Office of Financial Management
Forecasting Division

THE 1987 WASHINGTON STATE INPUT-OUTPUT STUDY

by

Robert A. Chase
Philip J. Bourque
Richard S. Conway, Jr.

Completed by Contractual Arrangement with:

Graduate School of Business Administration
University of Washington

September, 1993

TABLE OF CONTENTS

ACKNOWLEDGMENTS

The Washington Input-Output Study of 1987 was jointly supported during the 1991-93 Biennium by the Washington State Office of Financial Management (OFM) and the Washington State Department of Transportation (DOT). In particular, Len McComb, former Director of OFM, and Gary Robinson, Assistant Director of Forecasting at OFM, and Irv Lefberg, Coordinator of Economic Forecasting at OFM, as well as Gary Ray and Jay Ford in the Transit, Research, and Intermodal Planning Division at DOT, were instrumental in obtaining support for this study. The study was conducted under formal contract with the University of Washington, School of Business Administration.

In addition, various state agencies assisted in accomplishing the project objectives by providing staff time, data from files, cooperation, guidance, and advice. We are very appreciative of the contributions of time and talents made by the following individuals:

Byron Angel, Office of Financial Management
Bill Bafus, Department of Ecology
Scott Bailey, Employment Security Department
Robert Baker, Employment Security Department
Bret Bertolin, Office of the Forecast Council
Lorrie Brown, Department of Revenue
Dan Dodds, State Energy Office
Bob Edwards, Department of Natural Resources
Jay Ford, Department of Transportation
Dennis Fusco, Employment Security Department
Dick Gebhart, Department of Revenue
Alan Harger, Department of Trade and Economic Development
Dave Larson, Department of Natural Resources
Jonathan Lesser, State Energy Office
Irv Lefberg, State Office of Financial Management
Peter Lin, State Department of Revenue
Harold Nelson, State Office of Financial Management
Gary Ray, Department of Transportation
Bill Wildprett, Department of Community Development

These individuals join a long list of economists that have worked on previous Washington State input-output tables. Special appreciation is noted for the research assistance offered by Mr. Sun-Tae Kim, doctoral student in economics at the University of Washington. Sun-Tae provided programming expertise and worked extensively on services inputs and personal consumption expenditures.

A number of trade associations supported this endeavor by sharing unpublished information and by encouraging their membership to participate in our surveys. The assistance of the American Electronics Association, American Plywood Association, the Direct Services Industries Inc., Washington Forest Protection Association, and the

Washington Software Association have helped to make the results of this study more reliable.

Finally, appreciation is given to over a hundred Washington business firms who shared with us knowledge of the markets in which they buy and sell goods and services. In return, we hope this input-output study provides them with a useful and comprehensive overview of the state economy.

Robert A. Chase	Philip J. Bourque	Richard S. Conway, Jr.
Research Director	Professor Emeritus	Conway & Associates

PREFACE

A Brief Historical Overview of Regional Input-Output Modeling

Developed economies are characterized by a high degree of interdependence among producing sectors. Each economic sector not only produces goods or services, but is a consumer as well, purchasing other goods or services for use within their production process. These relationships have long been recognized. Francois Quesnay's *Tableau Economique* of 1758 dealt with circular flows between industries and general equilibrium concepts. More than a century later, Leon Walras developed the theory of general equilibrium in economics. In this work, Walras examined both the independence of producing industries and what each producing industry needed from other industries to produce a unit of a finished good.

The first development of input-output modeling as an economic analytical tool and the actual construction of the first input-output table for the United States was accomplished by Harvard University's Professor Wassily W. Leontief, for which he later received the Nobel Prize in Economic Science in 1973. In 1936, Leontief published the first input-output tables--for the years 1919 and 1929--of the U.S. economy. Leontief simplified Walras' general equilibrium model so that model's equations could be estimated empirically. Two simplifying assumptions were used. First, the large number of commodities in the Walrasian model were aggregated into relatively few outputs, one for each industry. In other words, the model assumes a single homogeneous output generated from the same inputs for each producing industry. And second, the supply equation for labor and the demand equations for final consumption were abandoned leaving the remaining production equations to be expressed in the simplest linear form. This assumption of linearity does not allow for factor substitution and economies of scale. The element of time is also missing (i.e., the model is static), yet the purchase of inputs by one industry to make goods to sell to other industries implies a period analysis.

Given these assumptions, the model is starkly simple. Its key variables are the outputs of industries into which the economy is divided. Each industry's output consists of summing its sales to all other industries and to final demand, that is, to ultimate consumers rather than other producing industries. Thus, the amount of each product consumed in each industry will depend upon the level of output for that industry. According to the model, equilibrium is attained within the economy when each industry's output equals its total purchases (i.e., inputs), which are in turn determined by the output of all other industries.

After Leontief's seminal input-output publication in 1936, input-output models of the U.S. economy were published by the Bureau of Labor Statistics of the U.S. Department of Labor and later the Bureau of Economic Analysis of the U.S. Department of Commerce. During World War II, Leontief also prepared a 1939 U.S. I-O table. Consisting of fewer than 50 sectors, this table was used to predict and plan for the post-World War II recovery in industry capacity and demand. One of its major findings was that there would be a serious shortage of steel in the postwar years unless capacity were increased. This finding proved to be right, despite the general consensus to the contrary. (Most economists initially asserted that there would be a serious postwar recession because of a lack in effective demand.) With the assistance of the I-O table, government analysts were able to observe that there was a tremendous backlog of demand for both consumption and investment goods that could be satisfied by increased production in nondefense industries and conversion of defense industries to the production of these goods.

After World War II, a number of other countries (including the United Kingdom, Canada, Russia, Japan, France, and Israel) began experimenting with producing I-O tables and the United Nations, in its work on *A System of National Accounts*, also became interested in the input-output accounts. Governments and industries alike have found the information provided by input-output models to be useful in economic planning and assessing the economicimpacts of selected investments and policies. Industries as well have used input-output models to assist in the procurement of input materials, intraindustry management of diverse but interrelated products and the estimation of expected direct and indirect consumption of products produced by direct customers.

Although originally conceived at the national level, interest in economic analysis conducted at the sub-national or regional level (whether "region" is defined as a group of states, an individual state, a county, or a metropolitan area) has led to a number of modifications in the input-output model to reflect the peculiarities of the region under consideration. Development of regional input-output models paralleled development of the economic base theory in regional analysis. Both the economic base model and input-output model stem from the same theoretical foundation; that is, regional growth is triggered and sustained by the output of its export industries. The input-output model, however, recognizes that the economic impact on a region from export expansion varies among industries. The size of the economic multiplier depends upon the degree to which the exporting industry is linked, through the respending process, to the rest of the economy. The input-output model is, in effect, a disaggregated economic base model.

Implicit in the development of a "regionalized" input-output table is the recognition of this analytical tool's broad array of uses--measuring the economic interdependence of the region's industrial structure; providing a set of more precise and sensitive disaggregated (industry-specific) multipliers; calculating the regional effects on economic activity from changes in the level and pattern of national demand; evaluating other economic impacts from changes in final demand; and as a technique for long-term projections and forecasts (Richardson, 1972).

There has been an enormous amount of input-output work done at the regional level. Some of the earliest regional applications of input-output modeling in the United States were conducted in Philadelphia, Utah, St. Louis, and the Pacific Northwest (Bourque and Cox, 1970; Giarratani, Maddy, and Socher, 1976). Throughout the years, a number of states have published input-output tables, notably Washington, Kansas, West Virginia, Texas, Colorado, and Nebraska.

In 1967, the first Washington State Input-Output Study (based on the year 1963) was published. With subsequent state input-output tables constructed for the years 1967, 1972, and 1982, the Washington State Input-Output Model has provided policy makers and researchers with a greater understanding of the state's changing economic structure, its markets and linkages, its opportunities and limitations, and its increasing international dependence. The model--through its set of impact multipliers--has been particularly useful in evaluating the ripple effects on the state's economy from changes in internal and external forces. Such multipliers have been widely used in a variety of policy documents and in assessments of the economic impacts of a multitude of developments.

Besides its extensive use in policy and planning, the Washington State Input-Output Model has had a rich and storied history within regional input-output research circles. Because the model is survey-based, it has been extensively used in testing the reliability of multipliers derived via other methods (e.g., nonsurvey techniques, hybrids, economic base models, and conjoined interindustry econometric techniques). One prominent regional economist called the Washington table--along with the West Virginia table--"the only really reliable survey-based input-output models for any U.S. state" (Stevens, et al., 1983). In this way, Washington input-output studies have made an important contribution beyond the state.

The Washington State Input-Output Model has also been a critical building block in the development of an interindustry econometric model used in making long-range forecasts and conducting impact analysis in the state of Washington. An initial attempt in using the Washington input-output study to forecast long-term regional income and employment growth (Tiebout, 1969) led to more extensive modeling efforts during the mid-1970s. The resultant model--the Washington Projection and Simulation Model (WPSM)--has been extensively used in over 30 studies since its beginning in 1977 (Conway, 1990). This interindustry econometric framework has been utilized in other settings (notably Hawaii and the Chicago metropolitan area) for regional economic forecasting and for simulating impacts of various alternative development scenarios.

This fifth table--for the year 1987--provides yet another look at the state's changing economic structure--its industrial interdependencies and its sensitivity to changes in final demand, both at the national and international level. Revised economic multipliers from the model should provide state policy makers, planners, and economists with important information in conducting economic impact analysis for a number of years.

THE 1987 WASHINGTON STATE INPUT-OUTPUT STUDY

1. INTRODUCTION

This report presents the 1987 input-output tables for Washington State. These tables provide a storehouse of economic information that can be used by economists, planners, and policy-makers to analyze various issues related to economic developments in the state. More specifically, the Washington state tables serve three practical purposes. First, the tables constitute a comprehensive and detailed set of accounts on all conventionally defined economic activities within the state. Economic activity is traced through the various purchases and sales among Washington industries and other sectors of the economy. For instance, the value of outputs produced by different industries is traced to the markets in which that output is sold, and the disposition of outlays (or purchases) by each industry for inputs to support its production is identified. Furthermore, with the series of comparable state tables, input-output analysis is a very useful framework for examining changes in the structure of the economy over time.

Second, the input-output tables provide the factual basis for estimating output, employment, and income multipliers, utilized in conducting economic impact analyses. Numerous applications of previous Washington input-output studies are illustrative of the role of economic multipliers. For instance, what would be the economic impacts associated with constructing a rapid rail transit system in the Puget Sound region, or from banning log exports in the state? What is the economic impact of the construction of a US Navy homeport facility at Everett, the closure of a pulp mill, the presence of the Goodwill Games in Seattle, or an increase in farm exports? Although each impact assessment application involves extensive research, each utilizes input-output multipliers as a critical phase in the investigation.

Finally, the input-output model is a suitable framework for conducting long-term regional economic and demographic forecasting. Some have suggested that by integrating regional input-output tables with econometric models the good qualities of both frameworks are combined (Glickman, 1977). The logical structure of a regional interindustry econometric model emanates from the economic base theory of growth, which recognizes two sets of economic demands placed upon a region--external (primarily export) and internal. Exports--the principal driving force behind regional economic growth--are forecast on the basis of national market demand. Local output required for export triggers internal demands, depicted through the input-output framework. For instance, the demand for regionally produced lumber establishes a chain of demands that affects production in the local logging and services industries, among others. The induced output in these industries sets up further intermediate demands, all of which are captured within the interindustry submodel. Essentially, through estimation with cross-sectional and time-series data, an interindustry econometric model attempts to capture the effects of induced investment and government spending thereby providing a more complete picture of the operation of the regional economy.

This 1987 study represents the fifth input-output study for Washington State. The four previous studies were conducted for the years 1963, 1967, 1972, and 1982. Together, these tables comprise a unique set of survey and semi-survey based regional studies. Spanning a twenty-five year period, these five cross-sectional portraits constitute a moving picture of the Washington State economy. The 1987 study differs from the earlier studies in one respect. Recognizing structural change in the state economy, the model's sectoring plan has been expanded from 51 to 62 sectors. Essentially, the transportation services, construction, trade, and services sectors have been disaggregated for this updated study.[1]

This report, which is divided into three parts, is intended for analysts and policy-makers who want to understand and apply the Washington State input-output tables. The first part describes the input-output model, specifically its sectors and transactions table. The foundation of an input-output model is the transactions table that shows the dollar value of the goods and services traded--bought and sold--by each sector of the economy. Also discussed in this first part are some important general definitions and conventions used in input-output analysis. The second part discusses the various methods utilized in updating the input-output tables to 1987. Finally, the third part describes the various applications of the input-output study.

