THE
2007 WASHINGTON INPUT-OUTPUT STUDY

(2007 WA I-O)

By

Dr. William B. Beyers
Dr. Ta-Win Lin

in association with

Marc Baldwin - Washington State Office of Financial Management
Jim Schmidt - Washington State Office of Financial Management
Lorrie Brown - Washington State Office of Financial Management
Don Brunell - Association of Washington Business
Bret Bertolin - Washington State Economic and Revenue Forecast Council
Greg Weeks - Washington State Employment Security Department
Alexander Roubinchtein - Washington State Employment Security Department
Robert Haglund - Washington State Employment Security Department
Ray Philen - Washington State Department of Revenue
Steve Smith - Washington State Department of Revenue
Lizbeth Martin-Mahar - Washington State Department of Transportation
Daniel Malarkey - Washington State Department of Commerce
Nothstein, Greg - Washington State Department of Commerce
Dave Wallace - Washington State Department of Commerce
Cameron Crump - Washington State Department of Agriculture
Mary Welsh - Joint Legislative Audit and Review Committee
Rick Peterson - - Washington State Legislature/House of Representatives

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Introduction
The 2007 Washington Input-Output Model

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In 2010, seven state agencies[1] and the legislative staff, under the direction of University of Washington Geography Professor, Dr. William Beyers, and Office of Financial Management (OFM) Assistant Director of Forecasting and Research Division, Marc Baldwin, initiated the estimation of a new version of the Washington State Input-Output model (I-O). OFM staff member Dr. Ta-Win Lin served as the project coordinator.

The Basic I-O Model

This input-output model represents a new estimate of the structure of the Washington economy. Economists from participating state agencies[2] helped conceptualize the new modeling effort, and helped compile, estimate, and review data and industry information used as inputs for this model. At the heart of this new model was a survey of businesses in the Washington economy. Over 2,500 establishments responded to this survey. The survey data were used with other benchmark information to create the new input-output model.

Chapter 1: The Washington Input-Output Table for 2007

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. Chapter 1 describes the 2007 table.

Chapter 2: Developing the 2007 Washington Input-Output Table –Methodology and Procedures

The 2007 study represents the eighth estimate of an input-output model for the Washington economy. The first table (based on the year 1963) was published in 1967. Subsequent state input-output tables were constructed for the years 1967, 1972, 1982, 1987, 1997 and 2002. The 1963, 1967, 1972, 1982, and 1987 tables were largely based on surveys of industrial establishments in Washington state. The 1997 table was estimated using a non-survey approach, and was based on the structure of the 1987 table. The 2002 and 2007 models have used extensive surveys of Washington industries to provide key information about markets and sources of supply. This survey data was supplemented by many other data sources to develop the input-output table and model reported here for the year 2007. Chapter 2 describes the industrial sectors defined in the 2007 table, and data sources and methodologies used in the construction of the table.

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[1] Including Washington State Office of Financial Management (OFM), Department of Agriculture (AGR), Economic and Revenue Forecast Council (ERFC), Employment Security Department (ESD), Department of Revenue (DOR), Department of Transportation (DOT), and Department of Commerce (DOC).

[2] Jim Schmidt (OFM), Lorrie Brown (OFM), Cameron Crump (AGR), Bret Bertolin (ERFC), Greg Weeks (ESD), Alexander Roubinchtein (ESD), Dave Wallace (ESD), Robert Haglund (ESD), Mary Welsh (JLARC), Ray Philen (DOR), Steve Smith (DOR), Eric Meale (DOT), Greg Nothstein (DOC), Rick Peterson (LEG).

Chapter 3: Input-Output Models as a Tool for Regional Impact Analysis

The input-output table provides estimates of the interdependence of industrial sectors in the state economy. It reports the distribution of sales and purchases of each sector in the state economy. It reports business sales to industrial sectors and to final demand categories (households, investors, and governments) located in Washington State, as well to markets outside Washington state (exports to other parts of the United States, to foreign countries, and to the federal government). The table also identifies purchases made by sectors from Washington industries, payments of labor income and other value added, and purchases made out-of-state.

The input-output table can then be used to build a model that traces out the circular flows associated with these purchases and sales relationships. The input-output model can be formulated so that it can be used as an analytical tool allowing estimation of ripple effects on the state economy as a result of these interdependencies. Two spreadsheets are provided that assists users in conducting economic impact analysis with this model – one for simple analysis and another for complex analysis. Chapter 3 discusses these impact models and describes how to use them.

