site. Using the national input-output model and the Washington Input-Output Model, it is possible to compare the proportion of purchases made among industries nationally, and the proportions within Washington. The difference between the two models can be translated into off-site purchases, or the proportion of purchases that are not made in Washington.

Using the differences between the two models and the proportion of inter-industry purchases to revenue minus wages from the Washington Input-Output Model, estimates of shares of purchases on-site and off-site by industry are made. These proportions are then used to determine purchases made by site, and contract revenue is reallocated accordingly. In the resulting modeling, new records are created for on-site and off-site work, which may represent more than one county.

Removal of Subcontract Value for Subcontracts Whose Prime Contractors are in or Performing in Washington

For economic impacts, fiscal impacts, and workforce composition modeling, it is essential to remove subcontract value that is already counted in prime contracts. For firm multiplier and firm purchase modeling, however, including these contract values will result in results more accurately tailored to individual firms.

To remove contracts, it is important to first understand why value is being double counted. At this point, the full universe of contracts counted in the model is any company located in or performing DOD or DHS contracts in Washington. However, some of these subcontracts are working on projects for prime contractors who are located or performing in Washington. In these cases, the value of those contracts is being counted twice. To remove these contracts, CAI simply selected and removed all subcontractors whose prime contractor was located in Washington or performed in Washington for the relevant prime contract. The resulting pool of contracts was used in subsequent economic impact, fiscal impact, and workforce modeling stages.

Economic Impacts

Economic impacts were estimated by way of an input-output modeling approach. The primary tool for these analytics is the Washington State Input-Output Model. This tool, published by the Washington State Office of Financial Management, is a modeled rendering of the Washington state economy, including inter- and intra-agency transactions, household spending, and final demand, the latter representing the sum of final household purchases, government purchases, investment, and exports.

Economic impact models are grounded in economic base theory, which articulates changes in final demand as the primary driver of economic growth. In this analysis, all defense spending originates from the federal government, outside of Washington state. These inflows of capital in the form transactions tied to defense contracts are the data input, the impacts of which are then modeled across the state.

All economic impacts are measured as revenues, jobs, and wages. Revenues represent business sales tied to defense contracts, either directly or through multiplier effects. Jobs and wages are estimated based on ratios of business revenues to worker per industry and industry-wide average wages, scaled to include benefits.

Measuring Economic Impacts—Direct, Indirect, and Induced

Three different types of economic impacts were reported. Direct impacts refer to the original event being modeled. In this they are case the value of defense contracts transactions flowing into Washington, along with associated (estimated) jobs and wages.

Indirect impacts refer to additional revenues, jobs, and wages across the economy associated with supply chain transactions in support of defense contracts. For example, indirect impacts would include business sales from a local machine shop to an aircraft manufacturer in support of a defense project, and associated jobs and wages.

Induced impacts refer to additional revenues, jobs, and wages associated with the spending of income by households earned through employment supported directly or indirectly by defense spending in Washington. Categories of induced impacts include business revenues spent on restaurants, retail, and healthcare.

County-based Impact Modeling

The Washington State Input-Output Model is a statewide model; it is not readily useable at the county level. County adjustments involve the following: 1) modifying the direct requirements within each county using a location quotient-based approach; 2) adjusting the induced impacts retained within a county through commuter patterns data; and 3) allocating the remaining economic impacts generated by a modeled activity within a county that accrue to other counties, or what is referred to as economic impact spillovers.

Modifying First Round Purchases and Direct Requirements. The first phase of the adjustment process involves modifying the first-round purchases made by a defense contractor in the county of the activity and the direct requirements matrix (prior to calculating the inverse matrix) through use of location quotients. Location quotients are calculations that represent the concentration of a given activity relative to a benchmark—in this case Washington state. The first step was to estimate jobs by each I-O industry and county across Washington, drawn from the Quarterly Census of Employment and Wages data series published by the U.S. Bureau of Labor Statistics, along with custom estimates for industries by county that were suppressed due to non-disclosure rules.

Location quotients were then applied to both the direct requirements, i.e., the immediate supply chain purchases of a defense contractor, to adjust for the amount of supply chain purchases within the county. For example, according to a statewide input-output model, a construction firm may purchase a certain percentage of all inputs by value from the mining industry in Washington. However, if the county in which the contract is performed has no mining industry, direct requirements must be adjusted to account for the possibility that the construction firm may still purchase these inputs within Washington, but not within the place-of-performance county.

Similarly, the direct requirements matrix is adjusted using location quotients to account for the distribution of industries and economic activities unique to the statewide economy. Subsequent calculations of the inverse matrix of direct requirements and Type I (indirect only) and Type II (indirect and induced) impact coefficients are therefore adjusted to reflect county-specific economic conditions.