The 62-industry input-output tables for 1987 are found in the Appendices A-D. Tables included are the interindustry gross flows, direct and total requirements. An example of the questionnaire used in the industrial survey is presented in Appendix E.

2. THE WASHINGTON STATE INPUT-OUTPUT TABLE FOR 1987

Description of the Transactions Table

The foundation of the input-output analytical system is the transactions table. A transactions table is a comprehensive and detailed set of accounts describing economic activity in an area (nation, state, region, or county) for a particular year. The current Washington State input-output table portrays the flow of commodities between producing sectors and consuming sectors--that is, the sales and purchases of goods and services among industries (measured in millions of current dollars)--for the year 1987. Information provided within this transactions table can be manipulated to derive input-output multipliers.

The input-output table is organized into a rectangular array of rows and columns. Each row and its corresponding column represent the transactions of an individual sector. The sales of the sectors are shown along the rows and the purchases of the sectors are

[1]A "bridge" table linking the sectoring plans of the various study years is available from the authors.

shown in the columns. The sum of a row is the total output of the sector represented by that row. The sum of a column is the total inputs of the sector represented by that column. The basic accounting relationship within the input-output table is that for each industry total output (or sales) equals total inputs (or purchases).

There are three principal components of the input-output table, each of which consists of a set of rows and columns. The first block is the interindustry transactions, that is the flow of goods and services which are both produced and consumed among the region's industries. Reading across a row gives estimates of the interindustry sales of the industry named at left, while reading down a column gives estimates of the interindustry purchases made by the industry named at the top. This block has also been called intermediate demand, consisting of those sectors that purchase inputs for the purpose of transforming them into a different product or service for subsequent sale to another purchasing sector. The second block contains the final demand sectors. This component of the table shows the sales by industry to "ultimate" consumers--to households, the capital goods sector (i.e., investment), governments, and markets outside the region (i.e., exports). These final demand sectors purchase output from the producing sectors, not for the purpose of further production or resale, but rather for final consumption or use. The third component of the table contains the final payments or primary inputs sectors. This block shows the value of inputs provided by the basic factors of production--labor, capital, and land (i.e., value added) as well as the purchases of imported goods and services.

For illustrative purposes, a highly aggregated version of the 1987 Washington State transactions table is shown in Table 2-1. Except for its obviously smaller size, this table is the same as that found in Appendix A. The table identifies three industry groupings (natural resources, manufacturing, and services and trade), three demand sectors (personal consumption expenditures, exports, and other final demand), and three final payment sectors (labor income, other value added, and imports). The estimates are measured in millions of 1987 dollars.

The table also contains two rows of employment: wage and salary, and total employment. Total employment includes wage and salary workers, along with self-employed persons, and part-time workers. Although not formally a part of the transactions table, the data found in these employment rows are useful for conducting economic impact analysis studies.

As an example of how to read the input-output table, consider the activities of the natural resources industries (agriculture, forestry, mining, and fisheries). In 1987, Washington natural resources industries' total output (sales) and input (purchases) amounted to $4,438.9 million. With regard to the distribution of its output, estimated sales to other Washington industries include $464 million to natural resources industries, $2,071.3 million to manufacturing, and $231.1 million to trade and services (including transportation, communications, utilities, finance, insurance, and real estate). Natural resource industries' sales to final demand were $259.9 million to Washington consumers,

$1,134.6 million in exports (both foreign and rest of U.S.) and $278.0 million to other final demand sectors (investment; state and local, and federal governments' expenditures).

Goods and services purchased as inputs to production by natural resource industries from other Washington industries included $464 million from natural resource industries, $366.8 million from manufacturing industries, and $384.7 million from trade and services. Natural resource industries also purchased $1,445.2 million of labor from Washington households, $1,330.5 million in other value added (e.g., rent, interest payments, and taxes), and $447.7 million of imported commodities (both foreign and rest of U.S.). Employment in natural resource industries amounted to 46,239 wage and salary employees; total employment (including proprietors) in these sectors was estimated at 95,997 workers.

Table 2-1

1987 WASHINGTON STATE INPUT-OUTPUT TABLE: AGGREGATED
(Millions of Dollars)

	Natural Resources	Manufacturing	Trade and Services	Subtotal	Personal Consumption	Exports	Other Final Demand	Total Output
Natural resources	464.0	2,071.3	231.1	2,766.4	259.9	1,134.6	278.0	4,438.9
Manufacturing	366.8	5,262.5	4,695.6	10,324.9	2,738.2	30,077.9	5,270.7	48,411.7
Trade & services	384.7	4,932.0	16,350.8	21,667.5	30,306.7	16,738.2	11,756.5	80,468.9
Subtotal	1,215.5	12,265.8	21,277.5	34,758.8	33,304.8	47,950.7	17,305.2	133,319.5
Labor income	1,445.2	9,230.6	30,109.5	40,785.3	0.0	0.0	8,213.3	48,998.6
Other value added	1,330.5	7,463.4	19,027.5	27,821.4	6,804.1	0.0	1,626.8	36,252.3
Total value added	2,775.7	16,694.0	49,137.0	68,606.7	6,804.1	0.0	9,840.1	85,250.9
Imports	447.7	19,451.9	10,054.4	29,954.0	14,962.5	0.0	3,226.4	48,142.9
Total input	4,438.9	48,411.7	80,468.9	133,319.5	55,071.4	47,950.7	30,371.7	266,713.3
Wage & salary employment	46,239	248,650	1,282,553	1,577,442	0	0	386,566	1,964,008
Total employment	95,997	318,000	1,626,040	2,040,037	0	0	386,566	2,426,603

Definitions and Conventions

Region

Any regional analysis presupposes a rigid definition of the area under study. The geographic area under study here is Washington State, defined in terms of its political boundaries. Such a definition may be all too obvious, but the objective is to account for the economic activity of all establishments operating within state borders. Output is defined on a place-of-performance basis; that is, output is counted only if it is produced by establishments operating within the boundaries of the state or in its adjacent waters. Excluded therefore are revenues accruing to Washington businesses from economic activity performed in other regions.

Two examples--the headquarters problem, and out-of-state production by Washington business firms--illustrate the need for a strict definition of region. With regard to the issue of headquarters, all production units operating in Washington State have administrative, management, and sales staff whose costs are supported by revenues from the sales of goods and services. However, these functions may be provided by offices located out-of-state, indicating the "importation of overhead services." Since these costs often are unrecorded (for example, in *Census of Manufactures*), the value of imported services are understated, and consequently, the value added of some Washington businesses are overstated. In contrast, some Washington companies (e.g., Boeing, Weyerhaeuser, Paccar, Burlington Northern, Microsoft) have based their headquarters facilities in Washington and as such, these "overhead" services are incurred in support of production facilities located out-of-state. These companies are engaged in the production of management services for export to other regions. The value of exports by sectors with large headquarters tend to be underestimated.

The place-of-performance basis is especially important in considering those industries that employ mobile resources or engage in productive activity beyond the borders of the state. For instance, for firms engaged in interstate transportation (e.g., trucking, airlines, river barges), the value of output includes only those revenues generated by the resources of production (i.e., land, labor, and capital) employed within the confines of the state boundaries. For construction firms, output is defined as the value of all new construction and maintenance and repair within the state, regardless of whether the activities of contractors are headquartered in or outside the state. Another illustration is the Washington fishing fleet, part of which regularly exploits the Alaskan fishery. Should the output of this industry include the value of that catch, most of which is landed within Alaskan waters? We have chosen--as in previous studies--to define the output of the fishing industry as the value of the catch landed within Washington waters as reported by the Washington Department of Fisheries. In contrast, the U.S. Department of Commerce, Bureau of Economic Analysis, in preparing their estimates of Washington State personal income, includes the earnings of Washington fishermen derived from the Alaskan fishery.

The place-of-performance definition of regional output has two distinct advantages over other alternative definitions. First, it precludes counting the same output in more than one region. Second, the definition is consistent with that of regional value added as the portion of gross national income earned by the factors of production located in the state. Included in this definition of regional value added are the returns to all capital located in the state, even if the owners of that capital reside elsewhere. Similarly, regional value added includes labor income of employees who work in-state but reside out-of-state. On the other hand, wages, rents, interest, and dividends which accrue to Washington residents but are associated with production elsewhere are not counted in the input-output transactions.

Base Year

The input-output tables presented in this report are for the year 1987. This year coincides with the most recent economic censuses undertaken by the Bureau of the Census of the U.S. Department of Commerce. Encompassing agriculture, mining, manufacturing, construction, transportation, services, and trade, these censuses provide detailed output and cost data on Washington industries.

Since the collection and publication of census data and the estimation of input-output tables are time consuming, the 1987 input-output tables may appear be out of date by the time of publication. This is certainly true with regard to the measurement of economic activity in Washington (e.g., gross state product, personal income).

However, the age of the tables should be viewed with respect to their immense usefulness. For applications which rely upon the estimated regional input coefficients, the 1987 table should remain useful for several years, since tests indicate that these coefficients are relatively stable over time (Conway, 1977)[2]. Certainly, where indications of changing purchase patterns are strong, as in the case of energy inputs, adjustments may be necessary. Still another perspective is that 1982 is the date for the most recent national benchmark input-output table (U.S. Department of Commerce, 1991).

Of greater concern than the age of the table should be the quality of the estimates (i.e., measurement error), the ability of the user to adapt the information to his or her analytical needs, and the particular context of the economy reflected in the base-year estimates. With regard to the condition of the state's economy, 1987 was a year of relatively normal economic expansion in Washington, as total employment increased by 4 percent and personal income increased by nearly 6 percent.

Sectoring Plan

---

[2]Relatively stable coefficients, and hence output and income multipliers, imply the model can be updated--for instance to 1992--by taking into account the price effects.

As mentioned previously, the 1987 Washington State input-output table has been constructed with 62 industries, seven final demand sectors, and four final payment sectors. Table 2-2 shows the industry definitions of the 1987 sectoring plan. For the most part, these industry definitions follow closely the classification scheme used in earlier studies.

The departures or differences in the 1987 sectoring plan from earlier studies represent a trade-off between comparability and increased economic importance of certain sectors. Major revisions[3] in the 1987 table include:

(1) a realignment of the iron and steel and other nonferrous metals sectors into one sector--other primary metals--due to the closure of the Asarco copper smelter in Tacoma in 1984;
(2) a realignment of the nonelectric motive equipment, machine tools, and nonelectric industrial equipment sectors into two sectors named industrial machinery and computer and office equipment;
(3) a disaggregation of the other manufacturing sector into two components--other manufacturing and instruments due to the growing importance of the instruments industry to the state's economy;
(4) a disaggregation of the construction sector into two sub-components--highway construction and other construction;
(5) a disaggregation of the transportation services sector into eight sub-components--railroad transportation, local and suburban transportation, motor freight and warehousing, U.S. Postal Service, water transportation, air transportation, pipelines, and transportation services;
(6) a disaggregation of the trade sector into three sub-components of wholesale trade, eating and drinking places, and other retail trade; and
(7) a disaggregation of the services sector into three sub-components of business services, health services, and other services.

Table 2-3 provides a listing and definitions of final demand and final payment sectors in the input-output table. The final demand sectors are personal consumption expenditures, gross private investment, state and local government expenditures, federal government expenditures, exports to the rest of the U.S. and foreign exports. The final payment sectors are labor income, other value added, imports from the rest of the U.S., and foreign imports.

Table 2-2
INPUT-OUTPUT INDUSTRY DEFINITIONS

Number and Industry Name	1972 SIC Codes

[3]Unless otherwise noted, stated revisions are made with regard to the previous 1982 input-output study (Bourque, 1987).