Chapter 4: Employment, Income, and Output Multipliers by Industry

The estimated ripple effects on the state economy resulting from an external change can be summarized into the "multiplier" concept. Input-output models can be used to estimate various types of multipliers. They simply show, given a specified economic change, the total impact on the state economy. This impact can be depicted in several ways, and Chapter 4 reports several estimates of multipliers for quick reference. In this chapter, employment, income, and output multipliers are reported.

Chapter 1
The Washington Input-Output Tables

The 2007 Washington State Input-Output (I-O) Study produced a 52-sector model of the state economy using the 2007 North American Industrial Classification System (NAICS) definition of industries. In addition to the industrial sectors, the model also contains six final demand categories (Washington personal consumption expenditures, Washington private investment outlays, Washington state and local government expenditures, sales by Washington sectors to the federal government, and sales by Washington sectors to elsewhere in the United States and to foreign customers). In addition to estimates of purchases from industrial sectors within the Washington economy, the table also 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.

The table can be downloaded through the following link: *2007 Washington I-O Table*

For illustrative purposes, a highly aggregated version of the 2007 Washington I-O table is shown in Table 1-1 below. Except for its lack of sector details, this table is the same as the detailed table found at the online link 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, other final demand, and export), a final payment sector (total of labor earnings and other value added), and imports.

Table 1-1
Aggregate 2007 Washington Input-Output Table

$ Millions	Resources & Utilities	Manufacturing & Construction	Trade & Services	Personal Consumption	Investment & Government	Exports	Total Output
Resources & Utilities	1952.7	4210.1	2150.7	6255.6	1519.8	8165.4	24254.4
Manufacturing & Construction	2101.1	19751.9	21152.5	10587.4	51658.6	121338.6	226590.0
Trade & Services	3015.6	31686.2	65850.9	126726.0	21790.8	103765.9	352835.3
Value Added	11444.8	56752.9	185160.8	30780.7	40885.5	0.0	325024.7
Labor Earnings	6738.3	40135.8	125665.8	0.0	34539.1	0.0	207078.9
Imports	5740.2	114188.9	78520.5	49634.3	33479.0	0.0	281562.9
Total Input	24254.4	226590.0	352835.3	223984.0	149333.6	233269.9	1210267.2

**Includes all the services not covered by the other two industrial groups.*

The input-output table can be divided into three principal components, each of which consists of a set of rows and columns:

- The first component is the block of interindustry transactions—the shaded part of Table 1-1. 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," meaning that industries purchase these inputs for the purpose of transforming them into a different product or service for subsequent sales.

- The second component contains the final demand sectors—the double-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 the purpose of further production or resale, but rather 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 state. The block bordered by the heavy black line in Table 1-1 represents this component. This block includes value-added (payments to labor input and other estimates of value added), as well as imports from the rest of the United States and from foreign countries.

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 -- 2007.

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 2007, total output (sales) of Washington manufacturing and construction industries amounted to $226.6 billion. Over 53.5 percent of this output, valued at $121.3 billion, was exported; and about 24.0 percent was sold to in-state final demand. In contrast, output of trade and services industries totaled $352.8 billion, 72 percent higher than manufacturing and construction, but only 29.4 percent of the total output was exported, while 42.1 percent or $148.5 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. 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 2007, $114.2 billion or 50.4 percent 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 22.3 percent, 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, and 2007), changes in the structure of the economy over time can be observed. The change from the SIC to NAICS industry classification in 1997 complicates comparisons of interindustry industrial structure over time. However, aggregate comparisons are possible. These comparisons need to be done 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 1963-2007 period.

Table 1-2
Changing Importance of Washington External Trade, 1963-2007

	% Industrial Outputs Exported (All Sectors)	**% 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%	32.9%	54.9%	22.3%

**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 1963-1987 period increased from 28.1% percent to 36.0%, but then changed little between 1987 and 2002. Part of the reason for a low export share in 2002 might have to do with the U.S. cyclical downturn depressing the state's export markets. However, 2007 continues the long-term trend in the increase in the share of industrial output that was exported, with a value of 41.3%. Since 1963, imports as a share of production inputs grew steadily for the state's services and trade industries, the share jumped to 22.3 percent in 2007. For manufacturing industries in the state, the import share of production inputs has also risen significantly, reaching 54.9 percent in 2007.

