The 2012 Washington input-output study

(2012 WA I-O)

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Introduction: The 2012 Washington Input-Output Study

The 2012 input-output model is the ninth estimate of an input-output model for the Washington State economy. We published the first table (based on the year 1963) in 1967. We constructed subsequent state input-output models for 1967, 1972, 1982, 1987, 1997, 2002, and 2007. You can find copies of these models in an Excel spreadsheet on our website. We based the 1963, 1967, 1972, 1982, and 1987 models on surveys of industrial establishments in Washington State. The 1997 table was estimated using a nonsurvey approach, which was based on the structure of the 1987 table. The 2002 and 2007 tables used extensive surveys of Washington industries to provide key information about markets and sources of supply. The 2012 table was estimated using a nonsurvey approach, which was based on the structure of the 2007 model.

We divided this report into four sections:

- **Section 1** describes the input-output model for the year 2012. The state I-O table provides a detailed and complete picture of the state's economic structure, including interindustry linkages, and the economy's dependence on U.S. domestic and international markets, as well as sources of inputs.
- **Section 2** describes the industrial sectors defined in the 2012 model, and data sources and methodologies used in the construction of the model.
- **Section 3** describes the use of these input-output models for impact analysis.
- **Section 4** reports input-output model impact multipliers.

The Basic I-O Model

This input-output model represents a new estimate of the structure of the Washington economy. The 2012 WA study assembled data to construct this new model. We attempted a survey of establishments, but it didn't bring about a satisfactory sample across the 52 sectors in the model. So, we used the structure of the 2007 Washington Input-Output model, along with other basic data sources, to estimate the 2012 model. While shares of the output of Washington sectors have changed over the history of the Washington input-output models, the internal Washington interindustry structure has not exhibited dramatic change. **That's why we argue that this new model is a statistically valid estimate of the interindustry structure of the state economy.**

Section 1: The Washington Input-Output Model

The 2012 Washington State Input-Output Study produced a 52-sector model of the state economy using the North American Industrial Classification System definition of industries. In addition to the industrial sectors, the model also contains six final demand categories:

- Washington personal consumption expenditure.
- Washington private investment outlays.
- Washington state and local government expenditures.
- Sales by Washington sectors to the federal government.
- Sales by Washington sectors to elsewhere in the United States and to foreign customers.

In addition to the items above, the table below provides estimates of payments of labor income, other value added, and purchases by Washington industries from elsewhere in the United States and from foreign countries. You can download the table though the website.

Except for its lack of sector details, this table is the same as the detailed table you find at the link we referenced above. The table identifies three industry groupings (natural resources and utilities, manufacturing and construction, and trade and services), three final demand sectors (personal consumption, investment and government, and exports), and a value added sector (labor income and other value added), and imports.

Table 1-1. Aggregate 2012 Washington Input-Output Table ($ Millions)

	Resources & Utilities	Manufacturing & Construction	Trade & Services*	Personal Consumption Expenditures	Investment & Government	Exports	Total Sales
Resources & Utilities	3065	4521	2498	6730	1353	8659	26826
Manufacturing & Construction	2056	16448	21499	11537	44917	125232	221689
Trade & Services*	3323	27752	76510	155828	27131	110033	400577
Value Added	13385	60005	216472	36463	47328	0	373652
Labor Income	7616	40451	141996	0	39717	0	229781
Imports	4998	112963	83596	59536	43652	0	304746
Total Inputs	26826	221689	400575	270094	164381	243924	1327491

*Includes all the services not covered by the other two industrial groups.
Zeros: entries here not applicable to this model

- The first component is the block of interindustry transactions—the part of Table 1-1 bounded in double black lines. Estimates in this block show the flow of goods and services that are both produced and consumed among the state's industries. Another name for these transactions is "intermediate demand." This means that industries purchase these inputs to transform them into a product or service for subsequent sales.

- The second component contains the final demand sectors—the double-red-line bordered part of Table 1-1. Transactions in this block of the table represent the sales by industry to "ultimate" consumers: households, the capital goods sector (Washington investors), governments, and export markets outside the state. These final demand sectors purchase output from the producing sectors in the state economy, not for further production or resale, but for final consumption or use.
- The third component of the table contains the payments to the basic factors of production—labor, capital and land—as well as to sources of inputs located outside Washington. The yellow block bordered by shaded lines in Table 1-1 represents this component. This block includes value-added (payments to labor and other estimates of other value added), as well as imports from the rest of the United States and from foreign countries.
- The fourth block of Table I-1, colored in blue, contains other elements of the matrix related to sales and purchases.

The Input-Output Table: A Comprehensive Description of the Washington Economy

The Input-Output table constitutes a detailed set of accounts on all economic activities within the state; it portrays the flow of commodities and services between producing sectors and consuming sectors. The table thus provides a complete description of the state economy at a point in time -- 2012.