NATURAL RESOURCE INDUSTRIES	
1. Field & Seed Crops	011,013 (ex. 0134), pt. 019
2. Vegetables & Fruits	0134, 016, 017, pt. 019
3. Livestock & Products*	02 (includes aquaculture)
4. Other Agriculture	18
5. Forestry	08, 097 (inc. National & State Forests, Christmas tree farms)
6. Fisheries	09 (ex. 097)
7. Mining	10-14
MANUFACTURING INDUSTRIES	
8. Meat Products	201
9. Dairy Products	202

Table 2-2 (continued)
INPUT-OUTPUT INDUSTRY DEFINITIONS

Number and Industry Name	1972 SIC Codes
10. Canning & Preserving	203, 2091,2092
11. Grain Mill Products	204
12. Beverages	208
13. Other Foods	205-207, 2095-2099
14. Textiles	22
15. Apparel	23
16. Logging	241
17. Sawmills	242
18. Plywood	2435, 2436
19. Other Wood Products	2431, 2434, 2439, 244, 245, 249
20. Furniture & Fixtures	25
21. Pulp Mills	261
22. Paper Mills	262
23. Paperboard, Other Paper	263-266
24. Printing & Publishing	27
25. Industrial Chemicals	281, 286, 287, 289
26. Other Chemicals	282-285
27. Petroleum	29
28. Glass Products	321-323
29. Cement, Stone & Clay	324-329
30. Aluminum	3334, 3353-3355, 3361
31. Other Primary Metals*	33 (ex. 3353-3355, 3361)
32. Structural Metal Products	344

33. Other Fabricated Metals	341-343, 345-349
34. Industrial Machinery*	35 (ex. 357)
35. Computer & Office Equipment*	357
36. Electrical Machinery	36
37. Aerospace	372, 376
38. Motor Vehicles	371, 374, 375, 379
39. Ship & Boat Building	373 (inc. Puget Sound Naval Shipyard)
40. Instruments*	38
41. Other Manufacturing	30, 31, 39
CONSTRUCTION	
42. Highway Construction*	1611, 1622
43. Other Construction*	15-17 (ex. 1611, 1622; inc. "do-it-yourself" repair & maintenance, and utility construction accounts

Table 2-2 (continued)
INPUT-OUTPUT INDUSTRY DEFINITIONS

Number and Industry Name	1972 SIC Codes
TRANSPORTATION	
44. Railroad Transportation*	40 (inc. AMTRAK)
45. Local & Suburban Transportation*	41 (inc. public transit)
46. Motor Freight & Warehousing*	42
47. U.S. Postal Service*	43
48. Water Transportation*	44 (inc. ferries, public port facilities)
49. Air Transportation*	45
50. Pipelines*	46
51. Transportation Services*	47
UTILITIES & COMMUNICATIONS	
52. Electric Companies	491, pt. 493 (in. BPA, PUDs, municipal utilities)
53. Gas Companies	492, pt. 493 (inc. municipal gas companies)
54. Other Utilities	Pt. 493, 494-497 (inc. public sewage, water, sanitary, and irrigation systems)
55. Communications	48
TRADE	
56. Wholesale Trade*	50, 51
57. Eating & Drinking Places*	58
58. Other Retail Trade*	52-57, 59
FINANCE, INSURANCE, AND REAL ESTATE	
59. Finance, Insurance & Real Estate	60-67 (inc. owner-occupied dwellings)
SERVICES	
60. Business Services*	73
61. Health Services*	80
62. Other Services*	07, 70,72, 75, 76, 78, 79, 81-84, 86-88

* Change in sector definition

Table 2-3
WASHINGTON INPUT-OUTPUT FINAL DEMAND AND FINAL PAYMENTS SECTOR DEFINITIONS, 1987

Sector Name	Definition
Personal consumption expenditures	Sales to consumers residing in Washington State.
Gross private investment	Sales for residential & non-residential private fixed capital formation & change in business inventories
State and local government expenditures	State & local government expenditures on both current and capital account, excluding operating expenses of government enterprises transferred to industrial sectors.
Federal government expenditures	Federal government civilian and defense expenditures on current and capital account for delivery both in-state and out-of-state. Excluded are operating expenses of government enterprises transferred to industrial sectors.
Exports to rest of U.S.	Sales of goods and services on both current and capital account to consumers and producers in the rest of the United States.
Foreign exports	Goods and services sold to foreign purchasers on both current and capital account.
Labor income	Charges against gross state product for wages, salaries, proprietors' income, & other labor income.
Other value added	Charges against gross state product for rental income, corporate profits, net interest, indirect business taxes, & capital consumption allowances.
Imports from rest of U.S.	Purchases of goods and services on current account from establishments in the rest of the United States.
Foreign imports	Purchases of goods and services on current

account from establishments in foreign countries.

While the industrial component of the sectoring plan is defined in terms of industries, the basic unit of observation for making input-output estimates is the establishment. An establishment is defined as "an economic unit, generally at a single physical location, where business is conducted or where services or industrial operations are performed." (Office of Management and Budget, 1987). In the 62-industry Washington input-output table, establishments are classified by industry according to their primary activities. Since establishments typically produce more than one good or service, each industry--defined on an establishment basis--incorporates all output (including secondary products) of establishments whose primary product is one of the products included under the sector definition (as listed under Table 2-2). This approach to classifying establishments follows the conventions used by the U.S. Bureau of the Census.

In the Washington State input-output study, not all industries are classified on an establishment basis. The natural resource industries--field and seed crops, fruits and vegetables, livestock and products, other agriculture, forestry, fisheries, and mining are defined on a commodity basis. Other industries, namely construction, are defined on an activity basis. Such sectors include the value of all commodities or services produced in the economy corresponding to the sector definition regardless of the sector origin of establishment. For these industries, the distinction between primary and secondary products becomes irrelevant.

Current and Capital Account

Transactions in the input-output tables cover expenditures on both current and capital account. Interindustry transactions, however, are on a current account basis only. From the standpoint of purchases, these transactions represent the annual operating expenses of industry.

The purchases of capital goods by the private sector of the economy are shown in the investment column of final demand. These purchases include the value of the private sector's additions of housing, plant, and equipment that are charged to fixed asset accounts. In the accounting of current production costs, only the annual capital consumption allowance (i.e., the current charge for the use of capital) is counted as an input, being part of the value added of each industry.

Producers' Prices

Input-output transactions are valued at producers' prices. Each transaction represents the revenue earned by the producer and not the cost incurred by the purchaser. Within the input-output framework, a commodity is sold from the producing sector to the consuming sector at producers' price ("free on board" at plant). The transportation cost involved in getting the commodity from the producer to the consumer is shown as a purchase from transportation by the consumer. Hence, the purchase of a commodity by another sector can be shown as a combination of (1) a purchase of the commodity and (2) the purchase of transportation service in having the commodity delivered. An additional "mark-up" occurs if the product passes through the various trade channels (i.e., wholesale trade and other retail trade). Thus, within the input-output accounting framework, consumers are shown as purchasing output from industries directly rather than aggregating all their transactions in the retail sector.

In sum, to arrive at purchasers' prices, it would be necessary to add the value of trade and transportation margins (i.e., distribution costs) to producers' prices. The producers' price convention implies that the "purchaser pays the freight" as well as the trade services of middlemen who act as intermediaries in the exchange of goods.

According to input-output accounting conventions, the costs of distributing a commodity are shown as direct sales of services from the trade sectors (namely wholesale trade and other retail trade) and transportation services (principally railroad, trucking and warehousing, water transportation, air transportation, pipelines, and transportation services) to the sector purchasing the commodity. For instance, the large expenditure by households from other retail trade represents the mark-up earned by Washington retail establishments acting as intermediaries between consumers and producers.

As a result of the producers' price convention, the input-output tables do not literally trace the flows to and from the trade industries. Any attempt to record such transactions would obscure the technical relationships that are the intended focus of the input-output model and virtually all commodities would then flow from one source, namely trade.

Differences with Conventions in National Input-Output Accounts

Although many of the conventions employed in the Washington input-output accounts are the same as those used in the national input-output tables, there are a number of differences. The more important differences relate to the handling of secondary products, the assignment of foreign imports, and the incorporation of government enterprises. Since the Washington input-output table generally adheres to the establishment as the basic unit of observation, the output of an industry includes both its primary and secondary products. For the national table, all secondary production is redefined by establishing a commodity-by-industry accounting framework.

In the Washington accounts, foreign imports are shown as purchases by the industry directly acquiring them. In contrast, the national accounts treat foreign imports as substitutes for domestically-produced goods and services and thus, imports are channeled through the respective domestic producing industry for redistribution to the using sectors. The result is that the national table does not directly assign foreign imports to the industries that purchase them; hence, the control total for an industry reflects total supply rather than domestic production. In the Washington input-output study, control totals are a measure of production, and foreign imports (as well as interstate imports) are directly distributed to the industries that procure them. No distinction is made in the Washington table between competitive and non-competitive imports.

Industry definitions in the Washington sectoring plan incorporate activities of both private and public enterprises. In the national accounts, a distinction is made between private and government enterprises. For instance, the output of electric companies in the Washington accounts include the output of private companies as well as public utilities.

Input-Output and Income and Product Accounts

The Washington input-output and income and product account series are related, since both show the composition of the state's gross domestic product. The final demand sectors of the input-output table measure the 1987 value of final production in the state. The final demand sectors include consumption, investment, government expenditures (state and local, federal), and exports (foreign and domestic). Net of imports, the sum of final production equals gross domestic product for the state. Again excluding imports, the final payments sectors measure the charges against the state's gross domestic product.

Table 2-4
GROSS STATE INCOME AND GROSS STATE PRODUCT IN WASHINGTON STATE, 1987
(in millions of dollars)

	Estimate	Percent of Total
Industrial value added	68,606.7	80.5%
Household value added	6,804.1	8.0%
State and local government value added	6,577.8	7.7%
Federal government value added	3,262.3	3.8%
Gross State Income	85,250.9	100.0%
Personal consumption expenditures	55,071.4	64.6%
Gross private domestic investment	10,078.0	11.8%
State and local government expenditures	11,964.5	14.0%
Federal government expenditures	8,329.2	9.8%
Exports to rest of U.S.	32,768.3	38.4%

Exports--Foreign	15,182.4	17.8%
(less) Imports from rest of U.S.	-41,653.9	-48.9%
(less) Imports--Foreign	-6,489.0	-7.6%
Gross State Product	85,250.9	100.0%

Using estimates from the 1987 Washington State input-output table, the two-way derivation of the gross domestic product for the state is shown in (Table 2-4). From the product side, the largest component of gross domestic product for Washington is personal consumption expenditures, accounting for about 65 percent of the total value of final product. Reflecting the importance of exports in the state economy, the value of exports (both foreign and domestic) account for over 55 percent of gross domestic product. On the income side (from Table 2-1), about 57 percent of the total charges against gross domestic product are payments to households for the services of labor.

3. CONSTRUCTION OF THE 1987 INPUT-OUTPUT TABLES

General Approach

It is generally recognized that there are three basic approaches to constructing regional input-output tables: survey, non-survey, and semi-survey or hybrid. The identifying characteristic of survey-based tables is they are developed largely from field surveys of firms and utilize other data sources which are regional-specific. Survey-based tables have been seen as more accurate and generally desirable, but effectively limited by expense and time factors. As an alternative to survey models, less exacting, speedier, and low-cost non-survey models have been developed in recent years. In general, these models are derived by manipulating national input-output relationships to estimate regional flows and their derivative multipliers, and as such do not incorporate regional-specific survey data. For instance, simple location quotients (i.e., indices of regional specialization) are applied to national procurement patterns to derive proxy values for direct regional input-output coefficients. Another adjustment method based on estimates from regression equations is the regional purchase coefficient. An RPC is simply the proportion of a good or service supplied locally to fulfill local demands. Such techniques are pursued extensively in the RIMS model developed by the U.S. Bureau of Economic Analysis (1992) and in the IMPLAN model developed by the U.S. Forest Service (Alward et al., 1993). As implied by its name, the semi-survey or hybrid approach contains elements of both survey and non-survey methods. Generally, non-survey methods provide an initial table which is then supplemented by region-specific data to ensure that particular elements of the regional economy are accurately represented in the resulting table.

No other state has had as much experience in the construction of survey-based input-output tables as Washington. The assembled state tables--representing the years 1963, 1967, 1972, 1982, and now 1987--are survey-based, loosely meaning that questionnaires and surveys are central elements, and augmented with available regional information, including census data, reports of regulatory agencies, trade reports, and the panoply of other arcane regional sources. Each study varies in the amount of and reliance upon information obtained from survey questionnaires. However, for most of the model's sectors (or the state's largest industries), the estimates of the sources of inputs and markets for outputs were based on returns from mail surveys of business establishments, interviews with representatives of companies and trade associations, and numerous phone conversations. In the 1987 study, questionnaires were sent to firms in 25 sectors.