More detailed analyses can be conducted, at the individual industry level, on shifting patterns of exports to other regions in the U.S. and to overseas markets, or on the changes in imports from the rest of the U.S. as opposed to from foreign producers.

Chapter 2
The 2007 Washington Input-Output Table: Methodology and Data

The 2007 Washington Input-Output (I-O) Study was based on a combination of data sources. The first step involved defining the sectors to be used in model development. The second step was development of a survey of establishments; the survey was conducted under contract from OFM by the Washington State Department of Employment Security. Simultaneously, output, value added, and employment were estimated for each sector. Also estimated were personal consumption expenditures, private investment, and government expenditures. Data sources for the estimation are: the 2007 Economic Census, the Bureau of Economic Analysis state employment, income, and gross domestic product by state data series, and other miscellaneous reports from trade associations and government.

The benchmark 2007 U.S. Input-Output Table was not available at the time the 2007 Washington input-output model was estimated. The 2002 Washington input-output table utilized an aggregated version of the 2002 U.S. benchmark input-output table as a part of the process of estimating the interindustry transactions matrix. Therefore, in the development of the current model, we utilized the bioproportional matrix adjustment technique to develop an initial interindustry transactions matrix. Careful analyses of sales and purchases distributions obtained from the survey were undertaken, comparing the survey-based distributions with the benchmark 2002 national input-output model, U.S. Bureau of Economic Analysis (BEA) estimates, and with prior Washington State Input-Output Models.

Step 1: Define target-year industrial sectors

Over time, new industries evolve or old industries decline in the state economy. Furthermore, existing establishments may change their production processes to adapt to new technologies or to shifting markets. These changes required re-definition of industrial sectors in the new I-O table, because in the I-O concept every industrial sector is assumed to be homogeneous, meaning 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 the sectoring plan for the 2007 table was defined, as shown in Table 2-1. In the 2007 table, we disaggregated two of the sectors in the 2002 table into more detailed sectors. Construction was divided into Highway, Street and Bridge Construction, and all other Construction. Retail trade was divided into non-store retailers, and all other retail trade.

Step 2: Survey of Industrial sectors

A sampling plan was developed jointly by OFM, the Washington State Department of Revenue, the Employment Security Department, and other members of the study team. The Employment Security Department distributed questionnaires to 6,010 establishments, and obtained 2,531 valid responses, a response rate of 42.1%. The gross business volume of this sample was $269.1 billion, or 54.2% of the recorded gross business income (GBI) of all establishments in Washington state in 2007. Coverage was good in about 40 of the

50 sectors in the I-O model. The cover letter and questionnaire used for this study are available at the links below.

Washington I-O Study cover letter
Washington I-O Study questionnaire

Table 2-1
2007 Washington Input-Output Study
Sectoring Plan

Industry Name	NAICS Code
1. Crop Production	111
2. Animal Production	112
3. Forestry and Logging	113 (Incl. state forests, etc.)
4. Fishing, Hunting, and Trapping	114
5. Mining	21
6. Electric Utilities	2211 (Incl. public, BPA, etc.)
7. Gas Utilities	2212 (Incl. public)
8. Other Utilities	2213 (Incl. public)
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/PSNS)
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 (Incl. state liquor stores)
32. Air Transportation	481
33. Water Transportation	483 (Incl. Ferry)
34. Truck Transportation	484
35. Other Transportation/Postal Offices	482, 485, 486, 487, 491, 492 (Incl. transit)
36. Support Activities for Storage, Transportation and Warehousing	488, 493 (Incl. public ports)
37. Software Publishers & Data Processing, Hosting, and Related Services	5112, 5182
38. Telecommunications	517

Table 2-1 *(Continued)*
2007 Washington Input-Output Study
Sectoring Plan

Industry Name	NAICS Code
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/Others, and Agriculture Services	562, 81, 115

Step 3: Compile the target-year data and information on Washington industries

Data on 2007 industrial output, value-added, government expenditures, consumption by Washington residents, capital (investment) spending, and external trade (exports and imports) were compiled. 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.

Step 4: Analysis of survey results

In the development of the 2007 Washington Input-Output survey, it was decided that establishments participating in the survey would not be asked to provide detailed interindustry sales and purchases estimates, but rather total interindustry sales and purchases made in Washington state. Data from the survey were analyzed, sector by sector.