Each row in the table shows the production and sales of an industry to all industries within the state and to final demand. For example, in 2012, total output (sales) of Washington manufacturing and construction industries amounted to $222 billion. 56% of this output, valued at $125.2 billion, was exported; and 44% was sold to in-state markets. In contrast, output of trade and services industries totaled $400.6 billion, 81% higher than manufacturing and construction, but only 27% of the total output was exported, while 46% or $183.0 billion of this output was used by in-state final demand.

Each column shows an industry's purchases of goods and services from its own or other industries in the state, from factors of production including labor, land, capital and tax payments to government. Total imports from other regions in the U.S. or from overseas are a part of an industry's purchases for use in its production process. Table 1-1 shows that, in 2012, $113 billion or 51% of total purchases by Washington manufacturing and construction industries for production use were imported. In comparison, the more "local" trade and service industries imported a relatively small amount, about 21%, of their total purchases.

The sum of a row is the total output of an industrial sector. The sum of a column is the total inputs to an industrial sector. The basic accounting rule dictates that for each industry the row total (i.e., total output or sales) equals the corresponding column total (i.e., total inputs or purchases).

The Input-Output Tables: Measuring Changes in the State's Economic Structure Over Time

With a series of historical tables available for Washington (i.e., 1963, 1967, 1972, 1982, 1987, 1997, 2002, 2007 and 2012), we can observe changes in the structure of the economy over time. The change from the SIC to NAICS industry classification in 1997 complicates how we compare interindustry industrial structure over time. However, aggregate comparisons are possible. These comparisons need to be viewed with reference to the particular prevailing cyclical situation each historical table reflects. For example, 1987 and 1997 were relatively comparable years of economic expansions in Washington, while 1982 and 1972 were years when severe contractions took place. Table 1-2 shows the changing "openness," or shifts in imports and exports, of the Washington economy over the 1963-2012 period.

Table 1-2. Changing Importance of Washington External Trade, 1963-2012

	Percent Industrial Outputs Exported (All Sectors)	**Percent of Industrial Inputs Imported**		
		All Sectors	Manufacturing	Services & Trade*
1963	28.1%	19.4%	28.0%	4.5%
1967	32.2%	25.6%	35.3%	9.3%
1972	35.6%	19.4%	31.2%	5.9%
1982	37.2%	23.9%	39.1%	8.4%
1987	36.0%	22.5%	40.2%	7.9%
1997	38.2%	22.7%	48.1%	9.8%
2002	35.9%	28.3%	53.7%	17.4%
2007	41.3%	32.6%	50.5%	23.2%
2012	37.6%	29.3%	51.0%	20.9%

*Includes finance, insurance and real estate (FIRE); exclude resources, construction, transportation, communication and utilities (TCU); since 1997, include telecommunication.

Exports as a share of total industrial output in the state during the 1963-1982 period increased from 28.1% to 37.2%, and then increased modestly between 1982 and 2007. Part of the reason for a low export share in 2002 might have to do with the U.S. cyclical downturn in that year depressing the state's export markets. However, 2007 continued the long-term upward trend in the share of industrial output that was exported, with a historically high value of 41.3%. Exports in 2012 were slightly lower than in 2007, 37.6% of output. Since 1963, imports as a share of production inputs grew steadily for the state's services and trade industries; the share increased to over 20% in 2007 and 2012. For manufacturing industries in the state, the import share of production inputs has also risen significantly, reaching 51.0% in 2012.

We can conduct more detailed analyses at the individual sector level that show shifting patterns of exports to other regions in the U.S. and to overseas markets. We can also do this for changes in imports from the rest of the U.S. and from foreign producers.

Section 2: The 2012 Washington Input-Output Table: Methodology and Data

The 2012 Washington Input-Output Study was based on a combination of data sources. The first step involved defining the sectors that we used in model development (Table 2-1). The second step was developing a survey of establishments, to estimate purchases and sales distributions. However, this survey did not result in a robust sample. So, we instead relied largely on basic data from the 2007 Washington Input-Output model to define final demand composition and input proportions. At the same time, we estimated output, value added and employment for each sector. Data sources for the estimation were: the 2012 Economic Census, Bureau of Economic Analysis state employment, income, and gross domestic product by state series, and other miscellaneous reports from trade associations and government (Table 2-2).

Step 1: Define 2012 industrial sectors

Over time, new industries evolve or old industries decline in the state economy. Existing establishments may change their production processes to adapt to new technologies or to shifting markets. These changes required examination of industrial sectors in the new I-O table, because in the I-O concept every industrial sector is assumed to be homogeneous. Homogeneity means all establishments in the sector have a similar production process or input/purchasing pattern. Empirically, limitations in data availability may force adoption of more aggregate industrial sectors. After all these considerations, we defined the sectoring plan for the 2012 table (as shown in Table 2-1). This is the same sectoring plan we used in the 2007 table. In the 2007 table, two of the sectors in the 2002 table were disaggregated into more detailed sectors. We divided the construction into highway, street and bridge construction, and all other construction. We divided retail trade into nonstore retailers, and all other retail trade.