Industry Survey

A stratified sample survey of Washington establishments of selected manufacturing and service industries was undertaken for the study. Sectors were selected for surveying on the basis of their overall importance to the state's economy. Given the overall scope and limited budget for the study, surveys were not taken in other industries. For the most part, the unsurveyed sectors have either excellent secondary source data (as in agriculture, fishing, mining, construction) or relatively simple input structures that could be estimated from national input-output data.

For each establishment surveyed, respondents were asked to estimate essentially three things: (1) the value of total output; (2) sales and purchases by sector; and (3) the proportion of each sale and purchase made within and outside of Washington.[4] Total output is measured as either total sales, shipments, receipts, or revenues for calendar year 1987. Sales by sector include transactions to the 62 sectors as well as to the final demand sectors. Purchases by sector cover flows from industries and the final payments sectors. The purchase analysis covered only transactions on current account.

Table 3-1
RESPONSES TO SURVEY QUESTIONNAIRES

			Coverage Factors Percent of Industry	
Industry		**Number of Responses**	**Employment**	**Shipments**
9	Canning & Preserving	3	7.0%	7.2%
16	Logging	4	2.3%	6.8%
17	Sawmills	13	13.1%	22.2%
18	Plywood	8	27.2%	42.0%
19	Other Wood	7	6.2%	10.5%
21	Pulp Mills	2	26.6%	22.2%
22	Paper Mills	6	37.0%	60.0%
23	Paperboard, Other Paper	6	25.4%	30.2%
26	Other Chemicals	2	18.0%	9.2%
30	Aluminum	7	85.0%	72.0%
31	Other Primary Metals	3	12.6%	4.8%
34	Industrial Machinery	2	1.2%	1.1%
36	Electrical Machinery	3	10.3%	23.6%
37	Aerospace	7	68.0%	86.1%
39	Ship & Boat Building	3	63.1%	51.9%
40	Instruments	4	6.0%	5.9%
47	U.S. Postal Service	1	100.0%	100.0%
60	Business Services	11	2.7%	6.0%
61	Health Services	10	7.4%	8.4%
62	Other Sectors	9	NA	NA
	TOTAL	111	NA	NA

[4]See Appendix E for an example of a questionnaire used in the sample survey.

The sample survey was designed to maximize coverage of each industry, but the response rate to the 620 mailed questionnaires varied from industry to industry, as shown in Table 3-1. A total of 111 usable questionnaires were returned for an overall response rate of about 18 percent. Coverage based on total employment in each industry ranged from nearly nothing to a full count. The highest coverage factors were obtained in aerospace, U.S. Postal Service, aluminum, paper, and ship and boat building. In terms of employment, total surveyed coverage in the non-agricultural sectors amounts to about 38 percent; but for manufacturing the figure is approximately 46 percent.

Use of Secondary Data: Known Transactions

In addition to the limited business survey, sources of published information were utilized to estimate many of the important entries in the input-output table.[5] In general, four types of entries can be estimated from existing sources of information:

1. Industry output. The economic census reports (e.g., *Census of Manufactures* and the *Census of Wholesale Trade*), state agriculture and fisheries publications, and other primary data sources provide most of the required information for estimating total output (i.e., value of production or sales) for each industry in the input-output table. Estimating procedures surrounding each industry do not differ from that used in previous input-output studies.

2. Industry value added. Again, the economic census reports provide the basis for estimating value added by industry. Other sources, including the U.S. Bureau of Economic Analysis' (BEA) annual Gross State Product (value added) series by industry were consulted. For most industries, adjustments for services inputs were made to the reported value added. The *Census of Manufactures*, for instance, only reports the cost of materials in production, not the cost of services inputs.

3. Labor income by industry. A major component of value added is labor income (or household income). Labor income is comprised of wages, salaries, proprietors' income, and other labor income. BEA regularly publishes labor income estimates at the two-digit level for each state. The labor income series currently extends through 1991.

4. Selected interindustry transactions and final demand. Some interindustry transactions and most final demands can be estimated with reasonable accuracy from trade journals and industry experts.

Balancing Routine

---

[5]A listing of sources for each sector is available from the authors.

A balancing routine is employed in the 1987 study to estimate the "unknown transactions" in the table. Two steps were involved in balancing the table. The first step develops the so-called "unbalanced (unknown) transactions" table. The control (column and row) totals in this table are essentially the known sums of the unknown transactions that require balancing. In each case, the control total is calculated as the difference between the control total in the known transactions table and the sum of the known intersectoral transactions. For the remaining unknown transactions in the unbalanced table, generally intersectoral flows, figures from the 1982 table are used as initial estimates.

The second step in the routine is to balance the flows. This is accomplished with a bi-proportional scaling routine. Looking at the unbalanced table from the sales point of view (i.e., across a row), the so-called unknown transactions must add up to total sales (the row control total of the unbalanced table). The most logical way to achieve this is to raise (or lower) all intersectoral transactions proportionally. After scaling is repeated for all "selling sectors," including imports, the table is balanced across the rows.

Given these new estimates of sales, the scaling procedure is then repeated down the columns for purchases. Generally, the newly balanced rows will impart imbalance down the columns. The subsequent column scaling will force balance down the columns but again imparts imbalance across the rows. However, after several rounds of alternatively scaling rows and columns, the estimates of the unknown transactions converge to values which balance the unknown transactions table across the rows and down the columns. After two hundred and fifty iterations of bi-proportional scaling, the table achieves total balance.

The final result is the estimate of the 1987 input-output table. The updated estimates of the direct purchase coefficients are shown in Table 3-2. Most of these estimates bear a strong similarity to the 1982 estimates. This is the desired outcome of the bi-proportional scaling routine, since many studies have shown that input-output coefficients tend to change slowly over time.

Table 3-2
1987 WASHINGTON STATE DIRECT PURCHASE COEFFICIENTS TABLE

	Natural Resource	**Manu-facturing**	**Trade and Services**	**Personal Consumption**
Natural resource	0.10453	0.04279	0.00287	0.00305
Manufacturing	0.08263	0.10870	0.05835	0.03212
Trade and services	0.08667	0.10188	0.20319	0.35550
Subtotal	0.27383	0.25336	0.26442	0.39067
Labor income	0.32558	0.19067	0.37418	0.00000
Other value added	0.29974	0.15417	0.23646	0.07981

Imports	0.10086	0.34483	0.12495	0.17551
Total Input	1.00000	1.00000	1.00000	0.64599

4. APPLICATIONS OF THE INPUT-OUTPUT MODEL

Descriptive Analysis

One of the most straightforward applications of the Washington input-output tables is as a description of economic activity. The input-output table provides a basis for measuring income and product accounts for Washington State. The gross state product (GSP) for Washington is the sum of the value added across all sectors of the economy. In 1987, the sum of value added amounted to $85.2 billion, or 1.9 percent of the U.S. gross domestic product (GDP). In 1963, the year of the first Washington input-output table, gross state product was valued at $9.1 billion, or 1.5 percent of U.S. GDP. After adjusting for inflation, the annualized growth rate of Washington's gross state product between 1963 and 1987 was 4.1 percent, compared to a real GDP growth rate of 2.9 percent. Over the long-term, Washington's economy has outpaced the nation's.

Estimates of the Washington GSP for the years covered by the input-output studies are shown in Table 4-1. During the most recent study interval, the Washington GSP growth rate of 3.5 percent per annum was slightly lower than that of the GDP annual growth rate of 3.8 percent.

Table 4-1
WASHINGTON STATE GROSS STATE PRODUCT, SELECTED YEARS
(in millions of nominal and constant 1987 dollars)

Year	Washington GSP Nominal $	Washington GSP 1987 $	Share of U.S. GDP	Constant $ Annualized Growth Rate
1963	9,066	31,589	1.4%	---
1967	12,733	40,551	1.5%	6.2%
1972	19,171	49,410	1.6%	4.0%
1982	58,487	71,517	1.9%	3.7%
1987	85,251	85,251	1.9%	3.5%

Sources of Gross State Product, By Industry

Estimates of the industrial origin of the Washington GSP are summarized in Table 4-2. The percentage contribution of each category to the total GSP over the years is quite revealing about long-term structural change in the state. In particular, the service and trade sectors account for an increasing share of income originating in Washington State. These labor-intensive sectors account for more than two-fifths of GSP. In comparison, the natural resource and manufacturing sectors have lost ground. Clearly, the commodity-producing industries are making a relatively smaller contribution to the Washington economy than in years past. The value added (measured in terms of labor compensation) in general government currently accounts for roughly the same proportion of GSP as it did nearly twenty-five years ago. Household value added, a measure of net rental value of occupied homes (or "gross housing product") has declined proportionately after a significant increase between 1972 and 1982.

Table 4-2
SOURCES OF WASHINGTON GROSS STATE PRODUCT
SELECTED YEARS
(current dollars)

	1987		1982		1972		1963	
	$Million	% Total	$Million	% Total	$Million	% Total	$Million	% Total
Gross State Product	85,250.9	100.0%	58,487.0	100.0%	19,171.1	100.0%	9,066.0	100.0%
Goods-producing Industries (1-43)	23,895.0	28.0%	18,378.0	31.4%	6,488.3	33.8%	3,664.3	40.4%
Agriculture, Fishing, Food Processing (1-4, 6, 8-13)	3,657.5	4.3%	3,127.0	5.3%	1,235.0	6.4%	712.0	7.9%
Forestry, Wood Products, Paper (5, 16-19, 21-23)	3,990.3	4.7%	2,262.0	3.9%	1,537.0	8.0%	821.0	9.1%
Primary and Fabricated Metals (30-33)	1,289.8	1.5%	1,143.0	2.0%	487.0	2.5%	262.0	2.9%
Aerospace (37)	3,754.4	4.4%	2,700.0	4.6%	863.0	4.5%	629.0	6.9%
Shipbuilding (39)	417.3	0.5%	1,260.0	2.2%	226.0	1.2%	147.0	1.6%
Service-producing Industries (44-62)	44,711.7	52.4%	27,472.0	47.0%	8,560.8	44.6%	3,474.1	38.3%
Transport, Communications, Public Utilities (44-55)	9,043.6	10.6%	6,478.0	11.1%	1,941.0	10.1%	852.0	9.4%
Finance, Insur, Real Estate, Trade, Services (56-62)	35,668.1	41.9%	20,994.0	35.9%	6,620.0	34.5%	2,622.0	28.9%
All Other Industry (7, 14-15, 20,24-29, 34-36, 38, 40-43)	10,785.7	12.6%	7,590.0	13.0%	2,140.0	11.2%	1,093.0	12.1%
Government: Federal and State and Local	9,840.1	11.5%	6,774.0	11.6%	2,513.6	13.1%	1,074.0	11.8%
Household Value Added	6,804.1	8.0%	6,159.0	10.5%	1,608.4	8.4%	853.6	9.4%

The Uses of Washington GSP

The markets for the output of the Washington economy are described in Table 4-3. Consumer markets within Washington are clearly the most important to industry; nearly two out of every three dollars spent by Washington consumers are for goods and services provided by within-state suppliers. Of total consumer outlays of $55.1 billion, all but $15.1 billion was spent "at home."

Net exports by industrial sectors (excluding federal markets) have increased significantly compared to earlier studies completed in the 1960s. These gains, however, have been offset by a decline in the proportion of GSP sold to the federal government. Washington state and local government has declined somewhat compared to 1982, while gross private investment shares are cyclically erratic.