Distributions of sales and purchases proportions for each sector were calculated, and compared to the 1997 and 2002 Washington Input-Output tables. In many cases the survey yielded reasonable estimates of these distributions. However, there were some sectors with very few respondents, and in which the patterns of sales and purchases were not consistent with other data sources. In some instances it was necessary to "triangulate" sales and purchases distributions based on prior or alternative estimates, and judgments.

Table 2-2
Input Data for the Target Year (2007)

Data Categories	Data Sources
Industrial Output	2007 Economic Census – Industrial Shipment $ Washington State Dept. of Agriculture – annual agricultural production by crop type Washington Dept. of Revenue – Gross Business Income database Bureau of Economic Analysis – 2002 U.S. Input-Output (Use) Table Washington Insurance Commissioner – Revenue and margins of insurance businesses
Value Added	Bureau of Economic Analysis – Gross State Product Bureau of Economic Analysis – labor earnings series Washington Employment Security Department – ES202 Wage and Salary series
Personal Consumption Expenditures	Bureau of Economic Analysis – National Income and Product Accounts Bureau of Economic Analysis – State personal income Series Bureau of Labor Statistics – 2007 Consumer Expenditure Survey
Government Spending	Census Bureau -- State and Local Government Expenditures series Census Bureau -- Federal Government Expenditures reports Washington Office of Financial Management – State government expenditures accounting records
Investment	Bureau of Economic Analysis – National Income and Product Accounts Census Bureau - Building Permit report Washington Dept. of Revenue – taxable sales database Bureau of Economic Analysis – 2007 Annual U.S. Input- Output (Use) Table
Exports and Imports	The World Institute for Strategic Economic Research (WISER) export database Census Bureau – The 2007 Commodity Flow Survey Washington Department of Commerce – studies of the impact of foreign exports and imports on the state economy

Step 5: Development of new transactions table

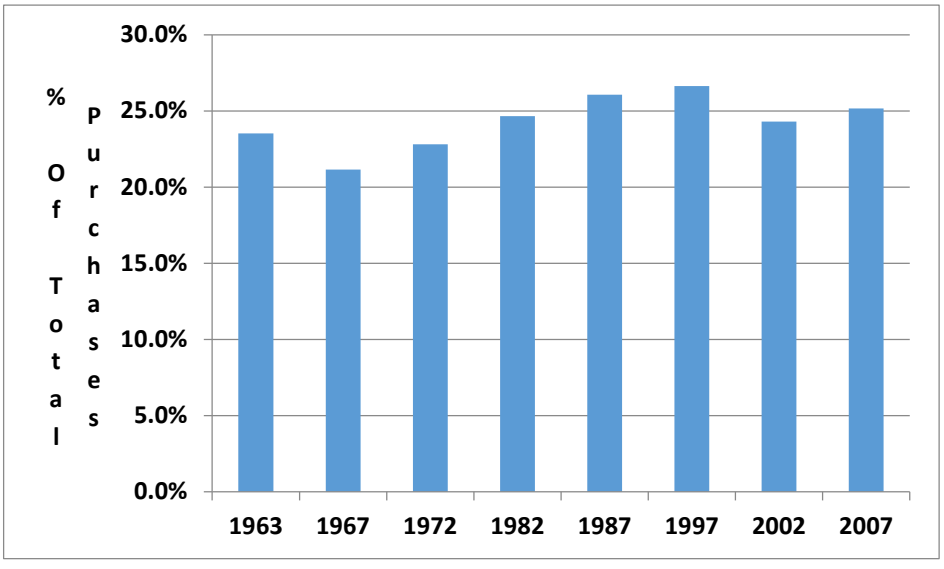
The survey provided sales estimates by Washington industries, as well as estimates of purchases by Washington industries. The survey instrument provided a much clearer definition of sales by Washington industries on intermediate account than was the case for purchases. The purchases questions asked recipients to distinguish between purchases made from wholesalers and retailers, as well as from manufacturers and other service industries. National data on trade and transportation margins were used to reduce reported purchases from wholesalers and retailers to the margin value, and it was presumed to most sales made by these businesses were of goods imported to Washington state. The purchases survey did not ask respondents to estimate their value added. Purchases percentage distributions from the survey were adjusted downward, given the estimates of value added developed for each sector. Even after these adjustments, the purchases survey resulted in a higher estimate of regional purchases than the sales survey. Good alternative estimates of imports from the rest of the US or from foreign sources were not available. Comparisons of these import propensities were made with the 1997 and 2002 Washington input-output models. The result of this initial process of developing a new transactions table was estimation of total intermediate sales and purchases by sector, with the sales and purchases levels summing to the same total.

