Potential Uses of DEPPS as an Analytical Tool for Policy Makers

Douglas Meade and Bryan Shone

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1. Introduction

Defense spending plays an important role in the U.S. economy, and the economic impacts of that spending have significant policy implications, both with regard to fiscal policy and to the implications for the industrial base. Conversely, the size and shape of the U.S. economy has important implications for the capacity to produce more or less defense related goods and services. The Defense Employment and Purchases Projections System (*DEPPS*) was designed to help analysts understand how industries, states and occupational groups are affected by changes in the defense budget. This system is used on an annual basis to analyze these impacts, and the results are published in *Projected Defense Purchases:Detail by Industry and State*[2]. However, the components of this system provide a rich database and modeling capabilities that can be applied in broader applications. This paper provides a brief description and review of the main components of DEPPS, and then provides summaries of several analytical applications of the DEPPS data and models.

To understand better the importance of U.S. defense spending, it is helpful to look at the current levels of spending in an historical context. Despite the fact that the U.S. military currently has significant deployments in Afghanistan and Iraq, the share of defense expenditures in GDP is not large by historical standards. Figure 1 shows the defense share of GDP over the period 1965 to 2010, with projections made using the FY11 Future Years Defense Plan. According to this measure, defense spending was 5.6% of GDP in 2010, and projected to decline during the next five years. The low point in spending was in 2000, when the share was 3.7%. Previous peaks include WWII (43% share in 1944), the Korean war (14.7% in 1953), Viet Nam (10.0% in 1967), and the Reagan buildup of the 1980s (7.4% in 1986).

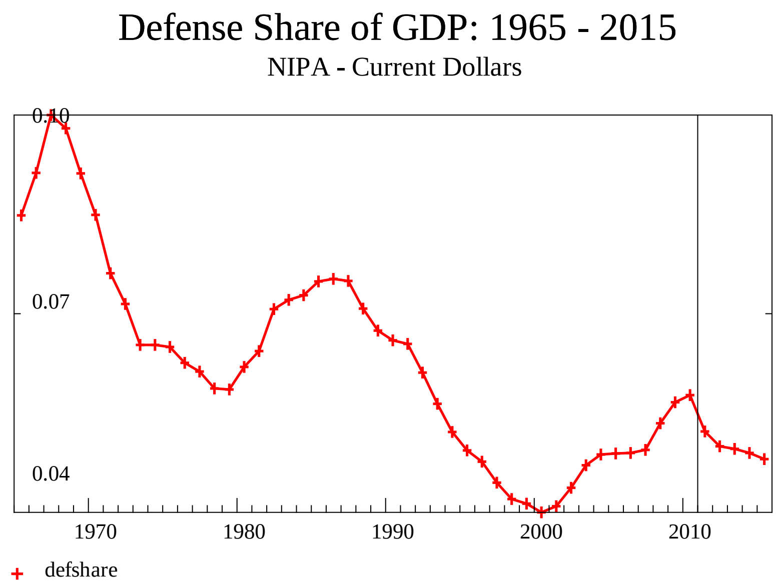
However, the defense budget is still arguably the most critical component of Federal government expenditures. Analysis of the impact of the defense budget sheds light on the economic growth or decline of industries and states. The level and composition of defense spending has changed significantly over time. The distribution of spending among industries and states is by no means uniform, and many of the economic effects are indirect. Both inside and outside the Pentagon, defense policy analysts, businessmen and economists are interested in the economic implications of these defense expenditures. To best perform this analysis, an analytical tool is needed to determine the economic impacts at the industry and state level. The effect of defense expenditures on employment, particularly of skilled and professional labor, is also of critical interest. For these reasons and others, *DEPPS* was developed by the Department of Defense.[3]

[1] Inforum, University of Maryland and Office of the Secretary of Defense, Cost Assessment and Program Evaluation.

[2] The most recently available version of this publication was produced in October 2010, and can be found at http://www.economics.osd.mil/DEPPS2010.pdf.

[3] The current version has been used continuously since 1996. An earlier version, named *DEIMS* (Defense Economic Impacts Modeling System) dates back to the 1970s.

Figure 1



DEPPS consists of three major components: an interindustry model, a state model, and an occupational model. The interindustry model (*IDEPPS*) consists of the INFORUM *Iliad* model, joined with the defense translator, a matrix that translates outlays on detailed defense budget programs to the industries that directly supply to these programs. The state model (*RDEPPS*) distributes defense spending by industry to the state level, based on state shares derived from historical data. The occupational model (*LDEPPS*) translates defense related employment by industry to the occupational level.

DEPPS is normally used in projections mode. The *DEPPS* projections are made for calendar year outlay estimates derived from the Future Years Defense Program (FYDP), as published in *National Defense Budget Estimates*.[4] The projections are also informed by recent historical industry and state spending patterns from various published and unpublished sources. Section 2 of this paper provides an overview of *DEPPS* and the information available in the projections.

As mentioned above, *DEPPS* can also be used for policy or scenario analysis. The INFORUM *Iliad* and *LIFT* models have been applied to many policy questions involving health care, defense, research and development, energy, taxes, and trade policy. The databases of these models, in conjunction with the *DEPPS* databases, provide a rich field for the analysis of defense issues. Section 3 of the paper provides examples of some of the types of policy and scenario analysis possible with *DEPPS*.

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[4] For the FY11 projections, done in summer 2010, the interval was 2009-2015.

2. *Overview of DEPPS*

2.1 IDEPPS – The Interindustry Component of *DEPPS*

The purpose of *IDEPPS* is to determine the defense-related production necessary to supply the goods and services implied by the FYDP. Defense-related production includes the direct purchases by DoD, such as an Abrams tank or a Comanche helicopter. It also includes indirect purchases, such as the semiconductors used to make the electronic systems in tanks, helicopters, ships and aircraft, as well as in the millions of computers purchased by DoD. From this information, one can examine how the planned defense budget contributes to the growth or decline of any given industry. One can also examine the projected share of total output comprised of defense-related production.