Table 2-1. 2012 Washington Input-Output Study Sectoring Plan

Industry Name	NAICS Code
1. Crop Production	111
2. Animal Production	112
3. Forestry and Logging	113 (Incl. DNR and USFS.)
4. Fishing, Hunting and Trapping	114
5. Mining	21
6. Electric Utilities	2211 (Incl. local public utilities and Bonneville Power Administration)
7. Gas Utilities	2212
8. Other Utilities	2213 (Incl. local public utilities)
9. Highway, Street and Bridge Construction	2373
10. Other Construction	236-238 except 2373
11. Food, Beverage and Tobacco Manufacturing	311, 312
12. Textiles and Apparel Mills	313, 314, 315
13. Wood Product Manufacturing	321
14. Paper Manufacturing	322
15. Printing and Related Activities	323
16. Petroleum and Coal Products Manufacturing	324
17. Chemical Manufacturing	325
18. Nonmetallic Mineral Products Manufacturing	327
19. Primary Metal Manufacturing	331
20. Fabricated Metals Manufacturing	332
21. Machinery Manufacturing	333
22. Computer and Electronic Product Manufacturing	334
23. Electrical Equipment Manufacturing	335
24. Aircraft and Parts Manufacturing	3364
25. Ship and Boat Building	3366 (Incl. federal Puget Sound Naval Shipyard)
26. Other Transportation Equipment Manufacturing	3361, 3362, 3363, 3365, 3369
27. Furniture Product Manufacturing	337
28. Other Manufacturing	316, 326, 339
29. Wholesale	423-425
30 Non-Store Retail	454
31. Retail	44-45 except 454
32. Air Transportation	481
33. Water Transportation	483 (Incl. WA State Ferry System)
34. Truck Transportation	484
35. Other Transportation/Postal Offices	482, 485, 486, 487, 491, 492 (Incl. local transit and U.S Postal System)
36. Support Activities for Storage, Transportation and Warehousing	488, 493
37. Software Publishers & Data Processing, Hosting and Related Services	5112, 5182
38. Telecommunications	517
39. Other Information	5111, 512, 515, 516, 519
40. Credit Intermediation and Related Activities	521, 522
41. Other Finance and Insurance	523, 524, 525
42. Real Estate and Rental and Leasing	53
43. Legal /Accounting and Bookkeeping / Management Services	5411, 5412, 5416, 5418, 5419, 55
44. Architectural, Engineering and Computing Services	5413, 5414, 5415, 5417
45. Educational Services	61
46. Ambulatory Health Care Services	621
47. Hospitals	622
48. Nursing and Residential Care Facilities, Social Assistance	623, 624
49. Arts, Recreation and Accommodation	71, 721
50. Food Services and Drinking Places	722
51. Administrative/Employment Support Services	561
52. Waste Management/ Other Services, and Agriculture Services	562, 81, 115

Step 2: Compile the target-year data and information on Washington industries

We compiled data on 2012 industrial output, value-added, government expenditures, consumption by Washington residents, capital (investment) spending, and external trade (exports and imports). Sometimes industrial details can only be derived through inferring, interpolating or extrapolating from available, but more aggregate estimates. Table 2-2 shows the data categories and the respective data sources used for construction of the 2012 model.

Table 2-2. Input Data for The Target Year (2012)

Data Categories	Data Sources
Industrial Output	2012 Economic Census – Industrial Shipment $ 2012 Agricultural Census – Industrial Shipment $ Washington State Dept. of Agriculture – annual agricultural production and sales by crop type Washington Dept. of Revenue – Gross Business Income reports Bureau of Economic Analysis – 2012 U.S. Input-Output (Use) Table Washington Insurance Commissioner – Revenue and margins of insurance businesses
Value Added	Bureau of Economic Analysis – 2012 gross domestic product Bureau of Economic Analysis – 2012 labor earnings series Washington Employment Security Department – ES202 Wage and Salary series
Personal Consumption Expenditures	Bureau of Economic Analysis – 2012 National Income and Product Accounts Bureau of Economic Analysis – 2012 State personal income Series
Government Spending	Census Bureau – 2012 State and Local Government Expenditures series Census Bureau – 2012 Federal Government Expenditures reports Washington Office of Financial Management – state government expenditures accounting records Washington State Employment Security Covered Wages and Salaries data series
Investment	Census Bureau - Building Permit report Washington Dept. of Revenue – abstract of county Assessed Values report Washington Dept. of Revenue – taxable sales database Bureau of Economic Analysis – 2012 U.S. Input-Output (Use) Table
Exports and Imports	The World Institute for Strategic Economic Research export 2012 database

Step 3: Development of Sales and Purchases Distributions

Step 2 developed "control values" from the various sources we described above, including sectoral output (sales), value added and labor income. We analyzed the structure of final demand (personal consumption expenditures, investment, state & local government, federal government, exports to other states in the United States, and foreign exports) for each sector using data from the 2002 and 2007 Washington input-output models. We also documented the share of intermediate sales by sector from the 2002 and 2007 models. We determined a draft sales distribution for each sector through these analyses.