Table 4-3
THE MARKETS FOR WASHINGTON OUTPUT
(SOURCES OF FINAL DEMAND FOR WASHINGTON GSP)
(millions of current dollars and percent of total)

	1987		1982		1972		1967		1963	
	$Million	% Total	$Million	% Total	$Million	% Total	$Million	% Total	$Million	% Total
Gross State Product	85,250.9	100.0%	58,487.0	100.0%	19,171.0	100.0%	12,733.0	100.0%	9,066.0	100.0%
Washington PCE purchased from WA suppliers	40,108.9	47.0%	27,724.0	47.4%	8,716.0	45.5%	6,474.0	50.8%	4,492.0	49.5%
Washington gross private investment purchased from WA suppliers	8,230.0	9.7%	3,579.0	6.1%	1,372.0	7.2%	1,432.0	11.2%	663.0	7.3%
Washington state & local government expenditures in WA	10,586.1	12.4%	8,618.0	14.7%	2,490.0	13.0%	1,537.0	12.1%	953.0	10.5%
Federal government expenditures in WA	8,329.2	9.8%	6,778.0	11.6%	2,384.0	12.4%	2,166.0	17.0%	1,864.0	20.6%
Net exports by industrial sectors	17,996.7	21.1%	11,788.0	20.2%	4,209.0	22.0%	1,124.0	8.8%	1,093.0	12.1%

The external trade relationships of Washington State are particularly impressive. The state, in both absolute and relative terms, is becoming more import-dependent and export-oriented (Table 4-4). Total exports of Washington industry--inclusive of federal government, exports to the rest-of-U.S., and foreign exports--amounted to $56.3 billion in

1987. This is eleven times greater than that of 1963. In comparison, the GSP over this period increased by 9.4 times (in nominal terms). Exports are obviously more important than formerly, but the composition of export markets has also changed. There is increasing reliance upon foreign markets. Exports to foreign markets have expanded many times faster than GSP during the period. Exports to the rest-of-U.S. have also grown faster than GSP, while exports to federal government have increased 4.5 times since 1963. Washington dependency upon federal spending--both civilian and military is much less than it used to be.

On the import side, Washington purchases from the United States by industry and by consumers have grown relative to GSP. Imports by state and local governments show weak growth, indicating a shift in state and local procurement toward the purchase of more locally provided goods and services.

Table 4-4
THE EXTERNAL TRADE ACCOUNTS OF WASHINGTON STATE
1963 AND 1987
(millions of current dollars)

	1987	1963
Total Exports by Markets	56,279.9	5,381.8
to federal government	8,329.2	1,864.4
to rest-of-U.S.	32,768.3	3,041.3
to foreign markets	15,182.4	476.1
Imports by sectors, all sources	48,142.9	4,567.7
Total imports from rest-of-U.S.	41,653.9	4,202.3
by consumers	13,623.4	1,526.7
by industry	25,288.1	2,139.9
by investors	1,408.0	288.9
by state & local governments	1,334.4	246.8
Total imports-foreign	6,489.0	365.4
by consumers	1,339.1	81.1
by industry	4,665.9	284.3
by investors	440.0	---
by state & local governments	44.0	---
Net Exports	8,137.0	814.0
Trade with rest-of-U.S.		
(including federal)	-556.4	703.4
Foreign trade	8,693.4	110.7

Gross State Product	85,250.9	9,066.0

On balance, Washington's net exports to the rest of the world were $8.1 billion in 1987. Net export growth has grown nine fold since 1963, roughly the same magnitude of increase as GSP during the period. This rise in trade surplus follows from the fact that both exports and imports have expanded faster than GSP, and exports--particularly to foreign countries, have increased faster than imports.

Washington's overall surplus on its external trade accounts displays significant shifts since 1963. While our trade surplus has risen substantially with respect to our foreign trading partners, our trade surplus with the rest-of-U.S. (including federal purchases) has turned decidedly negative. While federal procurement from Washington State has grown slowly, Washington producers have found new markets in the United States, and more significantly, abroad. Out-of-state producers--both foreign and domestic have also established a strong foothold in Washington markets.

Table 4-5
OUTPUT AND VALUE ADDED BY SECTOR, 1982 AND 1987
(millions of current dollars)

	Gross Output			Value Added		
Sector	**1982**	**1987**	**1987/1982**	**1982**	**1987**	**1987/1982**
Field & Seed Crops	1,158.0	864.7	75%	746.0	478.4	64%
Vegetables & Fruits	759.0	1,049.9	138%	592.0	782.8	132%
Livestock & Products	916.0	947.2	103%	291.0	330.2	113%
Other Agriculture	136.0	133.1	98%	116.0	95.6	82%
Forestry	603.0	884.3	147%	517.0	787.0	152%
Fisheries	94.0	177.0	188%	56.0	93.4	167%
Mining	238.0	382.7	161%	164.0	208.3	127%
Meat Products	1,091.0	1,334.4	122%	112.0	104.3	93%
Dairy Products	780.0	794.7	102%	114.0	111.0	97%
Canning & Preserving	1,594.0	2,006.8	126%	528.0	713.0	135%
Grain Mill Products	305.0	443.4	145%	50.0	105.4	211%
Beverages	694.0	972.2	140%	224.0	435.5	194%
Other Foods	598.0	745.3	123%	298.0	407.9	137%
Textiles	50.0	71.2	128%	22.0	55.2	251%
Apparel	189.0	340.9	180%	85.0	131.1	154%
Logging	1,738.0	1,908.6	110%	390.0	590.2	151%
Sawmills	1,081.0	1,947.6	180%	321.0	644.7	201%
Plywood	305.0	400.3	131%	79.0	129.5	164%
Other Wood Products	499.0	774.3	155%	167.0	267.5	160%
Furniture & Fixtures	164.0	255.8	157%	84.0	112.5	134%

Pulp Mills	355.0	682.8	192%	92.0	181.8	198%
Paper Mills	1,253.0	1,903.8	153%	382.0	839.7	220%
Paperboard, Other Paper	1,041.0	1,386.7	133%	314.0	549.9	175%
Printing & Publishing	865.0	1,435.1	166%	491.0	867.9	177%
Industrial Chemicals	857.0	1,457.2	171%	543.0	1,003.6	185%
Other Chemicals	185.0	186.2	100%	59.0	83.8	142%
Petroleum	4,629.0	3,729.4	80%	564.0	650.0	115%

Table 4-5 (continued)
OUTPUT AND VALUE ADDED BY SECTOR, 1982 AND 1987

Sector	Gross Output 1982	1987	1987/1982	Value Added 1982	1987	1987/1982
Glass Products	116.0	183.6	155%	52.0	86.7	167%
Cement, Stone & Clay	413.0	569.4	139%	194.0	258.8	133%
Aluminum	2,050.0	1,842.7	90%	470.0	508.0	108%
Other Primary Metals	563.0	548.1	97%	222.0	265.3	120%
Structural Metal Products	582.0	690.3	119%	236.0	267.8	113%
Other Fabricated Metals	520.0	680.8	131%	215.0	248.7	116%
Industrial Machinery	910.0	1,183.2	129%	472.0	608.8	129%
Computer & Office Equipment	299.0	531.5	175%	146.0	309.2	212%
Electrical Machinery	907.0	880.2	98%	522.0	403.5	77%
Aerospace	8,936.0	14,208.5	159%	2,700.0	3,754.4	139%
Motor Vehicles	502.0	685.5	137%	209.0	348.0	166%
Ship & Boat Building	1,890.0	1,254.7	66%	1,260.0	417.3	33%
Instruments	546.0	1,438.6	262%	400.0	805.4	201%
Other Manufacturing	590.0	937.9	159%	308.0	427.6	139%
Highway Construction	536.0	700.0	131%	268.0	322.3	120%
Other Construction	5,996.0	10,538.0	176%	3,007.0	4,103.0	136%
Railroad Transportation	640.0	577.0	90%	423.0	281.0	66%
Local & Suburban Transport	300.0	357.0	119%	202.0	271.0	134%
Motor Freight & Warehousing	1,380.0	1,858.7	135%	887.0	1,088.7	123%
U.S. Postal Service	365.0	469.4	129%	321.0	395.6	123%
Water Transportation	1,450.0	1,244.0	86%	400.0	599.0	150%
Air Transportation	1,151.0	1,533.3	133%	472.0	637.3	135%
Pipelines	34.0	32.0	94%	22.0	24.0	109%
Transportation Services	197.0	406.0	206%	132.0	231.0	175%
Electric Companies	2,565.0	3,906.0	152%	1,675.0	2,551.0	152%
Gas Companies	1,144.0	800.0	70%	175.0	122.0	70%
Other Utilities	327.0	700.0	214%	269.0	400.0	149%
Communications	1,912.0	2,772.8	145%	1,500.0	2,443.0	163%
Wholesale Trade	6,227.0	8,974.0	144%	4,679.0	6,723.0	144%

Eating & Drinking Places	1,757.0	3,824.0	218%	1,279.0	1,712.0	134%
Other Retail Trade	7,016.0	10,385.5	148%	5,042.0	6,682.5	133%
Finance, Insur, & Real Estate	3,800.0	11,281.4	297%	2,686.0	6,898.7	257%
Business Services	2,350.0	4,089.0	174%	1,445.0	2,862.0	198%
Health Services	3,562.0	6,650.0	187%	2,650.0	3,974.5	150%
Other Services	4,824.0	9,370.8	194%	3,213.0	6,815.4	212%
Total	88,534.0	133,319.5	151%	45,554.0	68,606.7	151%

Industrial Growth

Economic growth can be measured in several different ways. From a gross output perspective, industries in Washington State increased by 50 percent in the nominal value of their outputs between 1982 and 1987 (Table 4-5). Showing the most rapid output growth is finance, insurance, and real estate, a sector whose 1987 revenues are nearly three times those of 1982. A number of other sectors saw their output double including instruments, transportation services, other utilities, and eating and drinking establishments.

Slow growth industries include petroleum and aluminum--both due to the decline in crude commodity prices during the period. Other sectors in decline included shipbuilding, field and seed crops, and electrical machinery. A number of the forest products sectors, particularly hard hit during the early 1980s, saw dramatic improvements in output during the latter 1980s.

Another important measure of relative growth is the change in value added in sectors. Industrial value added doubled in a number of sectors over the five year period. Increases were greatest in finance, real estate, and insurance; instruments; other services; computer and office equipment; and paper mills. At the other end of the growth spectrum were shipbuilding, electrical machinery, field and seed crops, railroad transportation, and gas companies.

A detailed analysis of structural change is beyond the scope of this report. The information presented here, however, is an important step in determining the sources of real economic growth and productivity advances in the Washington economy (Holland and Cooke, 1992).

Impact Analysis

The input-output table provides more than a mere description of regional economic activity. As Leontief pointed out, "it is above all an analytical tool" (Leontief, 1963). The most common application of input-output tables is impact analysis. Impact analysis essentially measures the change in output (i.e., production), employment, and income in all regional industries as a consequence of change in the final demand of a particular industry. The transactions table and the tables of derived coefficients are the basic analytical tools used in conducting impact analysis. Central to any impact analysis are economic multipliers, which are derived from the inverse coefficients or total requirements table.

The concept of the multiplier was first introduced by R.F. Kahn in 1931 and later elaborated and incorporated by John Maynard Keynes in his general theory of income and employment. Both were concerned with aggregate multipliers--measuring total changes in income (and employment) in a national economy resulting from exogenous changes in investment. Keynes pointed out that if a certain amount of income were injected into the economy, consumer spending would rise although by an amount less than the initial injection. The proportion of added income spent by consumers becomes someone else's "new" income. The latter, in turn, spend some fraction of their additional income, and this behavior continues through successive rounds of spending. The approximate total addition in income which would result from a given injection of "new" income would be the multiplier times this initial injection.

Though aggregate multipliers are useful analytical tools in assessing total impacts, input-output models enable us to derive sets of multipliers, the main feature of which is that they are disaggregated. These input-output multipliers recognize that the total impact on income (or output, employment) will vary according to which sector experiences the initial expenditure change. Manipulation of the input-output table allows for the estimation of various types of multipliers, depending upon whether the interest is in output, income, or employment. In addition, the values attached to the income and employment multipliers are not uniquely determined but are governed by the degree of model closure.[6]

The objectives here are to describe how input-output multipliers are derived using an aggregated three-industry input-output table, to present several sets of sectoral multipliers from the 1987 Washington input-output table, to illustrate their use, and to examine some issues in conducting impact analysis.

<u>A Technical Digression on Input-Output</u>

In mathematical terms, the core of the input-output model is a system of linear equations showing the interrelationships among industries through their purchases and sales. The specification of the input-output model is based on two fundamental propositions. The first proposition simply states that each industry is related to every other sector in the regional economy. In terms of industry output, this relationship can be expressed by

$$X_i = X_{i1} + X_{i2} + ... + X_{in} + Y_i, \quad i = 1, n \tag{1}$$

where:

X_i is the total output from "selling" industry i;
X_{ij} is the output sold from industry i to regional industry j; and
Y_i is the output sold to sectors of final demand.