The intermediate sales and purchases totals were used with the 2002 transactions matrix to develop an estimated 2007 transactions matrix through the use of the biproportional method of matrix adjustment. This is an interactive process, in which row and column distributions are estimated repeatedly, until the row and column sums converge to the desired totals. Weights are developed in each iteration of the procedure. Initially, ratios of actual versus desired row sums by sector are calculated, and the row values are multiplied by these weights to force rows to total the desired value. This resulting matrix is then used as input to the adjustment of column values, with column sums compared to desired totals, and weights calculated that force column sums to the desired total. Then the process is repeated, adjusting row values with the matrix just described. This procedure of row and column adjustment proceeds until the difference between the row and column sums approaches zero. In the current modeling process, this iterative procedure was undertaken 12 times for both rows and columns.

It was necessary to introduce initial values into the beginning matrix for the two sectors included in this model, which were not specified in the 2002 model.

The initial regional transactions matrix underwent a number of adjustments. For example, the Washington State ferry system was included in the water transportation sector, but it did not participate in the survey. The Bremerton Naval Yard was also included in shipbuilding, but was not surveyed. Data were introduced into the transactions matrix for cases of this type, with their most likely markets and sources of supply defined. After these adjustments were made, comparisons were made with the 2002 and 1997 Washington transactions matrices to identify cases needing further evaluation and adjustment. The resulting matrix of interindustry transactions has a slightly higher estimated regional purchases as a share of sales (25.2%) than the 2002 Washington input-output model (24.3%). However, the share of intermediate purchases closely tracks the history of Washington State Input-Output Models.

Intermediate Purchases as a Share of Washington Total Industrial Input 1963-2007



Chapter 3
The Washington Input-Output Models for Impact Analysis

The most common application of regional input-output (I-O) tables is impact analysis. Actually, 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.

An impact spreadsheet file is provided for downloading. This file contains two sheets used to perform the simple analysis and the complex analysis, respectively:

"Simple" and Complex" impact worksheets

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 it takes to build an I-O impact analysis model is to convert the interindustry transactions into "direct purchase coefficients." This is done 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 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 0.01858 (=4210.1/226590.0) (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, for every dollar of its total input, requires $.01858 cents of natural resource/utility products from Washington establishments.

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 earnings.

Table 3-1
2007 Washington Direct Purchase Coefficients Table
(Dollars Purchased Per Dollar of Total Input)

	Resources & Utilities	Manufacturing &Construction	Trade & Services	Personal Consumption
Resources & Utilities	0.08051	0.01858	0.00610	0.03021
Manufacturing & Construction	0.08663	0.08717	0.05995	0.05113
Trade & Services	0.12433	0.13984	0.18663	0.61197
Labor Income	0.27782	0.17713	0.35616	0

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 is 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 2007 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 $0.0396 and $0.5039, respectively.

Table 3-2
2007 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	1.1138	0.0396	0.0367	0.0581
Manufacturing & Construction	0.1783	1.1542	0.1566	0.1602
Trade & Services	0.6250	0.5008	1.7630	1.1234
Labor Income	0.5636	0.3938	0.6658	1.4446

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. This computation is implemented in the impact spreadsheets.

Magnitudes of the estimated impact vary by the degree of model closure. The model developed in this study produces what are 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, and no substitution between intermediate goods, capital, and labor inputs; and 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 which 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.

Chapter 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 utilized multipliers obtained from the aggregated three-sector 2007 Washington I/O table presented in previous chapters (Table 1-1, Table 3-1, and Table 3-2).

Table 4-1
2007 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	10.422	2.194	0.5629	1.9150
Manufacturing/Construction	7.010	2.651	0.3950	1.6980
Trade and Services	13.756	1.839	0.6649	1.9535

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.