We also focused on the share of intermediate purchases, value added, labor income, other value added, imports from the rest of the United States, and from foreign countries reported in the 2002 and 2007 Washington input-output models. Data from Step 2 provided actual values for value added, labor income and total purchases. Initial estimates of total intermediate purchases and imports were made based on these analyses.

We summed initial estimates of intermediate sales and purchases. We slightly adjusted initial total intermediate sales and purchases so that these totals were identical. We adjusted exports and imports to achieve balanced intermediate sales and purchases distributions.

Step 4: Development of new transactions table

The columns in the 2007 intermediate transactions matrix was divided by total intermediate purchases in each sector, yielding coefficients documenting the share of purchases in each sector made from each other sector. We then multiplied these values by 2012 total intermediate purchases in each sector. This resulted in estimated 2012 intermediate purchases in each sector.

We converted the resulting intermediate transactions matrix into a direct requirements matrix then used it to calculate a direct and indirect requirements matrix. We then compared multipliers from this matrix to the 2007 model. The average multiplier in the 2007 model was 1.916, while the average multiplier in the 2012 model was 1.938, a difference of 1.1%. Figure 2-1 is a scatter gram of values for each sector in the 2007 and draft 2012 models. The correlation between the two estimates is .89.

Figure 2-1: Correlation of 2007 and 2012 Output Multipliers

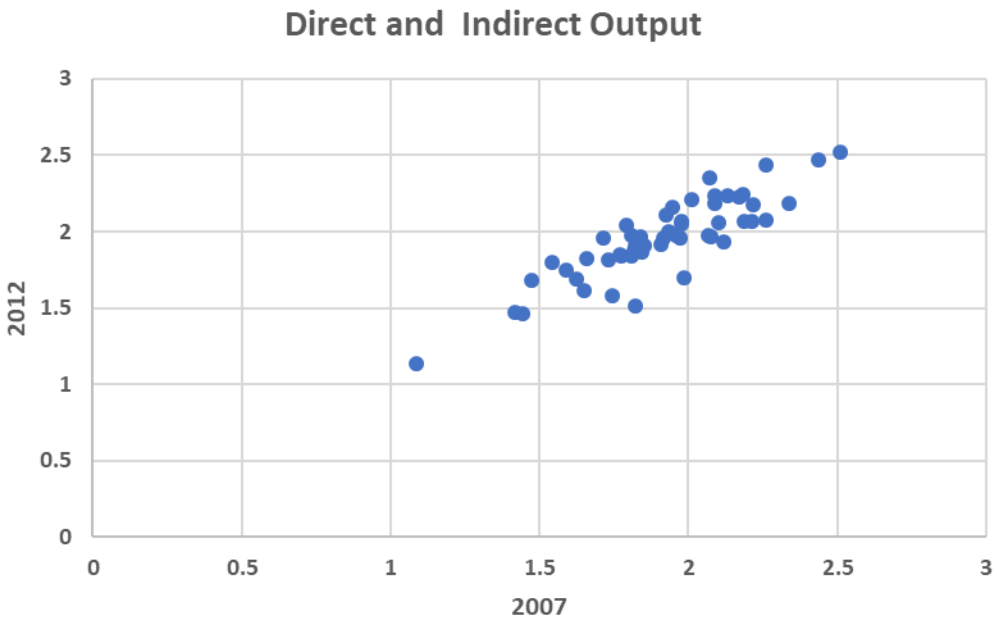

Figure 2-1 depicts a scatter gram of multiplier values for each sector in the 2007 and 2012 models. The correlation between the two estimates is .89.

The initial regional data estimates in Table 2-2 underwent a number of adjustments. For example, we included the Washington State ferry system in the water transportation sector. The Bremerton Naval Yard was also included in shipbuilding. We introduced data into the transaction matrix for cases of this type, and defined their most likely markets and sources of supply defined. The resulting matrix of interindustry transactions has slightly lower estimated regional purchases as a share of sales (24.3%) than the 2007 Washington input-output model (25.2%). However, the share of intermediate purchases closely tracks the history of Washington's input-output models. We included labor income in the computation of the direct, indirect and induced requirements matrix, along with intermediate purchases. The combined proportion of total purchases accounted for by intermediate purchase and labor income are very similar in the 2007 and 2012 models, .537 and .536 respectively.