Referring to the aggregated Washington input-output table (Table 2-1), equation (1) can be rewritten more explicitly as the following system of equations:

---

[6]"Closure" refers to the allocation of sectors between the endogenously determined portion of the model and final demand.

$$X_1 = X_{11} + X_{12} + X_{13} + X_{14} + Y_1$$

$$X_2 = X_{21} + X_{22} + X_{23} + X_{24} + Y_2$$

$$X_3 = X_{31} + X_{32} + X_{33} + X_{34} + Y_3$$

$$X_4 = X_{41} + X_{42} + X_{43} + X_{44} + Y_4 \qquad (2)$$

Each of these four equations is an accounting identity showing the industry's distribution of output or sales. These equations are also called "row equations," as they describe the transactions of industries as shown in the rows of the aggregated input-output table. The first three equations refer to the three industries--natural resource, manufacturing, and trade and services--while the household sector is represented by the fourth equation. In this version of the input-output model, households are considered to behave like industries, selling services (i.e., labor), earning revenues (i.e., wages, salaries, and proprietors' income), and making purchases (i.e., personal consumption expenditures). These input-output models with households endogenous (i.e., not one of the final demand sectors) are generally called Type II models.[7]

The second proposition, based on theories of production and trade, constitutes the key behavioral assumption of the regional input-output model. This assumption holds that the ratio of input required by industry j from regional industry i to the total output of industry j is constant:

$$r_{ij} = X_{ij}/X_j \qquad \text{for all i and j} \qquad (3)$$

Table 4-6
1987 WASHINGTON STATE DIRECT PURCHASE COEFFICIENTS TABLE

	Natural Resource	**Manu-facturing**	**Trade & Services**	**Personal Consumption**
Natural resource	0.10453	0.04279	0.00287	0.00305
Manufacturing	0.08263	0.10870	0.05835	0.03212
Trade and services	0.08667	0.10188	0.20319	0.35550
Value added	0.62531	0.34483	0.61063	0.07981
Total Employment	21.6	6.6	20.2	0.0
W&S Employment*	10.4	5.1	15.9	0.0

* Number of wage and salary employees per million dollars of output.

[7]This model is said to be "closed" with respect to the household sector. Input-output models with households exogenous--part of the final demand sector--are called Type I models. Since Type I models are rarely used in impact analysis, they are not discussed in this report. Most impact analyses use Type II models to capture the "induced" effects related to consumer spending.

Estimates of the direct input coefficients or r_{ij},are derived from base-year input-output tables. Recall that Table 3-2 (and duplicated above as Table 4-6 for convenience) presented the 1987 Washington State direct purchase coefficients from the aggregated transactions table.[8] For example, the value of r_{12}, the ratio of the purchases of natural resource industry inputs by manufactures to total manufacturing output, is .043 (=2,071.3/48,411.7; found in Table 2-1). This coefficient implies that the manufacturing industry requires 4.3 cents of natural resource industry inputs from Washington establishments for every dollar of manufacturing output. The coefficients in the last column of Table 4-6 are calculated by dividing household consumption in each category by total value added.[9] Thus, r_{24} is .0321 (=2,738.2/85,250.9), meaning that for every dollar of value added, households purchase roughly 3 cents of commodities from Washington's manufacturing sector.

Substituting these values for each r_{ij} (found in Tables 3-2 and 4-6) into equations (2) gives:

$$X_1 = .1045X_1 + .0428X_2 + .0029X_3 + .0031X_4 + Y_1$$

$$X_2 = .0826X_1 + .1087X_2 + .0584X_3 + .0321X_4 + Y_2$$

$$X_3 = .0867X_1 + .1019X_2 + .2032X_3 + .3555X_4 + Y_3$$

$$X_4 = .6253X_1 + .3448X_2 + .6106X_3 + .0798X_4 + Y_4 \quad (4)$$

Equation system (4) is essentially an input-output model of the Washington State economy with four equations and four unknowns (X_1, X_2, X_3, and X_4). This means that given values for the final demand variables (Y_1 ,Y_2, Y_3, and Y_4), the model can be solved for the output variables.

In addition to solving this simple input-output model, most impact analysis models are expanded to include an employment equation. For the aggregated Washington input-output model, this employment equation is developed from the following identity:

$$N = N_1 + N_2 + N_3 + N_4 \quad (5)$$

where

N is total employment (wage & salary and proprietor); and

---

[8]The direct purchase coefficients table is also called the direct requirements table or regional coefficients table.

[9]Alternative coefficients are calculated by dividing household consumption by total personal income.

N_j is total employment in industry j.

Similar to the assumption of fixed direct purchase coefficients, the model assumes that the direct employment requirements per unit of output, n_j, are constant for all levels of production, or in notation form:

$$n_j = N_j/X_j$$

or

$$N_j = n_jX_j \quad (6)$$

Like the direct purchase coefficients, the direct employment coefficients, n_j, are calculated from estimates of employment and output in the input-output table. For instance, the direct total employment coefficient for manufacturing industries is 6.6, measured in the number of jobs per million dollars of output. This means that the manufacturing sector requires 6.6 wage and salary workers and proprietors to produce one million dollars of manufacturing output. The direct total employment coefficients for the aggregated Washington input-output model are provided in Table 4-6.

Using these coefficients and substituting equation (6) into equation (5) gives the following employment equation:

$$N = 21.6X_1 + 6.6X_2 + 20.2X_3 \quad (7)$$

Note that since there is no employment in the household sector, the employment equation has only three terms, one for each of the industries in the aggregated table.

To briefly demonstrate how this five-equation input-output model can be used in impact analysis, consider the example of the total economic impact of a $50 million increase in manufacturing exports. Using the framework, this implies that:

$$X_1 = .1045X_1 + .0428X_2 + .0029X_3 + .0031X_4 + 0$$

$$X_2 = .0826X_1 + .1087X_2 + .0584X_3 + .0321X_4 + 50.0$$

$$X_3 = .0867X_1 + .1019X_2 + .2032X_3 + .3555X_4 + 0$$

$$X_4 = .6253X_1 + .3448X_2 + .6106X_3 + .0798X_4 + 0$$

$$N = 21.6X_1 + 6.6X_2 + 20.2X_3 \quad (8)$$

Since $Y_1 = 0$, $Y_2 = 50.0$ (the $50 million change in manufacturing final demand), $Y_3 = 0$, and $Y_4 = 0$ for this impact.

The reader can verify that the rounded-off solution is:

X_1 = 3.0, X_2 = 60.0, X_3 = 27.0, X_4 = 42.0, and N = 1,006

Thus, according to the model, a $50 million increase in manufacturing exports is expected to result in a $3 million production increase in natural resource industries. The total impact on industrial output (excluding households) is $90 million (=3+60+27). The direct and indirect impact of this export expansion on value added and total employment is $42 million and 1,006 jobs, respectively.

Table 4-7
1987 WASHINGTON STATE INVERSE COEFFICIENTS TABLE
(Total Dollars of Input Per Dollar of Output)

	Natural Resource	Manu-facturing	Trade and Services	Personal Consumption
Natural resource	1.13337	0.06161	0.01864	0.01311
Manufacturing	0.20243	1.19322	0.17124	0.10848
Trade and services	0.74812	0.53619	1.86554	0.74192
Value added	1.34249	0.84483	1.31481	1.62863
Employment*	40.9	20.0	39.2	16.0

* Number of wage and salary employees per million dollars of output.

Instead of resolving the input-output model for each new scenario of final demands, a standardized solution is generally used in economic impact analysis. This solution is given in the inverse coefficients or total requirements table (Table 4-7). The first column shows the total change in industry output and value added due to a dollar change in the final demand of natural resource industry production. That is, the first column entries represent the solution set to equations (4) and (7) given that Y_1 = 1.0, Y_2 = 0.0, Y_3 = 0.0, and Y_4 = 0.0. For instance, the table shows that for every dollar of natural resource industry output, $0.202 of output is required from manufacturing. The total employment requirement per million dollars of natural resource industry output is 40.9 employees (=1.1334*21.6+0.2024*6.6+0.74812*20.2).

Multipliers

An input-output multiplier is essentially a summary measure of an industry's impact on the economy. Although a multiplier is generally expressed as a single number, it is formally defined as the ratio of the industry's total impact to its direct impact.

The inverse coefficients or total requirements table is also called the multiplier table, since the most commonly used multipliers are obtained from it. Each cell shows the value of output from the industry named at left required directly, indirectly, and through induced household consumption to support a dollar of final demand delivered from the industry named at the top.

Defined with respect to a dollar of manufacturing output, the manufacturing value added multiplier is 0.8448, which is simply the fourth entry in the second column. The labor income multiplier, defined with respect to a manufacturing dollar of output, can be obtained by the product sum of each cell in the manufacturing column with its respective labor income coefficient. Thus, the labor income multiplier for manufacturing is 0.4482 (=0.3256*0.0616+0.1907*1.1932+0.3742*0.5362). Defined with respect to a million dollars of output, the manufacturing total employment multiplier is 20.2. Income and employment multipliers are commonly used with respect to direct changes in income and employment, rather than output.

Accordingly, the manufacturing employment multiplier is the total employment required in the economy per direct job in manufacturing. Since one million dollars of manufacturing requires 6.6 total direct manufacturing jobs (from Table 4-6) and 20.0 total jobs in the economy (from Table 4-7), the manufacturing total employment multiplier is 3.03 (=20.0/6.6). This multiplier can be interpreted to mean that for every new job in manufacturing, there are an estimated 2.03 additional jobs (wage and salary and proprietors) created throughout the economy.

Table 4-8 shows the four types of economic multipliers obtained from the aggregated input-output table. These five multiplier types are those most often utilized in impact analysis.

Table 4-8
1987 WASHINGTON STATE INPUT-OUTPUT MULTIPLIERS
Three Sector Model

Industry	Total Jobs (per $mil output)	Total Employment (per job)	Labor Income (per $ output)	Value Added (per $ output)
Natural resource	40.9	1.894	0.688	1.342
Manufacturing	20.0	3.045	0.448	0.845
Trade and services	39.2	1.941	0.737	1.315

The formal definitions of these multipliers are as follows:

1. Total jobs multiplier (jobs/$million output). The total employment (wage and salary workers) generated in all sectors of the economy per million dollars of output in the industry.

2. Total employment multiplier (jobs/job). The total employment (both wage & salary workers and proprietors) generated in all sectors of the economy per job in the industry.

3. Labor income multiplier ($income/$output). The total labor income (wages, salaries, proprietors' income and other labor income) generated in all sectors of the economy per dollar of output in the industry.

4. Value added multiplier ($value added/$output). The total value added generated in all sectors of the economy per dollar of output in the industry.

For most forecasting exercises, the constant coefficient assumption regarding value added, labor income, and regional coefficients is reasonable; however, a constant job coefficient is not. This is primarily due to productivity changes, which tend to reduce the amount of labor needed to produce a unit of output, and thus the values of n_j,

1987 Washington State Multipliers

Multipliers for the 62-industry Washington State input-output model are reported in Table 4-9. The input-output model is a Type II model, that is, households are an endogenous part of the model. Included for each industry are Type II total jobs, Type II total employment, Type II labor income, and Type II value added. The labor income and value added are stated in terms of dollar of income per dollar of output delivered to final demand by the industry named at left in the table. The jobs multiplier is given in terms of the total number of jobs generated in the economy per million dollars of output. This set of multipliers is then divided by the estimated total job coefficients to obtain the set of total employment multipliers.