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

Table 4-2
2007 WASHINGTON STATE INPUT-OUTPUT MULTIPLIERS

		Total Jobs (Per $ million direct Output)	Total Employment (per direct job)	Total Output (per $ final demand)	Total Labor Income (per $ final demand)
IO-01	Crop Production	17.71	1.55	1.94	0.63
IO-02	Animal Production	15.29	2.14	2.26	0.66
IO-03	Forestry and Logging	9.87	3.10	2.07	0.50
IO-04	Fishing, Hunting, and Trapping	8.59	2.82	1.97	0.58
IO-05	Mining	10.85	2.15	1.92	0.49
IO-06	Electric Utilities	7.08	4.45	1.96	0.60
IO-07	Gas Utilities	3.27	6.11	1.44	0.19
IO-08	Other Utilities	12.06	2.59	2.11	0.66
IO-09	Highway, Street, and Bridge Construction	10.08	2.88	1.97	0.56
IO-10	Other Construction	10.89	2.58	1.97	0.54
IO-11	Food, Beverage and Tobacco Manufacturing	6.64	3.46	1.77	0.32
IO-12	Textiles and Apparel Mills	10.57	2.10	1.82	0.46
IO-13	Wood Product Manufacturing	10.05	3.14	2.21	0.49
IO-14	Paper Manufacturing	5.85	3.90	1.77	0.35
IO-15	Printing and Related Activities	12.23	1.98	1.91	0.58
IO-16	Petroleum and Coal Products Manufacturing	0.58	6.80	1.09	0.04
IO-17	Chemical Manufacturing	5.84	3.11	1.62	0.41
IO-18	Nonmetallic Mineral Products Manufacturing	6.34	2.36	1.59	0.33
IO-19	Primary Metal Manufacturing	6.63	3.88	1.81	0.36
IO-20	Fabricated Metals Manufacturing	9.36	2.30	1.80	0.46
IO-21	Machinery Manufacturing	7.62	3.28	1.84	0.41
IO-22	Computer and Electronic Product Manufacturing	8.56	3.73	1.98	0.53
IO-23	Electrical Equipment Manufacturing	6.29	2.92	1.66	0.36
IO-24	Aircraft and Parts Manufacturing	5.17	2.67	1.45	0.36
IO-25	Ship and Boat Building	9.51	2.88	1.91	0.58
IO-26	Other Transportation Equipment Manufacturing	5.50	2.75	1.54	0.29
IO-27	Furniture Product Manufacturing	11.39	1.92	1.84	0.51
IO-28	Other Manufacturing	9.76	2.28	1.85	0.47
IO-29	Wholesale	9.56	2.17	1.73	0.55

Table 4-2 *(Continued)*
2007 WASHINGTON STATE INPUT-OUTPUT MULTIPLIERS

		Total Jobs (Per $ million direct Output)	Total Employment (per direct job)	Total Output (per $ final demand)	Total Labor Income (per $ final demand)
IO-30	Non-Store Retail	13.69	1.60	1.74	0.49
IO-31	Other Retail	17.54	1.48	1.81	0.65
IO-32	Air Transportation	5.71	2.75	1.65	0.32
IO-33	Water Transportation	8.59	3.24	1.93	0.49
IO-34	Truck Transportation	13.04	2.08	2.06	0.63
IO-35	Other Transportation/Postal Offices	13.99	2.11	2.18	0.77
IO-36	Support Activities for Storage, Transportation and Warehousing	13.52	2.62	2.21	0.72
IO-37	Software Publishers, Data Processing & Internet Service Providers	7.16	3.96	1.71	0.52
IO-38	Telecommunications	6.68	3.53	1.82	0.39
IO-39	Other Information	10.95	2.08	1.79	0.69
IO-40	Credit Intermediation and Related Activities	8.47	4.20	2.07	0.49
IO-41	Other Finance and Insurance	16.02	2.77	2.51	0.82
IO-42	Real Estate and Rental and Leasing	13.59	1.31	1.47	0.33
IO-43	Legal /Accounting and Bookkeeping /Management Services	20.00	1.85	2.25	1.19
IO-44	Architectural, Engineering, and Computing Services	14.31	2.09	2.00	0.85
IO-45	Educational Services	23.34	1.66	2.33	0.75
IO-46	Ambulatory Health Care Services	18.58	2.35	2.43	0.98
IO-47	Hospitals	14.08	2.46	2.13	0.75
IO-48	Nursing and Residential Care Facilities, Social Assistance	25.38	1.50	2.18	0.83
IO-49	Arts, Recreation, and Accommodation	20.48	1.64	2.10	0.67
IO-50	Food Services and Drinking Places	22.80	1.44	2.08	0.64
IO-51	Administrative/Employment Support Services	27.72	1.39	2.08	1.01
IO-52	Waste Management/Other, and Agriculture Services	17.01	1.89	2.17	0.69