Figure 2-2: Intermediate Purchases as a Share of Washington Total Industrial Input, 1963-2012

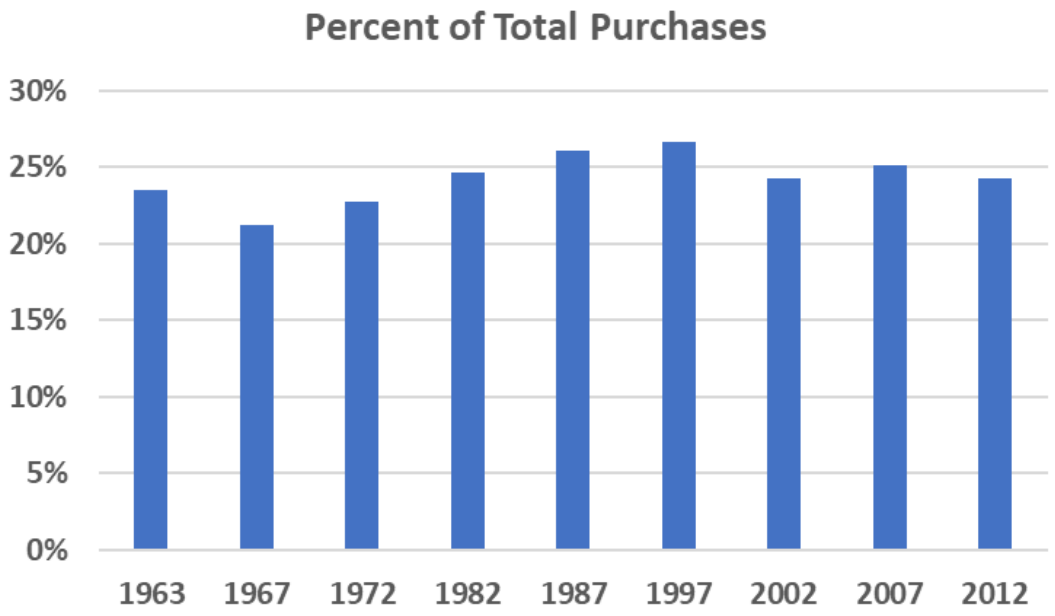

Figure 2-2 depicts the combined proportion of total purchases accounted for by intermediate purchase and labor income and are very similar in the 2007 and 2012 models, .537 and .536 respectively.

Section 3: The Washington Input-Output Tables for Impact Analysis

The most common application of regional input-output tables is impact analysis. In most cases, the sole reason for constructing a regional I-O table is to use it as an analytical tool for conducting economic impact analysis. The analysis measures the changes in output (i.e., production), employment, and labor income in all state industries as a consequence of: (1) known demand changes in the output of some particular industries in the state—the **Simple Analysis**; or (2) a new activity or industry not identified in the input-output table—the **Complex Analysis**. The complex analysis procedure presumes that the output, employment, labor income and first-round purchases of the activity/project are known.

We provided an impact spreadsheet file for downloading. This file contains three sheets we used to perform the simple analysis and the complex analysis, respectively: We also presented two versions of the simple model. The Type I model can be used to estimate direct and indirect impacts of interindustry linkages in the Washington economy, while the Type II model captures the impacts of labor income and personal consumption expenditures. The complex model makes use of the Type II model to compute impacts.

"Simple" and Complex" impact worksheet

To be used as a tool for economic impact analysis, the I-O table needs to be transformed into an analytical "model." This model should be able to quantify how an external change in final demand will invoke a chain of reactions in the economy: the demand-induced increase in one industry's output will require it to raise its inputs/purchases, which then raises the demand for other industries' output and their purchases of inputs, and so on. The chained reactions are generally referred to as the "ripple effect." The interindustry transaction or intermediate demand part of an I-O table (component 1 of Table 1-1) actually serves this purpose, and thus is used as the core of the I-O impact model.

The first step to build an I-O impact analysis model is to convert the interindustry transactions into "direct purchase coefficients." We do this by dividing each interindustry transaction in Table 1-1 by the respective industry's total input (i.e., value in the last cell of the industry column). Table 3-1 contains the resulting industries' direct purchase coefficients for the aggregate Type II Washington input-output model. For example, in the manufacturing/construction industry column, the value in the first cell shows the ratio of the purchases of natural resource/utilities industry inputs by manufacturing/construction industry to total manufacturing/construction input; the value is 0.01835 (=4,067/221,689) (the transaction values can be found in Table 1-1).

Each coefficient (a_{ij}) can be interpreted as the proportion of industry *j*'s total production input supplied by industry *i*. So the value of a_{12} implies that the manufacturing/construction industry

requires $1.84 cents of natural resource/utility products from Washington establishments for every dollar of the manufacturing/construction industry's total input.

Entries in the fourth row are labor earnings as a portion of the industry's total input payments. The fourth column contains entries showing personal consumption of industry *i*'s product as a portion of total labor income.

Table 3-1. 2012 Washington Direct Purchase Coefficients Table

(Dollars Purchased Per Dollar of Total Input)

	Resources & Utilities	Manufacturing & Construction	Trade & Services	Personal Consumption
Resources & Utilities	0.11424	0.02039	0.00624	0.02929
Manufacturing & Construction	0.07664	0.07420	0.05367	0.05021
Trade & Services	0.12388	0.12518	0.19100	0.67816
Labor Income	0.28391	0.18247	0.35448	0.00000

The interindustry transactions or output needed to satisfy a given level of gross output can be shown as:

$$O = AX$$

where A denotes a matrix containing the direct purchase coefficients, X is a vector consisting of the industries' gross output; and the product O is a vector containing the intermediate demand for industries' output.