Table 4-9
WASHINGTON STATE INPUT-OUTPUT MULTIPLIERS, 1987

Industry	Total Jobs (per $million of output)	Total Employment (per job)	Labor Income (per $output)	Value Added (per $output)
Field & Seed Crops	27.178	2.750	0.625	1.204
Vegetables & Fruits	70.629	1.409	0.894	1.486
Livestock & Products	29.373	4.293	0.739	1.268
Other Agriculture	68.292	1.412	0.898	1.386
Forestry	27.019	4.167	0.492	1.621
Fisheries	85.258	1.298	0.804	1.205
Mining	28.901	2.434	0.565	1.136
Meat Products	15.631	5.794	0.338	0.620
Dairy Products	29.171	14.489	0.676	1.259
Canning & Preserving	39.324	5.405	0.598	1.233
Grain Mill Products	14.572	4.615	0.302	0.659
Beverages	24.958	8.987	0.482	1.250
Other Foods	28.529	3.544	0.544	1.291
Textiles	36.030	2.138	0.825	1.437
Apparel	28.474	1.798	0.439	0.826
Logging	31.004	5.801	0.594	1.482
Sawmills	30.208	4.173	0.599	1.306
Plywood	33.258	3.598	0.653	1.328
Other Wood Products	21.089	6.532	0.443	1.029
Furniture & Fixtures	36.479	2.456	0.659	1.203
Pulp Mills	21.900	9.346	0.478	1.087
Paper Mills	24.251	6.995	0.532	1.277
Paperboard, Other Paper	28.579	5.081	0.588	1.358
Printing & Publishing	33.047	2.407	0.641	1.288
Industrial Chemicals	27.146	3.629	0.643	1.407
Other Chemicals	22.763	3.853	0.462	1.058
Petroleum	5.476	8.879	0.112	0.358
Glass Products	29.931	3.233	0.600	1.289
Cement, Stone & Clay	28.281	3.501	0.574	1.198
Aluminum	18.128	4.639	0.443	0.927
Other Primary Metals	24.484	3.273	0.544	1.128
Structural Metal Products	22.884	2.468	0.487	0.884
Other Fabricated Metals	23.755	2.788	0.478	0.919
Industrial Machinery	26.338	2.397	0.555	1.061
Computer & Office Equipment	28.685	2.772	0.601	1.236
Electrical Machinery	27.179	2.416	0.563	1.031
Aerospace	14.397	2.301	0.383	0.535
Motor Vehicles	19.242	3.664	0.479	1.011
Ship & Boat Building	26.239	1.814	0.623	0.756

Instruments	25.061	2.752	0.548	1.128
Other Manufacturing	30.569	1.880	0.483	0.977

Table 4-9 (continued)
WASHINGTON STATE INPUT-OUTPUT MULTIPLIERS, 1987

Industry	Total Jobs (per $million of output)	Total Employment (per job)	Labor Income (per $output)	Value Added (per $output)
Highway Construction	29.553	2.486	0.703	1.083
Other Construction	30.238	2.667	0.614	1.029
Railroad Transportation	26.469	2.674	0.706	1.076
Local & Suburban Transport	47.212	1.718	0.959	1.441
Motor Freight & Warehousing	38.077	2.151	0.754	1.261
U.S. Postal Service	47.736	1.710	1.183	1.529
Water Transportation	23.455	2.792	0.575	1.014
Air Transportation	26.423	3.130	0.635	1.039
Pipelines	22.912	9.400	0.463	1.486
Transportation Services	50.942	1.736	0.972	1.279
Electric Companies	22.788	7.161	0.495	1.464
Gas Companies	8.958	3.084	0.245	0.380
Other Utilities	34.245	3.471	0.766	1.499
Communications	28.974	3.259	0.675	1.564
Wholesale Trade	35.777	2.716	0.739	1.518
Eating & Drinking Places	57.955	1.632	0.716	1.251
Other Retail Trade	49.433	1.869	0.803	1.419
Finance, Insur, & Real Estate	42.592	2.543	0.706	1.510
Business Services	51.655	1.674	0.883	1.398
Health Services	45.174	2.009	0.920	1.360
Other Services	63.483	1.645	1.008	1.555

These multipliers are relatively consistent compared with those of earlier studies (Bourque and Conway, 1977, Bourque, 1987). This issue of stability is important especially if sectoral multipliers are to be useful for predictive purposes.

What is meant by multiplier stability? Simply, stability refers to the level of consistency in sectoral multipliers observed over time. In addition to simple measurement error, there are numerous sources of temporal change operating to influence the magnitude of multipliers. Changes in technical methods of production, changes in geographic patterns of procurement, changes in product mix within sectors, and changes in the span of processing within establishments take place over time. Such changes become manifest in the direct production coefficients from which multipliers are derived. Changes in direct coefficients are themselves functions of still more complex forces including changes in technology, relative costs, economies of scale, and regulatory mandates. The critical question is whether these dynamic forces making for changing regional direct coefficients undermine the usefulness of multipliers for the purposes of impact analysis.

Value added multipliers for individual sectors for this study have been compared with other study years (see Table 16, page 33, Bourque 1987). As in other studies, the average (unweighted mean) and median multiplier values continue to decline. In the 1987 study, the average value added multiplier across all sectors was 1.18 and the median was 1.25. Further analysis indicates that differences among sector multipliers not only tend to be persistent, but that their levels tend to change systematically over the time frame covered by these input-output studies.

Impact Estimation Procedures

Presented in this section are two simple impact analyses illustrating the application of the detailed Washington input-output model:

1. Computer and office equipment impact. The first example is estimating the impact on the Washington state economy of an additional $50 million order in computer equipment (namely computer printers). The direct and total impacts of such an expansion are shown in Table 4-10.

Table 4-10
COMPUTER AND OFFICE EQUIPMENT
IMPACT ON WASHINGTON STATE ECONOMY

	Impact
DIRECT IMPACT	
Computer & Office Equipment output ($ million)	50.0
Computer & Office Equipment total employment	517
Computer & Office Equipment labor income ($ million)	13.5
TOTAL IMPACT	
Output ($ million)	96.4
Total employment	1,434
Labor income ($ million)	30.0

The direct impact amounts to $50 million of production, 517 jobs, and $14.0 million of labor income within the computer and office equipment industry. The direct employment and income impacts are estimated by multiplying the $50 million by the direct employment and income coefficients, respectively. For example, since the direct income coefficient is $.2709 million per million dollars of output, the direct labor income impact is $13.5 million (=.2709*50.0).

These direct impacts can be calculated by multiplying the exogenous change by the appropriate multipliers from Table 4-9. For instance, the total increase in labor income from the increased production of $50 million in computer and office equipment is $30.0 million (=50.0*.601).

2. Health care industry impact. This second example is estimating the impact on the state economy from a hospital expansion. This example is more complicated than our first example in that the expansion amounts to $100 million in new construction with an additional $50 million in projected revenues in the health care industry. However, as the following calculations demonstrate, the overall impact of this expansion is simply the sum of the total impacts of construction and operation.

The direct and total impacts of the hospital expansion (construction and operation) are shown in Table 4-11. The first three columns present the direct output, employment, and labor income impacts for other construction and health care sectors. The direct employment impacts, for instance, are calculated by multiplying the direct output impacts by the corresponding employment coefficients.

Table 4-11
HOSPITAL EXPANSION
IMPACT ON WASHINGTON STATE ECONOMY

	DIRECT IMPACT			**TOTAL IMPACT**		
	Output ($ mil.)	**Employment**	**Labor Income ($ mil.)**	**Output ($ mil.)**	**Employment**	**Labor Income ($ mil.)**
Other Construction	100.0	1,134	28.1	196.4	3,024	61.4
Health Care	50.0	1,124	25.9	104.9	2,259	46.0
Total	150.0	2,258	54.0	301.3	5,283	107.4

The second set of three columns of Table 4-11 show the total output, employment, and income effects (in 11 industries) as a consequence of the direct impact of both construction and health care. For example, $100 million in other construction output leads to a total employment impact (both wage & salary workers and proprietors) on the economy of 3,024 jobs. As before, the total employment impact is calculated by multiplying the direct other construction employment impact by that industry's total employment multiplier, which is 2.667 (=1,134*2.667) (Table 4-9).

Considerations in Economic Impact Analysis

When conducting an impact analysis using these input-output tables, a number of considerations should be kept in mind. Most of these comments concern the use of multipliers.

1. Critical in the analysis is identifying the initial change in final demand. If the issue under analysis is not clearly specified, then the impact analysis will not be completed successfully. Such mundane matters as the sector and study area under consideration are critical. Here, the analyst needs to determine whether (1) the change is in final demand; (2) there are offsetting changes in the economy; (3) new construction is required by the change;[10] and (4) final demand change is in more than one sector. Take for example, the matter of offsetting changes in the economy. Positive multiplier effects of public sector projects are often trumpeted without a careful consideration of the negative offsets by taxpayers who finance them.

2. There is no single multiplier for the Washington economy. Often asked is what is "the" multiplier for Washington? Related, is what is "the" multiplier for aerospace in Washington? Since there are in fact multiple kinds of multipliers for each industry, such a question makes very little sense. Table 4-9 presents 248 multipliers and still does not exhaust the possibilities. Conceivably, there are an infinite number of possible multipliers, depending upon the degree of model closure and the formulation of the income and expenditure functions. Remember that a multiplier is simply the ratio of two changes, the dependent change being the numerator and the independent change being the denominator.

3. Multipliers are specified according to quite simplified behavioral assumptions in response to changes in demand and income. The value for any given multiplier is dependent upon the behavioral assumptions underlying the input-output model. In the equation set (2), four key restrictions are placed upon the Type II value added multipliers: (1) the behavioral relations are linear; (2) regional coefficients are constant; (3) consumption is a simple function of value added; and (4) the effects of induced state and local government expenditures and induced investment spending are zero, that is the model is not closed with respect to government and investment expenditures.[11] Obviously, if any of these assumptions are altered, the multiplier estimates would change. One underlying issue is how much bias a set of assumptions might introduce into the assessment of an impact.

---

[10]Recall that because input-output transactions are on a current account basis, construction (for example, a new facility) represents a capital account purchase, and as such, requires specifying a separate increase in final demand (investment).

[11]These restrictions also apply to the other Type II labor income, total jobs, and total employment multipliers.

Table 4-12
VALUE ADDED MULTIPLIERS UNDER ALTERNATIVE SPECIFICATIONS, 1987
(dollar per dollar of output delivered to final demand)

Industry	Type II	Alternative Consumption Function	State & Local Government Endogenous
1 Field & Seed Crops	1.204	0.915	1.477
2 Vegetables & Fruit	1.486	1.192	1.823
3 Livestock	1.268	1.005	1.556
4 Other Agriculture	1.386	1.144	1.701
5 Forestry	1.621	1.056	1.989
6 Fisheries	1.205	1.006	1.478
7 Mining	1.136	0.851	1.393
8 Meat Products	0.620	0.480	0.761
9 Dairy Products	1.259	0.968	1.545
10 Canning & Preserving	1.233	0.916	1.513
11 Grain Mill	0.659	0.481	0.808
12 Beverages	1.250	0.866	1.534

Table 4-12 (continued)
VALUE ADDED MULTIPLIERS UNDER ALTERNATIVE SPECIFICATIONS, 1987
(dollar per dollar of output delivered to final demand)

Industry	Type II	Alternative Consumption Function	State & Local Government Endogenous
13 Other Foods	1.291	0.917	1.584
14 Textiles	1.437	1.133	1.764
15 Apparel	0.826	0.633	1.013
16 Logging	1.482	1.038	1.819
17 Sawmills	1.306	0.953	1.602
18 Plywood	1.328	0.991	1.629
19 Other Wood	1.029	0.736	1.263
20 Furniture	1.203	0.932	1.476
21 Pulp Mills	1.087	0.783	1.334
22 Paper Mills	1.277	0.905	1.567
23 Paperboard	1.358	0.973	1.667
24 Printing	1.288	0.965	1.580
25 Industrial Chemicals	1.407	1.026	1.727
26 Other Chemicals	1.058	0.760	1.299
27 Petroleum	0.358	0.235	0.440
28 Glass Products	1.289	0.945	1.581
29 Cement & Stone	1.198	0.887	1.470
30 Aluminum	0.927	0.686	1.138
31 Other Primary Metals	1.128	0.837	1.384
32 Structural Metals	0.884	0.686	1.085
33 Fabricated Metals	0.919	0.699	1.127
34 Industrial Machinery	1.061	0.809	1.302
35 Computer Equipment	1.236	0.919	1.516
36 Electric Machinery	1.031	0.798	1.265
37 Aerospace	0.535	0.460	0.656
38 Motor Vehicles	1.011	0.745	1.240
39 Ship & Boat Building	0.756	0.692	0.928
40 Instruments	1.128	0.838	1.384
41 Other Manufacture	0.977	0.731	1.199
42 Hwy Construction	1.083	0.895	1.329
43 Other Construction	1.029	0.823	1.263
44 Railroad Transport	1.076	0.892	1.320
45 Local Transport	1.441	1.202	1.768
46 Trucking	1.261	1.009	1.547
47 US Post Service	1.529	1.359	1.876
48 Water Transport	1.014	0.795	1.244
49 Air Transport	1.039	0.838	1.275

50 Pipeline	1.486	0.974	1.824
51 Transport Services	1.279	1.128	1.569

Table 4-12 (continued)
VALUE ADDED MULTIPLIERS UNDER ALTERNATIVE SPECIFICATIONS, 1987
(dollar per dollar of output delivered to final demand)

Industry	Type II	Alternative Consumption Function	State & Local Government Endogenous
52 Electric Companies	1.464	0.979	1.796
53 Gas Companies	0.380	0.313	0.466
54 Other Utilities	1.499	1.133	1.840
55 Communications	1.564	1.120	1.918
56 Wholesale Trade	1.518	1.129	1.862
57 Eating & Drinking	1.251	0.985	1.535
58 Other Retail Trade	1.419	1.112	1.741
59 FIRE	1.510	1.109	1.852
60 Business Services	1.398	1.142	1.715
61 Health Services	1.360	1.142	1.668
62 Other Services	1.555	1.284	1.908

Since input-output models cannot depict exactly an economy's complex reaction to any given change, it is not possible to measure the "true" impact of a change in the economy. Thus, it is not possible to state how much bias is associated with a given multiplier; that is, we cannot tell how much forecasting error is entailed with the use of a given multiplier model. Table 4-12 shows three sets of multipliers, each purporting to estimate the dollar change in total regional value added per dollar of final demand delivered by the industry named at the left. The first set is a repeat of the Type II value added multipliers given in Table 4-9, which follow the specification of equation set (2). In contrast, the second and third sets are value added multipliers based on other, though still reasonable, input-output model assumptions.