The *IDEPPS* projections can be summarized as follows:

- They are produced at a level of 360 industries, the same as that used in the detailed INFORUM *Iliad* model of the U.S. economy.
- They are made in constant (inflation-adjusted) dollars, by calendar year, for the interval defined by the FYDP.
- They reflect planned expenditures or outlays, not appropriations or budget authority.
- They reflect DoD expenditures for military programs only.

For each of the 360 industries that supply directly or indirectly to defense, several tables of information can be compiled. In this paper, three sample tables are presented for the Semiconductor industry. These tables are shown for the years of the FYDP, in millions of constant 2011 dollars.

Table 1. Projected Defense Purchases of Semiconductors, 2009-2015
(In millions of 2011 dollars)

	2009	2010	2011	2012	2013	2014	2015
Summary of Defense Purchases							
Direct	154	171	147	132	127	127	135
Indirect	3,321	3,409	2,953	2,712	2,546	2,520	2,480
Total	3,476	3,580	3,100	2,844	2,673	2,647	2,615
Indirect Defense Purchases by Purchasing Sector							
Missiles	259	282	263	243	233	232	232
Ammunition	30	34	29	24	22	23	23
Tanks and Tank Components	35	30	21	13	9	8	8
Other Ordnance	21	23	20	16	15	16	15
Communications Equipment	1,052	1,135	965	909	852	876	852
Other Electronic Equipment	241	250	234	226	218	227	225
Motor Vehicles	30	29	17	10	7	6	5
Aircraft and Parts	82	88	85	79	75	79	78
Aircraft Engines and Parts	25	27	25	24	23	24	24
Shipbuilding	118	83	94	108	126	87	96
All Other	1,428	1,429	1,199	1,061	965	943	921
Total	3,321	3,409	2,953	2,712	2,546	2,520	2,480

Table 1 shows how total defense-related purchases are divided between direct and indirect purchases. For the indirect purchases, it also indicates from which major direct purchasing sector they are derived. For example, Table 1 indicates that in 2011, $965 million *indirect* expenditures for semiconductors are projected to be needed to supply the *direct* expenditure of Communications equipment to DoD. Note that the semiconductor industry is one in which a large share of defense purchases are indirect. In 2011 DoD is projected to spend about $147 million directly, and $2,953 million indirectly.

Table 2. Sources of Projected Defense Purchases of Semiconductors, 2009-2015
(In millions of 2011 dollars)

	2009	2010	2011	2012	2013	2014	2015
Military Personnel	32	31	29	28	28	27	27
Operations & Maintenance + Revolving Funds	851	796	626	542	485	478	478
Procurement	1,886	2,044	1,773	1,640	1,577	1,621	1,626
Aircraft	359	407	406	389	381	407	406
Missiles	186	216	191	182	173	195	187
Weapons and Tracked Vehicles	209	236	113	63	39	37	29
Ships and Conversions	135	118	134	149	173	131	152
Ammunition	36	43	41	35	32	34	34
Other	961	1,023	888	822	778	818	818
RDT&E	658	653	623	588	545	486	453
Military Construction	43	51	44	42	36	31	28
Family Housing	6	6	5	4	3	3	3
Total	**3,476**	**3,580**	**3,100**	**2,844**	**2,673**	**2,647**	**2,615**

Table 2 shows the origins of defense-related demand for Semiconductors from the major headings of the DoD budget. This table can help to understand how the demand for an industry may shift as purchases are reallocated from one major budget category to another. From this table we can see that operations and maintenance (O&M) procurement and research, development, test and evaluation (RDT&E) comprise almost all of the defense-related demand for this industry. Within the procurement budget, the largest sources of demand are Other procurement, Aircraft and Missiles.

Table 3. Projected Domestic Production, Defense Purchases and Imports for Defense Production of of Semiconductors, 2009-2015
(In millions of 2011 dollars, except as noted)

	2009	2010	2011	2012	2013	2014	2015
Domestic Production	62,499	68,803	70,334	74,445	78,522	81,894	84,519
Plus Imports	12,352	14,034	14,549	16,383	17,612	19,091	20,373
Less Export	23,679	27,687	29,033	32,106	35,471	38,464	41,173
= Domestic Use	51,172	55,150	55,850	58,722	60,663	62,521	63,719
Import Share (percent)	24	25	26	28	29	31	32
Defense Purchases	3,476	3,580	3,100	2,844	2,673	2,647	2,615
Less Imports	793	857	759	746	729	757	780
Domestic Defense Purchases	2,683	2,723	2,341	2,098	1,945	1,890	1,835
Domestic Defense Purchases as a Share of Domestic Production (percent)	4.3	4.0	3.3	2.8	2.5	2.3	2.2

Table 3 is useful for examining trends in defense and nondefense purchases for a given industry. Shown in the first block of items in the table are projections made by INFORUM of economy-wide domestic production, net imports (imports less exports) and domestic use. (Domestic use is the sum of domestic production and net imports.) Also shown is the projected share of domestic use supplied by imports. Shown at the bottom of the table are estimates of the share of total domestic production accounted for by defense purchases. In 2009, this was 4.3 percent, but is projected to decline to 2.2% by 2015. This is due to a combination of a projection of fairly rapid production, coupled with a projected decline in the FYDP.

Figure 2 summarizes how the *IDEPPS* projections are computed. The FYDP is the starting point. The next step starts with estimates of projected constant price outlays and converts these to implied direct purchases from each of the 360 industries, using what is called the *defense translator*. The translator is a matrix that embodies information on many detailed defense programs. Any particular program may purchases inputs from a dozen or more industries.