An industries total output (X) equals the sum of the intermediate demand for its output and the total final demand for its output:

$$X = O + D$$

where D denotes a vector containing total final demand (including exports) for each industry's output. The two equations can be combined:

$$AX + D = X$$

and then rearranged as follows:

$$D = (I - A)X$$

leading to:

$$X = (I - A)^{-1}D$$

and thus $\Delta X = (I - A)^{-1}\Delta D$

The last equation indicates a change in total output as the product of a change in total final demand multiplied by $(I-A)^{-1}$. The inverse matrix $(I-A)^{-1}$ is generally referred to as the *"Leontief Inverse"* in input-output modeling. Table 3-2 shows the inverse matrix for the 2012 three-sector aggregate I-O Table. The elements in this matrix are "total requirement coefficients." For example, values in the second data column of the table show that, for a one-dollar increase in final demand for the state's manufacturing/construction sector, local resources/utilities and trade/services industries have demands that raise their output by $0.04319 and $0.52129, respectively.

Table 3-2. 2012 Washington State Inverse (Total Requirement) Coefficients Table

(Total Dollars of Input per Dollar of Output)

	Resources & Utilities	Manufacturing & Construction	Trade & Services	Personal Consumption
Resources & Utilities	1.15832	0.04319	0.03928	0.06273
Manufacturing & Construction	0.17096	1.13586	0.14777	0.16225
Trade & Services	0.71941	0.52129	1.84523	1.29860
Labor Income	0.61507	0.40430	0.69221	1.50774

Once an Inverse I-O matrix is derived, total impact of a proposed project or activity on the state economy can be estimated by multiplying this matrix by changes in the final demand caused by the respective project/activity. We implemented this computation in the impact spreadsheets.

Magnitudes of the estimated impact vary by the degree of model closure. The model we developed in this study produces what we generally referred to as the "type II" impact estimates. Basically, the impact estimation captures the interindustry ripple effects and earnings-induced changes in personal consumption. The model excludes the effects on the government sector and on investment spending. Other I-O models that incorporate government and/or investment will result in higher impact estimates.

Limitations of Input-Output Impact Analysis

The input-output model for impact analysis inherits all of the properties of an input-output table:

- The input-output table represents a static depiction of the economy at a point in time.
- The linear, fixed-proportion production function implied in an input-output table dictates constant returns to production scale.
- No substitution between intermediate goods, capital and labor inputs.
- The assumption of additivity (i.e., total output is the sum of the individual output) among industrial sectors excludes the consideration of external economies or diseconomies.

All of these properties, or assumptions, impose restrictions on the uses of input-output models for impact analysis:

(1) The model will better approximate the economy the closer to the year for when the model is constructed. In other words, the farther away from the model year, the less accurate the impact estimation would be.

(2) The model assumes a fixed employment-to-output ratio at the industry level and uses these ratios to calculate employment impact. Moving away from the model year, growth in labor productivity would increasingly reduce the validity of using these fixed ratios to estimate employment impact.

(3) The model assumes local supply is perfectly elastic, meaning there is no capacity problem. For this assumption to be upheld, the projects or activities to be assessed need to be small or marginal relative to the economy's production input system. Otherwise, the projects will disrupt equilibrium prices, leading to significant factor or import substitution.

(4) I-O analysis estimates total impact from an external change in final demand. For projects that bring into the state investment money or other spending from outside the state and thus result in direct external changes in final demand, using an I-O model to estimate total economic impact caused by these projects is straightforward. When the project's funding is not external, such as a local government investment activity funded by tax dollars, the impact needs to be evaluated on both the activity (positive effect) and the corresponding funding (taxes' negative effect on consumption) to derive a "net" impact.

Section 4: The Input-Output Impact Multipliers

An impact multiplier is defined as the ratio of an industrial sector's or a project's total impact to its direct impact. Expressed as single numbers, multipliers are used as a quick reference for a summary measure of estimated total impacts; thus they lack industrial details.

There are numerous types of Input-Output impact multipliers. Table 4-1 shows the four most widely used multipliers obtained from the aggregated three-sector 2012 Washington I/O table presented in previous chapters (Table 1-1, Table 3-1 and Table 3-2).

Table 4-1. 2012 Washington State Input-Output Multipliers
Three Sector Model

	Total Jobs (per $ Million direct output)	Total Employment (per direct job)	Total Labor Income (per $ direct output)	Total Output (per $ direct output)
Natural Resources / Utilities	11.040	2.210	0.692	2.049
Manufacturing / Construction	6.312	2.790	0.404	1.700
Trade and Services	13.016	1.924	0.692	2.032

The formal definitions of these multipliers are:

1. **Total jobs multiplier** (jobs per $million direct output). Total number of jobs (wage and salary workers, and proprietors) generated in all sectors of the economy per million dollars of the industry's direct output change in the economy.