The second set of multipliers posits an alternative consumption function where consumption is a linear function of personal income rather than value added. Changes in personal income are in turn assumed to be equal only to changes in labor income as a consequence of the increased production in the region. In some ways, this model of consumption behavior is more reasonable than our prior specification, since personal income is a more immediate trigger of household spending than value added. However, there still remains a gap in achieving an ideal formulation of the output-income-consumption linkage. For instance, property income is assumed to be unresponsive to an impact. Yet, any increased activity in the economy will increase the property income of Washington residents in at least two ways. First, an expansion in production will mean increased income to the non-labor factors of production, some of which will go into the pockets of local residents. Second, greater output will also entail higher employment and some in-migration into the state, with migrants bringing with them property income in the form of dividend, rent, and interest payments.

The third set of multipliers attempts to capture the effects of induced state and local government spending. In this formulation, we return to the original specification of household behavior; that is, state and local public expenditures are a linear function of value added. Assuming that state and local spending is related to regional income is not unreasonable. The demand for public services has been found to be similar in nature to the demand for consumer services and thus is predictable from household income levels. Another research finding is that tax revenues determine expenditures, and taxes are also predictable from total income.

As shown in Table 4-12, the value added multipliers with the alternative consumption function are lower in value than the Type II multipliers. The average reduction is about 23 percent, but there is considerable range about the mean. For instance, the multiplier for Ship and Boat Building declines only 8 percent, while the decline for Forestry is 35 percent. The rankings of multipliers (i.e., a measure of their relative values) is not disturbed much with the alternative specification, although there are notable exceptions such as Forestry whose ranking fell from first to 15. When state and local government expenditures are made endogenous to the input-output model, all multipliers increase above their Type II values by 22 percent. The mathematical structure of the input-output model accounts for this across-industry percentage increase. Of course, this does not alter multiplier values relative to one another.

4. Multipliers reported in this study are applicable to the Washington economy, but not to its subdivisions. As a general rule, the smaller the economic region, the greater will be the import propensities of producers and consumers, and hence, the smaller and less stable will be the multipliers. There are reduction techniques for estimating multipliers from a national or state-level input-output table, and such methods should be applied as circumstances warrant.

5. High multipliers are **not** necessarily good, and **low** multipliers are not necessarily bad. When promoting the relative benefits of alternative projects, it is often suggested that the development with the highest multiplier should be promoted. This may not be the case because (1) results of the evaluation generally depend upon the kind of multiplier used--for instance, a project with a high income multiplier may have a low employment multiplier; and (2) relative costs--public investment, tax incentives, capital costs--of the proposed developments are neglected. Also, the size of multiplier depends upon the scope of interactions incorporated in the model. Multipliers with households

endogenous, for instance, will be larger than those that exclude the repercussions associated with household spending. Multipliers that include government spending or even investment spending reactions will be larger still.

6. Multipliers and impact measurements are only estimates of the anticipated economic effects of an external change. Impact analysis is essentially a forecasting exercise, and forecasts to a certain degree are bound to be wrong. Inaccuracies in impact analysis occur for any number of reasons. Misuse of models, model misspecification, outdated input-output coefficients are only some reasons why analyses go awry. Analysts should also recognize that multipliers generated from static input-output models are timeless. Market adjustments, such as inventories, make the time period before the full multiplier effects become operative quite uncertain.

REFERENCES

Alward, Greg, Eric Siverts, and Susan Winter. *Micro IMPLAN User's Manual. Version 91-F*. Fort Collins, CO: USDA Forest Service Land Management Group; and St. Paul, MN: University of Minnesota IMPLAN Applications and Development Group, May 1993.

Beyers, William B., Philip J. Bourque, Warren R. Seyfried, and Eldon E. Weeks. *Input-Output Tables for the Washington Economy, 1967.* Seattle, WA: University of Washington, Graduate School of Business Administration, December, 1970.

Bourque, Philip J., Edward J. Chambers, John S.Y. Chiu, Frederick L. Denman, Barney Dowdle, Guy Gordon, Morgan Thomas, Charles Tiebout, and Eldon Weeks. *The Washington Economy: An Input-Output Study*. Seattle, WA: University of Washington, Graduate School of Business Administration, June, 1967.

Bourque, Philip J. and Eldon E. Weeks. Detailed Input-Output Tables for Washington State, 1963. Pullman, WA: Washington Agricultural Experiment Station Circular 508, Washington Experiment Station, College of Agriculture, Washington State University, 1967.

Bourque, Philip J. and Milicent Cox. *An Inventory of Regional Input-Output Studies in the United States*. Seattle, WA: University of Washington, Graduate School of Business Administration, 1970.

Bourque, Philip J. and Richard S. Conway, Jr. *The 1972 Washington Input-Output Study*. Seattle, WA: University of Washington, Graduate School of Business Administration, June, 1977.

Bourque, Philip J. *The Washington State Input-Output Study for 1982*. Seattle, WA: University of Washington, Graduate School of Business Administration, March, 1987.

Bourque, Philip J. *Washington State Transport-Oriented Input-Output Study.* Olympia, WA: Washington State Department of Transportation, Planning, Research and Public Transportation Division, August, 1987.

Conway, Richard S., Jr. "The Stability of Regional Input-Output Multipliers." *Environment and Planning A.* (1977) 9:197-214.

Conway, Richard S., Jr. "The Washington Projection and Simulation Model: A Regional Interindustry Econometric Model." *International Regional Science Review* (1990) 13:141-165.

Conway, Richard S., Jr. *1987 Input-Output Tables for Hawaii State, Hawaii County, and Kauai County*. Report prepared for Hawaii State Department of Business, Economic Development, and Tourism. Seattle, WA: Dick Conway & Associates, January 1993.

Giarratani, Frank, James D. Maddy, and Charles F. Socher. *Regional and Interregional Input-Output Analysis: An Annotated Bibliography*. Morgantown, WV: West Virginia University Library, 1976.

Hastings, Steven E. and Sharon M. Brucker. "An Introduction to Regional Input-Output Analysis." Paper prepared for Conference on Input-Output Modeling and Economic Development Applications. Kansas City, Missouri, February 28, 1989.

Hewings, Geoffrey J.D. *Regional Input-Output Analysis*. Scientific Geography Series, Volume 6 (G.I. Thrall, editor). Beverly Hills, CA: Sage Publications, 1985.

Holland, David and Steven C. Cooke. "Sources of Structural Change in the Washington Economy: An Input-Output Perspective." *Annals of Regional Science* (1992) 26:155-170.

Leontief, Wassily. "The Structure of Development." *Scientific American* (1963) 209: 149-153.

Miernyk, William H. *The Elements of Input-Output Analysis*. New York: Random House, 1965.

Miller, Ronald E. and Peter D. Blair. *Input-Output Analysis: Foundations and Extensions*. Englewood Cliffs, NJ: Prentice-Hall, 1985.

Office of Management and Budget, Executive Office of the President. *Standard Industrial Classification Manual, 1987*. Washington, D.C.: U.S. Government Printing Office, 1988.

Richardson, Harry W. *Input-Output and Regional Economics*. New York: John Wiley & Sons, 1972.

Stevens, Benjamin H., George I. Treyz, David J. Ehrlich, and James R. Bower. "A New Technique for the Construction of Non-Survey Regional Input-Output Models and Comparison with Two-Survey-Based Models." *International Regional Science Review* (1983) 8:271-286.

Tiebout, Charles M. "An Empirical Regional Input-Output Projection Model: The State of Washington 1980." *Review of Economics and Statistics* (1969) 51: 334-340.

U.S. Department of Commerce, Bureau of Economic Analysis. Regional Multipliers: A User Handbook for the Regional Input-Output Modeling System (RIMS II). Washington, D.C.: U.S. Government Printing Office, 1992.

U.S. Department of Commerce, Bureau of Economic Analysis. *The 1982 Benchmark Input-Output Accounts of the United States*. Washington, D.C.: U.S. Government Printing Office, 1991.

MS-Excel (4.0) documents

Inverse1 (83,561 bytes) Ready to print Appendix C table with C=f(GSP) and VA=f(
X)

Inverse 2 (83,517 bytes) Ready to print appendix D table with C=f(YP) and EARN=
f(X).

INVERSE 3 (388,090 bytes) File copy of I-R matrix and inverse matrix with calcu
lation of labor income, total jobs and w&s jobs multipliers

RegCoef1 (83,458 bytes) Ready to print appendix B table--regional requirements
or direct coefficients

SAMPLE (12,444 bytes) Sample survey questionnaire (lumber & wood products secto
r) of WAIO study for Appendix E

TRANS87F (91,235 bytes) Ready to print appendix A table--gross flows or transac
tions table in millions of dollars

APPENDIX A:
1987 WASHINGTON STATE INPUT-OUTPUT TABLE

APPENDIX B:
1987 WASHINGTON STATE REGIONAL COEFFICIENTS

APPENDIX D:
1987 WASHINGTON STATE INVERSE MATRIX (Type II)
[C = f(YP), EARN = f(X)]

This total requirements table is an alternative inverse to that shown in Appendix C. In this table, the induced consumption is driven by earnings rather than value added, and the consumption coefficients are based on total personal income. The U.S. Bureau of Economic Analysis estimated 1987 total personal income for Washington State as $71,198.9 million. The output multipliers (b_{ij}) are generally smaller than those of the value added model.

APPENDIX C:
1987 WASHINGTON STATE INVERSE MATRIX (Type II)
[C = f(GSP), VA = f(X)]

In this inverse table, induced consumption is driven by value added rather than earnings. Each element in this matrix (b_{ij}) shows the output associated with a $1 change in the autonomous expenditures for the activity designated at the top of the column. These consequences are commonly referred to as "ripple effects."

Rows and columns 1 through 62 of the inverse matrix follow the usual industry designations. Row 63 is the value added multiplier row, and column 63 is the multiplier for autonomous personal consumption. Other Type II multipliers--total jobs (wage and salary and proprietor jobs), w&s (wage and salary) jobs, and earnings--are listed in designated rows.

The elements of the 62 x 62 portions of the inverse are called output multipliers. One can read the changes in the gross output of a designated row industry associated with a change in the (non-PCE) final demand for output of the designated column industry. Unlike the more useful value added multipliers, there is extensive duplication in the output multipliers. These b_{ij} elements actually measure the transactions that occur, and their magnitudes are significantly affected by the accounting conventions utilized in the input-output study.

Note that there are no aggregate output multipliers (column totals) because of they are often a source of confusion and misunderstanding. Given the concepts that lie behind each output measure, it does not make much economic sense to combine, for instance, the shipments of pulp mills with the margins of the insurance industry into an aggregate transactions measure.

APPENDIX E:
SAMPLE SURVEY QUESTIONNAIRE