Figure 2. General Flow of IDEPPS Computations

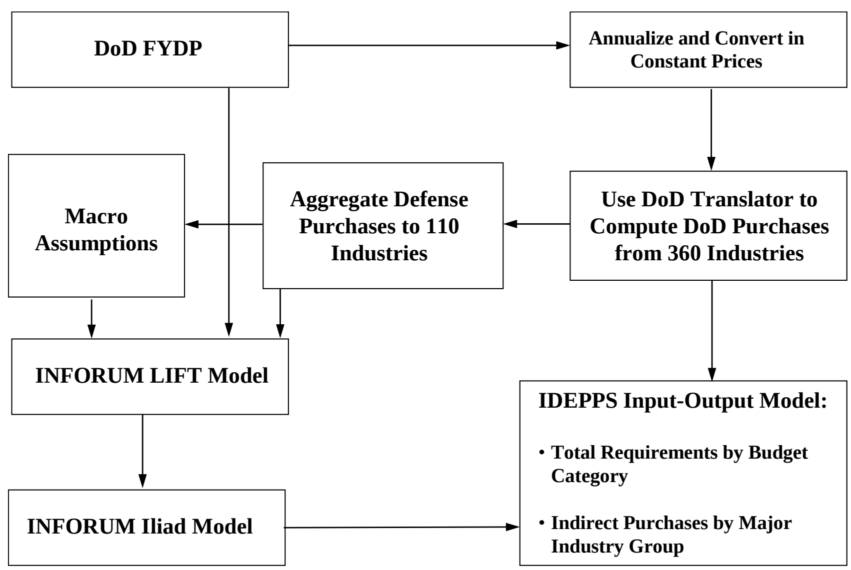

Table 4 illustrates how the translator for the Aircraft procurement budget account would allocate outlays in 2011. Note that in this example, about 79 percent of the outlays go to the three aircraft-related industries

The translators for the major accounts allow the computation, from the budget data described above, of direct defense purchases from each of the 360 industries in the system. These projections are computed in the constant dollars of the upcoming budget year.

Table 4. Estimated Distribution Among Industries of Outlays from the Aircraft Procurement Account, 2011
(In millions of 2011 dollars)

Industry Number	*Industry Title*	*2011*	*Share (%)*
198	Other communications equipment	338	0.8
201	All other electronic components	354	0.9
203	Search, detection, and navigation instruments	796	2.0
235	Aircraft	21,060	52.6
236	Aircraft engines and engine parts	3,763	9.4
237	Other aircraft parts and auxiliary equipment	6,761	16.9
273	Scenic and sightseeing transportation and support activities for transportation	665	1.7
303	Architectural, engineering, and related services	2,768	6.9
310	Scientific research and development services	337	0.8
343	Commercial and industrial machinery and equipment repair and maintenance	441	1.1
	Total	**40,074**	**100**

The *IDEPPS* projections of total defense purchases are made using the 360-sector interindustry INFORUM model. This model is used to calculate the indirect requirements of the expenditures indicated by the translator, as well as to determine what proportion of total requirements is satisfied by imports in each industry.

The interindustry model is used several times in *IDEPPS,* for the DoD purchases associated with:

- the DoD budget as whole;
- each of the major aggregate DoD budget accounts (see Table 2); and
- each of 11 aggregate industrial sectors of direct purchases (see Table 1).

The *DEPPS* report includes projections made of total production for each industry. These projections are derived from two types of data: 1) the DoD budget data used in *IDEPPS* and 2) other assumptions underlying the projections made by INFORUM in its published baseline forecasts.

2.2 RDEPPS – The State-Level Projections Component of *DEPPS*

IDEPPS addresses the question: "What industries produce goods and services required for defense?" *RDEPPS* addresses the question: "Where will this defense-related production occur?" In this component of *DEPPS*, the geographical distribution of the industry level purchases from *IDEPPS* is determined. Due to limitations in the available data, these projections are made at the level of 110 industries, which corresponds to the sectoring of the INFORUM *LIFT* model. The projections are made for each of the 50 states and the District of Columbia. Unlike *IDEPPS*, RDEPPS also determines the spending impacts of active duty and military retirement pay that is spent in the U.S.

The expenditure projections are presented in two formats. One is designed to show the level and composition of potential expenditures in individual states, and the other to show the geographic distribution of purchases from given industrial sectors.

Table 5. New Mexico Summary
(In millions of 2011 dollars)

	2009	2010	2011	2012	2013	2014	2015
AGGREGATE MEASURES							
Total Direct Expenditures (Purchases and Pay)	4,495	4,540	4,059	3,909	3,909	3,568	3,569
Indirect Defense Purchases Resulting from Direct Purchases	2,323	2,287	1,981	1,831	1,652	1,627	1,576
Indirect Defense Purchases Resulting from Pay	867	906	845	871	970	1,089	1,101
Total Nondefense Expenditures	150,059	153,774	157,399	164,030	165,140	172,265	173,211
Total Output	157,771	161,533	164,305	170,658	171,689	178,566	179,473
Government Industry Compensation	1,859	1,928	1,831	1,874	2,037	1,741	1,767
LARGEST PURCHASES BY INDUSTRIAL SECTORS							
Total Direct Expenditures (Purchases and Pay)							
85 Professional, scientific and technical services	963	980	905	860	815	782	759
13 New construction	190	207	168	153	131	122	115
14 Maintenance and repair construction	193	183	138	116	100	99	99
86 Computer systems design and related services	150	139	119	110	103	101	102
88 Administrative and support services	166	153	113	95	82	82	82
Indirect Defense Purchases Resulting from Direct Purchases							
85 Professional, scientific and technical services	378	377	342	322	304	292	287
88 Administrative and support services	360	351	302	278	260	254	254
4 Crude oil extraction	282	278	230	223	159	179	150
44 Semiconductors and other electronic components	161	157	133	115	103	97	90
25 Petroleum and coal products	105	102	86	78	69	69	67

Table 5 illustrates the format of the state expenditure projections, using the projection for New Mexico as an example. The first block of the table shows aggregate measures, in dollar value, of projected direct and indirect defense expenditures in the state during each year of the FYDP. A projection of nondefense activity and total output for New Mexico prepared by INFORUM is also provided. The second and third blocks of the table show the industrial sectors projected to lead in defense or defense-related sales over the period of the FYDP.