2. **Total employment multiplier** (jobs per direct job). Total number of jobs (wage and salary works and proprietors) generated in all sectors of the economy per direct job change in the industry.

3. **Labor income multiplier** ($ earnings per $dollar direct output). Total labor income (wages, salaries, proprietor's income and other labor income) generated in all sectors of the economy per dollar of direct output change in the industry.

4. **Total output multiplier** ($output per $dollar direct output). Total output generated in all sectors of the economy per dollar of direct output change in the industry.

We reported multipliers for all industries defined in the Washington State Input-Output Table in Table 4-2. Again, as we discussed in Chapter 3, the input-output model is a Type II model, which treats households as an endogenous part of the model. So the multipliers presented here are Type II multipliers.

Table 4-2. 2012 Washington State Input-Output Multipliers

		Jobs /$Mil Output	Total / Direct Job	Output /$FD	Total Labor Income /$FD
IO-01	Crop Production	12.45	1.53	2.09	0.66
IO-02	Animal Production	3.02	3.10	2.10	0.44
IO-03	Forestry and Logging	2.41	4.40	2.44	0.69
IO-04	Fishing, Hunting and Trapping	4.07	2.15	1.90	0.51
IO-05	Mining	10.98	1.52	1.95	0.57
IO-06	Electric Utilities	1.50	4.43	1.97	0.60
IO-07	Gas Utilities	2.96	2.07	1.62	0.26
IO-08	Other Utilities	3.35	2.63	1.87	0.56
IO-09	Highway, Street and Bridge Construction	3.47	3.01	2.12	0.61
IO-10	Other Construction	3.95	2.74	2.09	0.58
IO-11	Food, Beverage and Tobacco Manufacturing	2.07	3.27	1.82	0.34
IO-12	Textiles and Apparel Mills	3.22	2.70	1.86	0.55
IO-13	Wood Product Manufacturing	2.68	3.29	2.20	0.48
IO-14	Paper Manufacturing	1.26	4.15	1.76	0.33
IO-15	Printing and Related Activities	2.33	3.34	1.89	0.57
IO-16	Petroleum and Coal Products Manufacturing	0.07	11.21	1.14	0.05
IO-17	Chemical Manufacturing	1.85	3.13	1.67	0.43
IO-18	Nonmetallic Mineral Products Manufacturing	2.97	2.37	1.70	0.38
IO-19	Primary Metal Manufacturing	1.50	4.06	1.81	0.36
IO-20	Fabricated Metals Manufacturing	3.70	2.29	1.78	0.46
IO-21	Machinery Manufacturing	1.96	3.40	1.80	0.39
IO-22	Computer and Electronic Product Manufacturing	1.87	3.35	1.69	0.55
IO-23	Electrical Equipment Manufacturing	1.92	3.32	1.76	0.39
IO-24	Aircraft and Parts Manufacturing	2.09	2.42	1.47	0.37
IO-25	Ship and Boat Building	2.60	3.20	1.92	0.54
IO-26	Other Transportation Equipment Manufacturing	2.08	3.28	1.80	0.37
IO-27	Furniture Product Manufacturing	4.63	2.24	1.93	0.63
IO-28	Other Manufacturing	3.32	2.57	1.86	0.54
IO-29	Wholesale	5.29	1.97	1.80	0.57
IO-30	Non-Store Retail	8.38	1.42	1.56	0.39
IO-31	Other Retail	9.13	1.64	1.92	0.61
IO-32	Air Transportation	1.66	2.81	1.58	0.30
IO-33	Water Transportation	3.53	2.68	2.07	0.52
IO-34	Truck Transportation	5.70	2.02	2.05	0.56
IO-35	Other Transportation/Postal Offices	3.16	2.86	2.04	0.66
IO-36	Support Activities for Storage, Transportation and Warehousing	5.67	2.17	2.07	0.66

Table 4-2. 2012 Washington State Input-Output Multipliers *(continued)*

		Jobs /$Mil Output	Total / Direct Job	Output /$FD	Total Labor Income /$FD
IO-37	Software Publishers, Data Processing & Internet Service Providers	1.72	4.67	1.95	0.64
IO-38	Telecommunications	1.55	2.96	1.61	0.32
IO-39	Other Information	0.97	7.88	2.35	0.55
IO-40	Credit Intermediation and Related Activities	2.09	3.31	1.82	0.40
IO-41	Other Finance and Insurance	10.47	1.89	2.36	0.78
IO-42	Real Estate and Rental and Leasing	10.22	1.39	1.62	0.46
IO-43	Legal /Accounting and Bookkeeping /Management Services	10.23	1.91	2.42	1.22
IO-44	Architectural, Engineering and Computing Services	6.69	2.19	2.20	0.96
IO-45	Educational Services	11.62	1.62	2.17	0.73
IO-46	Ambulatory Health Care Services	7.80	2.24	2.44	1.05
IO-47	Hospitals	4.77	2.66	2.18	0.78
IO-48	Nursing and Residential Care Facilities, Social Assistance	16.94	1.45	2.20	0.81
IO-49	Arts, Recreation and Accommodation	13.41	1.49	2.00	0.68
IO-50	Food Services and Drinking Places	12.58	1.53	2.10	0.64
IO-51	Administrative/Employment Support Services	12.92	1.61	2.24	0.93
IO-52	Waste Management/Other, and Agriculture Services	8.50	1.86	2.16	0.70

Reviewer comments

Eric Whitaker and Pete van Moorsel, Joint Legislative Audit and Review Committee

Thank you for the opportunity to review the Washington I-O model.