Adjusting Induced Impacts. The second step in developing a county-based model is the adjustment of induced impacts to account for the flow of workers supported by defense spending in each county. Induced retention

coefficients were developed through use of county-level journey-to-work data published by the U.S. Census Bureau, with coefficients ranging from 0 to 1. These county-level coefficients are then applied to induced impacts to estimate the share of additional impacts generated through worker income expenditures retained within the county of interest.

Economic Impact Spillovers. The two steps explained above yield economic impacts by county for defense contracts and grant activities performed in those counties. As a last step, the remaining impacts—those not retained within each place-of-performance county, but still retained across the state—must be allocated for county impacts to sum to statewide impacts. For example, if a manufacturing contract is performed in Kitsap County, the two aforementioned steps model the economic impacts created and retained within Kitsap County. The remaining, residual impacts from this contract performed in Kitsap County accruing to other counties is the difference between the county-based model and the statewide model. This residual is allocated across other counties based on the distribution of employment by I-O sector and county.

Using the above manufacturing example, if the remaining indirect and induced impacts not retained within Kitsap County sum to 400 jobs in chemical manufacturing (I-O sector 17), and King County chemical manufacturing employment represents 20% of all chemical manufacturing employment outside of Kitsap County, then 80 of these jobs (20% * 400 jobs) are allocated to King County.

State Fiscal Impacts

Fiscal impacts are calculated as state government tax revenues supported—either directly or through secondary (indirect and induced) impacts, by defense contracts.

Total economic output calculated above is then converted to GBI based on the I-O sector-based industry ratios of output-to-GBI for a benchmark year, in this case 2007 (the year the I-O model is intended to represent). Output and GBI differ slightly due to the business income reporting structure of Washington's Department of Revenue. GBI is not fully representative of the total output of the business.

Effective tax rates per tax type are then calculated for each year being modeled, calculated as state tax payments-to-GBI for each I-O sector. These rates are then applied to estimated GBI per I-O sector, yielding modeled total state tax payments (and by type of tax) supported—either directly or through multiplier effects—by defense spending.

Workforce Composition

The estimated occupational workforce composition of jobs directly supported by defense contract spending in Washington was produced using industry-

occupational matrices published by the Washington State Employment Security Department.

First, the state industry-occupational matrix was split into two matrices: one matrix that included every industry but only occupations that were determined to be primarily on-site jobs—those that would realistically be carried out by employees at the place of performance for a transaction, e.g., construction workers—and another matrix that included all industries but only occupations that were determined to be primarily off-site—jobs carried out by employees at a company's headquarters and not on a work site. Next, the on-site matrix was divided by the sum of on-site jobs by industry and the off-site matrix was divided by the sum of off-site jobs by industry, resulting in occupational shares by industry for both matrices.

Separately, jobs by transaction were summed according to place of performance (where on-site jobs were most likely) and company location (where off-site jobs were most likely). Finally, the sum of jobs by industry and off-site or on-site were multiplied by the two matrices to estimate, on average, the occupational breakdown supported by transactions.

Firm Multipliers

Firm multiplier analysis relies on data from the Employment and Wages section that has not yet had subcontracts removed. This is because the firm multiplier analysis estimates each individual firm's economic impact multipliers, and does not assess total economic impacts.

To estimate firm multipliers, contract revenue for each firm for each IO sector were summed up. Next, CAI assigned the relevant impact multipliers to each IO sector. Then, each multiplier was weighted by multiplying it by the firm's contract revenue in that IO sector divided by the firm's total contract revenue. Finally, each weighted multiplier was summed up by firm to result in four multiplier values for each firm.

Firm Purchases

Firm purchase shares were estimated in a similar way to the firm multipliers. First, CAI summed up contract revenue for each firm for each IO sector. Then, CAI assigned that IO's purchase shares for each IO sector to each row. Then, CAI multiplied each purchase share by the firm's contract value in that row's sector divided by that firm's total contract revenue. Finally, CAI summed up each of the weighted IO sector purchase shares for each firm. This resulted in a weighted purchase share for each firm's purchases from every IO sector.

Firm Pages

Firm-level pages utilize data made available through impact estimates and OMB prime contractor and subcontractor data. Contract dependency as reported in the firm pages is based on the value of Washington state contracts for the specified firm divided by companywide revenues, the latter informed by the companywide revenue field included in OMB data. When companywide revenue is not reported by the OMB, the dependency ratio in turn is also not reported. The ratios used for levels of dependency were:

- Low: less than 1%
- Medium: between 1% and less than 25%
- High: 25% and above