In 2011, some $4,059 million in direct expenditures is projected to be disbursed by DoD in New Mexico to pay its employees and reimburse its direct suppliers for the goods and services they provide. Pay to military and civilian employees accounts for a large share of DoD's expenditures in the state ($1,831 million). Indirect purchases of $1,981 are projected to result from DoD direct purchases (in whatever state) and purchases made by DoD employees in New Mexico. In terms of defense-related expenditures, the industry Professional, scientific and technical services absorbs the largest amount of both direct ($905 million) and indirect ($342 million) expenditures in 2011.

Table 6. Top 10 States in Direct Purchases of Communications and Audio-Video Equipment, 2009-2015
Ranked by 2011 Value
(In millions of 2011 dollars)

	2009	2010	2011	2012	2013	2014	2015
California	3,733	3,991	3,417	3,248	3,013	2,956	2,811
New York	1,090	1,274	967	928	864	941	908
Maryland	1,014	1,172	903	864	804	865	834
Massachusetts	602	675	550	527	491	502	477
Indiana	581	688	521	502	468	511	490
Virginia	533	564	478	452	417	414	398
Colorado	371	403	336	319	296	297	284
Iowa	349	401	316	304	283	298	285
Texas	286	333	254	244	227	247	238
Oregon	222	229	209	199	185	171	160
Top 10 Total	8,780	9,730	7,950	7,586	7,049	7,203	6,885
Total U.S.	**10,683**	**11,835**	**9,611**	**9,157**	**8,498**	**8,740**	**8,386**

Tables 6 and 7 illustrate the format of the state industry projections, using estimated purchases from the Communications and audio-video equipment sector as an example. Two tables are provided for each of 110 industrial sectors, the first showing the top 10 states in which the sector is projected to make the bulk of its direct defense sales over the projection period, and the second showing the top 10 states in which indirect sales are projected to be concentrated. Altogether, the 10 states represented in table 6 are estimated to account for 83 percent of the total direct purchases of this industry in 2011. The top 10 states in table 7 comprise 73 percent of total indirect spending in 2011.

Table 7. Top 10 States in Indirect Purchases of Communications and Audio-Video Equipment, 2009-2015
Ranked by 2011 Value
(In millions of 2011 dollars)

	2009	2010	2011	2012	2013	2014	2015
California	332	349	324	306	291	304	302
Texas	183	193	179	169	160	168	167
Oregon	135	142	132	125	118	124	123
Massachusetts	90	95	88	83	79	83	82
Arizona	76	81	75	71	67	70	70
New York	52	55	51	48	46	48	47
New Mexico	46	48	45	42	40	42	42
Minnesota	43	45	42	39	37	39	39
Florida	38	40	37	35	34	35	35
Illinois	36	38	36	34	32	33	33
Top 10 Total	1,032	1,087	1,007	952	905	947	939
Total U.S.	**1,422**	**1,498**	**1,387**	**1,312**	**1,246**	**1,305**	**1,294**

2.3 LDEPPS – The Defense-Related Employment and Skilled Labor Component of *DEPPS*

This component of *DEPPS* tracks employment generated by DoD direct hire, and from direct and indirect purchases. Note that it does not include military personnel, but deals only with civilian employment. This model uses the projected occupational employment by industry matrix to show the employment for each of about 100 occupational groups.

Questions about the effect of defense purchases on the demands for labor of various occupational groups are interesting for a number of reasons. Defense-related employment is an important segment of employment for several professional and skilled occupations. This is particularly true for certain categories of scientists and engineers. Forecasting the demand for these occupational categories can help individuals decide whether this is a good field of study in which to invest in education. For policy makers, it is helpful to know if certain occupations may be in relatively short supply, thus leading to bottlenecks or excessive wage costs.

LDEPPS employment projections are based on the projections of defense-related production combined with projected changes in labor productivity. Employment by occupation is then calculated using the occupational shares matrix. The BLS occupational shares describe, for example, what share of employment in the automobile industry will be mechanical engineers. Labor productivity is the ratio of gross constant dollar output divided by total hours worked, in each industry. *LDEPPS* relies on the productivity and employment projections calculated in the INFORUM *LIFT* model.

For each occupation, both total and defense-related employment are classified among 67 industries comprising the total economy. These 67 industries are essentially the industries in the INFORUM *LIFT* model that have employees.

Table 8 shows the projections of employment of aerospace engineers. The top half of this table shows what is called "defense-related employment". Defense-related employment of people in a given occupation or industry is defined as the sum of:

- Employment in that occupation by DoD (direct hire);
- Private sector employment in that occupation directly engaged in defense production (direct suppliers or contractors for DoD).
- Private sector employment in that occupation indirectly engaged in defense production (suppliers to the suppliers).

Shown in the lower half of the table is projected total employment (both defense and nondefense) of aerospace engineers. Nondefense employment (not shown separately) is the difference between total and defense-related employment in this category.