We tested the I-O worksheet using the simple and the complex analysis. In each instance, we compared the I-O results to similar analyses we completed in REMI's 170- sector statewide model. The results of each of the parallel analyses were sufficiently similar: they did not immediately give rise to any questions of the IO model. A summary of these analysis is below:

Simple analysis

We completed the simple impact analysis for the 2012 update to the Washington I-O model by replicating an impact analysis we ran in 2016 using REMI's Tax-PI model. That project involved running a few different scenarios where the ship and boat building sector (NAICS 3366) saw reduced output due to potential changes in Washington's ferry procurement practices.

In Table 1 of the Simple Analysis tab on the I-O Impact worksheet, we *reduced* the sector's output in 2019 by an equivalent amount. Following the ripple effects of this reduction in the sector's output, the I-O model shows a pattern of contraction like what we observed using REMI. Specifically, the state economy saw similar reductions in overall output, aggregate income and total employment. The ship and boat building sector in the 2012 I-O model saw a smaller employment reduction than the same industry in REMI, but we do not see any major issues with the underlying structure or the estimates of the I-O model.

Complex analysis

We also tested the complex analysis, again using REMI as a comparison. In this case, we used the baseline REMI model to extract the output, employment and labor income, as well as an estimate of first-order purchases, for an existing industry (coal mining). We used both models to estimate the impact of a doubling of the output of that relatively small industry.

Because our REMI version includes more detailed industry classifications, we collapsed these to the 52 industry classifications used in the IO model. We omitted-the first order purchases from government and military, as these are not included in the IO model. As detailed in the instructions, we entered the 2019 output, employment, and estimated labor income in columns C, F and G. We placed the estimated first-order purchases for the coal mining industry in Column B of Table 2.

We ran a comparative analysis using our REMI model. We created a custom REMI industry identical to the coal mining industry, less the intermediate purchases from the government sectors. And, we increased the output for that custom industry by the same output used in the IO model.

The REMI scenario presented higher output and personal income figures, but a lower employment figure. However, the results were certainly comparable. We suspect the differences may be explained by differences in the IO matrices underlying our 2020 REMI and the 2012 IO models. Still, the similarities between model results do not give rise to any immediate questions about OFM's model. Thanks again for the opportunity to provide feedback. We certainly hope our comments are helpful.

Jeff Mitchell, Senate Ways & Means Committee Washington State Legislature

Thank you for providing a chance to review the model. I ran a couple old scenarios that I saved and got pretty similar results.

I do have one structural recommendation: Would it be possible to include a simple analysis that also provides a Type 1 analysis?

Response: *A type-1 model, which isolates the inter-industry effects is now included in the 2012 WA IO model.*

Hart Hodges, Western Washington University

Everything seemed to function fine. On the simple analysis tab for procedure 1, perhaps clarify that you need to enter the output change. Or, if that change is not known but the change in employment is known, go to procedure 2. Alternatively, perhaps add a note above the two procedure descriptions to tell the user when to use which procedure (and not both).

Response: *Instructions on how to input the required data are included, and have been clarified, at the top of the Simple and Complex analyses worksheets.*

The study explains that the shares of output of Washington sectors have changed over time, yet the interindustry structure has not changed significantly. Can this hypothesis be tested?

Response: *A structural change analysis is underway that will study industry sector changes over time.*

There are numerous references to the 2012 Economic Census (and other years). Many people do not know who does the census or the frequency. It might help to note when the Census Bureau conducts its economic census.

Response*: We have clarified data sources and years.*

Dick Conway (retired), The Puget Sound Economic Forecaster

I spent my time checking the table. Since the balancing method is only as good as the control totals, I initially planned to look at the final demand and output estimates. Except for state and local expenditures, I thought the final demand estimates looked reasonable. Since Washington is a low-tax state, I expected that — as a percent of gross domestic product — state and local expenditures would be less than U.S. expenditures.

I did notice that your estimate of Washington GDP ($373.7) is less than Washington GDP ($400.6) reported by BEA. Since BEA reports Washington GDP (value added) by industry, I decided to compare your estimates with theirs.

Response:
The differences in magnitudes is due to the transfer of some value added from state/local and federal government to select private sectors. The value-added dollars that were transferred from state/local and federal government to the private sectors include those in ship and boat building, courier services, ferry and marine systems, and forestry. These transfers reduce our state and local government and federal government thus making them lower than that reported by the Bureau of Economic Analysis.

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