Table 8. Top 5 Industries Employing Aerospace Engineers
Total U.S. Employment and Defense-Related Employment
(Thousands of Workers, Ranked by Level in 2011)

	2009	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*
Defense-Related Employment							
66 Federal defense	3.67	3.67	3.66	3.66	3.66	3.65	3.65
48 Miscellaneous professional, scientific and technical services	2.14	2.11	1.84	1.69	1.57	1.50	1.46
51 Administrative and support services	0.09	0.08	0.07	0.06	0.06	0.06	0.05
49 Computer systems design and related services	0.09	0.08	0.07	0.06	0.05	0.05	0.05
29 Air transportation	0.07	0.07	0.06	0.05	0.05	0.05	0.05
Total U.S. Employment							
48 Miscellaneous professional, scientific and technical services	18.13	18.33	18.40	18.62	18.84	19.07	19.21
67 Federal nondefense	4.25	4.69	4.79	4.83	4.87	4.91	4.94
66 Federal defense	3.67	3.67	3.66	3.66	3.66	3.65	3.65
51 Administrative and support services	1.62	1.66	1.68	1.71	1.74	1.76	1.77
49 Computer systems design and related services	1.42	1.39	1.38	1.43	1.45	1.46	1.46

The format of the projections is the same for all of the 100-odd occupations included in *LDEPPS*. The Aerospace engineers occupation is a good example because employment is concentrated in relatively few industries. It is, however, unrepresentative in two respects. First, employment in most occupational categories is much more widely distributed among industries. Second, defense-related employment is about 30 percent of total employment of aerospace engineers. (This is not surprising, as DoD and defense-related employment account for over half of the output of the domestic aerospace industries). For most occupations, including other engineering specialties, the defense-related share of employment is much smaller.

Table 9 shows total employment and defense-related employment for the top 10 occupations, ranked by the share of defense-related employment in the total. Overall, defense-related employment makes up only 2.6 percent of total employment in 2011. However, for the occupations presented in this table, defense-related employment is a much larger share, ranging from 12 percent to 41 percent.

Table 9. Share of Defense-Related Employment by Occupation, 2011
(Thousands of Workers)

	Total	*Defense Related*	*Percentage Share*
TOTAL EMPLOYMENT	**150,977**	**3,938**	**2.6**
Air traffic controllers and airfield operations specialists (Occ 94)	6	2	41.2
Avionics technicians (Occ 49)	22	8	37.2
Aircraft assemblers (Occ 56)	43	13	29.9
Aircraft mechanics and engine specialists (Occ 52)	130	34	26.2
Aerospace engineers (Occ 6)	31	6	18.5
Astronomers, physicists, atmospheric and space scientists (Occ 18)	20	3	16.4
All other physical scientists (Occ 19)	20	3	15.8
Water transportation occupations (Occ 99)	85	12	13.9
Electrical and electronics engineers (Occ 9)	285	39	13.5
Model makers and patternmakers, metal and plastic (Occ 74)	14	2	12.4

3. Analytical Applications of DEPPS

As described above, *DEPPS* is comprised of a set of economic models, or tools, that interpret the impacts or results of assumptions about the level and composition of defense spending. Although used each year to make a set of baseline projections about the economic implications of the current FYDP, these tools can also be used to analyze the impacts of alternative spending assumptions. In this section, we'll review a set of examples of these analytical applications:

1. Deriving multipliers on output and jobs, by state or industry. In this type of analysis, *DEPPS* is run with two or more different sets of spending assumptions. Multipliers can be determined from this analysis which may have more general applicability.
2. Determining the impacts of base closures. Pay and spending components of base closures can be calculated which have impacts predominantly in one state. The impacts of these pay and spending reductions can be estimated using *RDEPPS*.
3. Projecting cost deflators for major spending categories. The Inforum *LIFT* and *Iliad* models also forecast prices by industry. These industry price forecasts can be weighted by the composition of the industries in the defense outlays by major budget category to estimate price changes for these categories.
4. Determining import dependence and possible bottlenecks. The import shares of most commodities in the U.S. economy have increased drastically over the last 15 years. This import dependence can be monitored using *IDEPPS*. Unacceptable levels of import dependence for certain commodities may represent possible bottlenecks that may arise if world trade were restricted in a wartime scenario.
5. Projecting DoD energy requirements. DoD is a significant consumer of motor fuel, jet fuel, distillate and residual fuel oil, as well as electricity and natural gas. The total size of the defense energy requirements can be modeled as the interaction of the level of activity and increased energy efficiency gains.

The following sections provide a brief summary and some examples of these analytical applications of *DEPPS*.

3.1 Analyzing effects of alternative spending patterns: multiplier impacts on output and jobs by industry, state and occupation

The DEPPS projections provide a rather static picture of the extent of defense-related output and jobs by industry and state, for the period of the FYDP. Given the political and budget uncertainties involved in projecting defense expenditures, it is occasionally worthwhile to examine an alternative view or scenario, where the level and composition of defense expenditures are different from the FYDP.

If enough care is given to deriving detailed assumptions about the budget, a new defense translator can be built, that incorporates the alternative assumptions at the most detailed level.[5] For example, if the commodity composition and cost of a single F16 fighter jet is known, we can estimate the differential impact on direct and indirect defense

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[5] An unpublished version of the translator is constructed at the level of 495 commodity rows, and up to 117 columns, which represent weapons programs, or categories of expenditure.

expenditures by industry of increasing or reducing the number of F16s procured in a given year.

Estimating these impacts is important. However, the derivation of a completely new translator matrix can be quite time consuming and costly. A simpler and less expensive method is the derivation of *multipliers* for a certain type of expenditure, such as Aircraft procurement. A multiplier is simply the ratio by which one economic variable increases in response to an increase in another economic variable. For example, one multiplier that may be constructed is the number of additional jobs in the aircraft industry due to a $500 million increase in aircraft procurement. Once a multiplier has been estimated, the same multiplier can be used, within certain bounds, to reliably estimate the effects of increases or decreases in certain categories of defense spending. Other multipliers that may be of interest include the effects of defense spending on:

- Real GDP
- The federal budget deficit
- Real output by industry
- Net exports by industry

Any of these multipliers may be considered in either a static or a dynamic framework. A static framework is simply a calculator based on input-output calculations that determines the amount of output, jobs or imports associated with a certain bill of goods for defense. A multiplier from this framework informs us of the level of output or jobs attributable to a given level and composition of defense spending.

However, such a multiplier is not valid in a dynamic, macroeconomic framework such as represented by the Inforum *LIFT* model. The first distinction that should be made is between the short-term and the long-term effects of spending. A given increase or decrease in defense spending, if maintained, may be expected to have smaller effects on overall GDP or employment as we move further in time, since the economy has a tendency to return to a stable growth path that tracks potential GDP. The unemployment rate has a tendency to return to 'normal' levels, although this may take several years in some cases, as in the current global economic crisis. This means that the dynamic multipliers of aggregate variables tend to become smaller over time. For similar reasons, dynamic multipliers tend to be larger in times of economic slack or recession, and smaller when the economy is booming, running at or above potential GDP.

Dynamic multipliers may be calculated by running a model such as *LIFT* with exogenous spending changes. Multipliers stemming from different types of spending can be compared. For example, increases in Aircraft procurement will have different effects from increases in Military personnel. The former is composed of purchases of durable investment goods, R&D, and engineering services. The latter is composed of a large share of active duty military pay, along with expenditures for subsistence, uniforms and other personnel needs. Both the overall aggregate impact, as well as the distribution to industries will be different in each case.

The derivation and analysis of defense spending multipliers can be a useful way to develop 'rules of thumb' that summarize the large amount of detailed information available in the defense budget and in DEPPS.

3.2 Determining impacts of base closures

The closing of a DoD base can have significant ripple effects on the local and state economy. Base personnel may move away from the area, and local industries serving the base may experience significant declines in their business. The severity of the impact is related to the extent of economic diversification of the affected area, as well as the relative size of the base in the local economy. The effect of reductions in base procurement may have an impact which affects industries at the national level. The overall impact at the national level depends on whether the base closure is a result of a reallocation of expenditures between different areas, or a reduction in total U.S. expenditures.

Determining the total effect of the closure of a single base, or a set of bases requires modeling at both the state and national level. First, assumptions need to be derived as to the effect of the base closure on expenditures and pay. A good source of publically available information on the size of total base expenditures by base and by state is the *Atlas/Data Abstract for the U.S. and Selected Areas*.[6] This publication contains information on total expenditures by state, as well as payroll outlays and grants and contracts expenditures by base. For example, in fiscal year 2009, total base expenditures at Huntsville, Alabama were $5,744 million. Of this total, $366.5 million were for payroll and $5,377.9 million were for grants and contracts. The total number of personnel at this base was 2,542, of which 218 were military, and 2,324 were civilian. At the total state level, the publication shows a more detailed breakdown of both spending and personnel. For example, pay is divided into the following categories:

1. Active duty military pay
2. Civilian pay
3. Reserve and national guard pay
4. Retired military pay

Contracts and grants are available at the following level of detail:

1. Supply and equipment contracts
2. RDT&E contracts
3. Service contracts
4. Construction contracts
5. Grants

These data can be combined to obtain a set of assumptions about the likely distribution of expenditures and pay that would be reduced through the closure of a given base.[7] Combining the assumptions on the closure of all bases nationally would provide a set of assumptions on the total reduction of pay and expenditures, and these could be allocated

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[6] This publication can be found in PDF at http://siadapp.dmdc.osd.mil/personnel/L03/fy09/09top.htm, for fiscal year 2009, the latest available at this time.

[7] For example, one might assume that the distribution of military and civilian pay in Huntsville was proportional (or at least related) to the distribution of active duty and military employees. The distribution of expenditures between the 5 categories listed above could be assumed to be the same as at the total state level, unless better data were available.

to major defense budget categories, such as Milpers, O&M, RDT&E, Procurement and Milcon.

These changes at the national level would then be processed through the defense translator, to obtain a new set of direct defense spending by industry for the *LIFT* and *Iliad* models, which would then be processed in the defense industry model *IDEPPS*.

What is different from the normal operation of *DEPPS* in projections mode is the handling of the base closure impacts at the state level. State level changes in spending by 5 major budget categories by industry are first derived, based on the distribution shown in the RDEPPS industry distribution matrix. Then *RDEPPS* would be run with these modified assumptions, to estimate the effects of the changes in spending at the state level.

Note that this technique is not only useful for estimating the effects of *reductions* in defense spending.[8] It can also be used to estimate the impact of new defense installations, if the composition of pay and expenditures can be realistically estimated. Often these expenditures can be estimated by analyzing the expenditure pattern of an already existing base that is judged to be similar to the new base.

3.3 Projecting cost deflators for major spending categories

There has long been a need for defense budget planners to understand the effects of inflation on the ultimate cost of a given budget. In particular, what price deflators should the DoD use to capture historical inflation and to budget for projected inflation? Since the DoD buys a mix of goods and services that is quite different from that of the overall economy, general measures of inflation, such as the GDP deflator, may not be appropriate for defense budgeting. Are the historical deflators developed by the Bureau of Economic Analysis (BEA) a better measure than those currently employed by the DoD? Furthermore, are the adjustments for quality change incorporated in the BEA estimates appropriate as a metric for changes in the cost of a budget? Such adjustments may overestimate the amount of cost savings implied by quality change. In this section, we review briefly the methods currently used by the DoD Comptrollers' office to project cost deflators, and discuss some alternatives.

Each year the DoD Comptroller publishes the *National Defense Budget Estimates*, known colloquially as the Green Book. The most current edition is for Fiscal Year (FY) 2012 and provides both current and constant dollar historical time series and projections for the various components of the budget. Historical data for cost deflators is available from 1970 to 2009 while projections currently extend from FY 2010 to FY 2016. The Green Book contains DoD deflators for three standard budget measures: budget authority (BA), total obligational authority (TOA) and outlays.

The DoD Comptroller has identified four "commodities" that make up the Defense budget: Military Pay, Civilian Pay, Fuel, and Other Purchases. Each commodity is associated with a separate inflation assumption, a funding policy, and, consequently, a

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[8] CBO used an earlier version of the Inforum defense modeling system in 1992 to estimate reductions in defense spending. DoD contracted with Inforum to develop estimates of base closings in 2001, but the results of this study were not published.

spendout rate. Civilian and military pay makes up about 24 percent of the DoD budget, while other purchases and fuel account for 76 percent.

All six appropriations categories in the DoD's budget are a linear combination of these four commodities. Most DoD appropriations combine two or more commodities. For example, the military personnel appropriation includes military pay and other purchases for moving expenses. The O&M appropriation includes civilian pay, fuel, and other purchases. The procurement appropriation, on the other hand, is made up entirely of the other purchases commodity. Appropriations with more than one commodity have a composite weighted-average price index.

The OMB issues inflation guidance to all government agencies based on the "Troika's" forecasts and assumptions. This "Troika" consists of the director of OMB, the secretary of the Treasury, and the chair of the Council of Economic Advisors. It makes 5-year projections on a limited number of economic statistics including the employment cost index (ECI), the GDP deflator, fuel prices, and interest rates. The OMB incorporates the Troika's forecasts into its annual defense guidance memorandum. The DoD Comptroller, in turn, issues its annual "Revised Inflation Guidance" memorandum. This guidance is used for the upcoming Programming Phase.

Civilian and military pay assumptions reflect the Troika's forecast of the Employment Cost Index (ECI) for wages & salaries. Projected civilian and military pay raises are equal to the ECI. Fuel inflation is based on the administration's estimate of Refiner's Acquisition Cost (RAC)--the average price oil refiners pay for crude oil inputs, including transportation from well to refinery. The "Other purchases" inflation is based on the Troika's forecast of the GDP deflator. The DoD, after determining the commodity mix for each appropriation, uses these assumptions and projections, the OMB-supplied DoD topline, and the projected spendout rates to calculate the outlay deflators for each appropriation and commodity.

An alternative version of defense deflators, referred to here as the input-output (I-O) based deflators, may be constructed using spending weights from the Defense Employment and Purchases Projections System (*DEPPS*), along with forecasts of prices at the detailed commodity level. As described in section 2, the industry component of *DEPPS* (*IDEPPS*) projects industrial requirements of defense purchases using a detailed 360-sector input-output model, developed by Inforum. The Inforum model makes forecasts of both outputs and prices by commodity. The I-O database is comprised of historical data from 1998 through 2009, as well as projections through the last year of the FYDP--2009 for the Fiscal Year 2011 edition of the *National Defense Budget Estimates*.

IDEPPS also makes use of a matrix known as the defense translator, which is a bridge matrix showing the distribution of defense expenditures by 11 major categories to the 360 Inforum sectors. Using detailed commodity output prices from the 360 sectors, a set of 11 defense deflators can be constructed as:

$$\mathbf{d}_t = \mathbf{p}_t'\mathbf{T}$$

where:

d is the vector of defense deflators for major budget categories;

p is the 360-order vector of commodity output prices; and

T is the 360 by 11 defense translator matrix, showing the commodity distribution of defense purchases from 11 budget categories to 360 commodity level goods and services.

Certain caveats must be kept in mind when using the I-O based deflators. No special attention is given to differences in the prices of defense versus non-defense goods. The vector p applies to all domestic output, regardless of its final destination. The matrix T does not change over time. The bridge matrix is an estimate for the 2010 distribution of defense expenditures. Despite these caveats, this deflator is useful as a benchmark, for it provides a simple estimate of what the defense budget cost growth would be if the price of output by commodity sold to defense were to grow like the total output price, which includes nondefense sales. Furthermore, by using the I-O price forecasts, projections of this deflator can be made, which could provide an alternative to GDP deflator projections.[9]

3.4 Determining import dependence and possible bottlenecks

Globalization has created an increase in both imports and exports in the U.S., with imports increasing at a higher rate than exports. As a result, a greater share of defense spending comes from purchases that are indirect. While many economists would view globalization as a chance to benefit from comparative advantage and economies of scale, defense analysts are concerned that increased foreign influence could create national security issues in the future.

Arguments against reliance of imports for defense requirements include the benefits of self-sufficiency in times of war (particularly when shipping may be disrupted), insulation from economic blackmail or sanctions, and development and maintenance of a domestic defense industrial base. One important lesson learned during past wars relates to "energy security," which attempts to ensure that supplies (such as oil) can be secured and used during times of war.

For the U.S., national security concerns relating to import dependence include general economic performance and national defense production. General economic performance relates to the idea that countries with more income/wealth can afford more security, and therefore if a country is dependent upon foreign suppliers, that creates strategic vulnerability that foreign adversaries may potentially exploit. National defense production relates to the idea that parts of the final product (such as the electronics or the airframe in a jet fighter) may be produced in foreign countries and these foreign countries could strategically supply parts that are detrimental to the U.S.

As early as 1988, the Under Secretary of Defense for Acquisition, Technology, and Logistics (USD(AT&L)) warned that the U.S. was relying on inputs from foreign sources

[9] Meade and Lile (2001) contains a more complete description of this technique, along with comparisons of these deflators with the *Green Book* and defense deflators published by the Bureau of Economic Analysis.

at an increasing rate. Policy responses to reduce the reliance on imports include stockpiling, import protection, and diversifying supply sources.

The National Defense Stockpile, which dates back to the first World War, is managed by the Defense Logistics Agency (DLA) using models developed by the Institute for Defense Analysis (IDA). Determining the goods to stockpile and their appropriate inventory levels requires detailed projections of defense and non-defense direct and indirect requirements by industry, which is conveniently provided by the Inforum LIFT and Iliad models.

The Iliad database maintains data on output, imports, exports, and many other variables at the 360 commodity level. Not surprisingly, these data show that the import share of total consumption has been increasing for most commodities since 1997. IDEPPS is used to make projections of defense requirements over the period of the FYDP and import requirements are calculated by commodity and by major spending category. Therefore, import reliance can be estimated and forecasted for the out years for specific industries or for major spending categories to see potential bottlenecks in defense production prior to conflicts, an important tool for policy makers.

Meade, Summers, and Chong (2009) used this methodology to examine the economic issues surrounding imports for U.S. defense. Numerous results were found:

- Increased reliance on imports, along with the trade deficit, have been accompanied by reduced shares of domestic mining and manufacturing capacity.
- The import share of defense (3.5 percent to 5 percent) is still substantially lower than the import share for the overall U.S. economy (17 percent).
- The import share for select commodities is 50 percent or more.

Inforum's Iliad and IDEPPS models have proven to be important tools in evaluating U.S. defense import dependence.

3.5 Projecting DoD energy requirements.

The DoD is the primary consumer of energy in the world, accounting for about one percent of natural-site delivered energy in the U.S. The DoD spent approximately $3.4 billion on energy to operate its facilities in Fiscal Year 2007 which accounted for about 63 percent of all federal facilities and buildings energy consumption (Andrews 2009).

Understanding energy requirements and costs associated with energy requirements is important to policy makers in the DoD, particularly when energy costs are increasing substantially relative to other goods and services. As energy costs have risen, Congress has implemented mandates to reduce DoD energy consumption by improving building efficiencies and reducing reliance on fossil fuels.

One way to examine the impacts of Congressional mandates on DoD energy consumption is to evaluate the effects of specific energy-saving technologies and practices by linking them to the Inforum Long-term Interindustry Forecasting Tool (LIFT) model. The LIFT model forecasts output, employment, prices, and many other variables for about 100 industries and shows their interrelationships (i.e., who buys what from whom).

Using the LIFT model, one can link energy consumption in units (such as gallons, kilowatt-hours, tons, etc.) to indicators of use (such as square feet, flying hours, number of ships, etc.), with efficiency coefficients that summarize the effects of technological efficiencies or conservation achievements. The price drivers from the LIFT model can be used to forecast prices of electricity, coal, gas, and petroleum products. These price forecasts can then be used to estimate future spending.

The LIFT model helps predict both a "status quo" situation (i.e., a situation in which there is no change in energy efficiency associated with buildings, aircraft, ships, and vehicles) and a "policy change situation (i.e., a situation in which various policy and technology changes are adopted). The difference between these two situations gives policy makers an indicator for the effects of technological changes on energy consumption.

Meade and Chong (2008) looked at the effects of technological changes on DoD energy consumption using this approach. Their findings indicate that various policies created an improvement in energy efficiency for buildings, installations, and renewable energy of about 28 percent between 1985 and 2005. Part of this decline in building energy use comes from the general decrease in square footage, while the other part of this decline is associated with the assumption that the DoD would reach the Congressionally-mandated target of 20 percent renewable energy consumption by 2020.

Meade and Chong (2008) also found that fuel associated with aircraft use would decline by approximately 181 million gallons, or 7 percent, if Congressional mandates were implemented. This was accomplished by linking flight times with aircraft and their respective fuel efficiency levels, then linking the impacts of policies on these fuel efficiency levels.

Forecasting into the future, Meade and Chong (2008) suggest that annual costs in DoD energy from FY 2007 to FY 2020 will decrease by approximately $1.3 billion.[10] This estimate is valuable to policy makers when considering the effects of Congressional mandates on DoD energy consumption.

4. Summary and Conclusions

DEPPS is a valuable set of models and databases developed by DOD and Inforum that can be used to examine many topics related to U.S. defense. IDEPPS allows analysts to investigate the effects of the planned defense budget on growth or decay in any given industry. RDEPPS allows analysts to examine the effects of defense spending by industry on state-level economic activity. LDEPPS allows analysts to translate defense-

[10] See Meade and Chong (2008) for details on the assumptions made.

related employment by industry to the occupational level to understand jobs created (either directly or indirectly) by U.S. defense.

This paper illustrates five specific ways to use DEPPS (or parts of DEPPS) to investigate particular policy questions that have been examined recently. The five specific examples included in this study are:

- Analyzing effects of alternative spending patterns: multiplier impacts on output and jobs by industry, state and occupation
- Determining impacts of base closures
- Projecting cost deflators for major spending categories
- Determining import dependence and possible bottlenecks
- Projecting DoD energy requirements

Of course DEPPS can be used in many other ways to assist defense analysts in analyzing an array of issues. For example, one could examine the impacts of environmental policies on defense sectors (similar to methods used by Meade and Chong (2008), who examined the impacts of energy policies on defense sectors). Another study could use results from DEPPS input-output models to better inform policy makers of within-industry trends to understand future technology requirements.

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