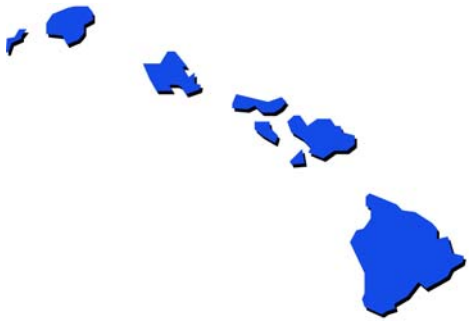
DBEDT
THE DEPARTMENT OF BUSINESS, ECONOMIC DEVELOPMENT & TOURISM
STATE OF HAWAII

THE HAWAII INPUT-OUTPUT STUDY

1997 Benchmark Report



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PREFACE

This report is the seventh in a series of input-output (I-O) studies of Hawaii's economy prepared by the Department of Business, Economic Development and Tourism (DBEDT), Dr. Seiji F. Naya, Director. It succeeds studies conducted for 1967, 1972, 1977, 1982, 1987, and 1992. These years coincide with Economic Censuses of industries, conducted every five years by the U.S. Bureau of the Census, which provide some of the key data for updating the I-O table.

The report was produced by the DBEDT's Research and Economic Analysis Division (READ), under the direction of Dr. Pearl Imada Iboshi, Division Head. It was prepared by Aaron Peterson and Dr. Khem Sharma of the Economic Research Branch, with input from several other READ staff; in particular Dr. John Mapes, Dr. Christopher Grandy, Mary Blewitt, Dr. Eugene Tian, Glenn Ifuku, Robert Shore and Diane Dunphy. The Department would like to extend its appreciation to the various agencies of the Federal, state, and local governments, as well as numerous private agencies and individuals for providing necessary data for this study.

I. INTRODUCTION

This report presents the 1997 input-output (I-O) table for the State of Hawaii. The I-O analysis furnishes important information on inter-relationships that exist among industries, final users (households, visitors, government, and exports), and factors of production within an economy. This information can be used to determine the role and relative importance of each sector in terms of its output, value added, income, and employment contributions and to analyze inter-sectoral linkages in the economy.

By providing the comprehensive and detailed information on sales and purchases of goods and services among the various sectors in the economy, the I-O tables provide a useful analytical tool for economists, planners and policy-makers in: (i) analyzing a wide range of problems related to regional and community economic development; (ii) formulating new economic and environmental policies and their effects on industry output and input patterns; and (iii) assessing impacts of new economic development efforts and exogenous (external) changes on the economy (e.g. development of new exports). More specifically, the I-O tables form the factual basis for estimating output, income, employment, and other multipliers, which are frequently used in economic impact analyses. The I-O model also provides critical information for long-range economic and demographic projections as well as for social accounting matrixes (SAM) and computable general equilibrium (CGE) modeling for public policy and alternative economic scenario simulations.

Two versions of I-O tables are presented. The two tables contain exactly the same information, but differ in terms of the level of aggregation. One is composed of 131 industry sectors, while the other one is more condensed, containing 20 sectors. A list of sectors included in the 1997 detailed and condensed tables along with their respective North American Industry Classification Systems (NAICS) codes is presented in Appendix A. The main purpose of the condensed table is to describe and illustrate the I-O analysis, including the inter-industry transactions table, direct and total requirements tables, and computations of multipliers. Various I-O multipliers for the 131 sectors included in the detailed table are also presented in this report. The corresponding transactions, direct requirements and total requirements tables are available on the DBEDT Web site at: www.hawaii.gov/dbedt/.

The 1997 I-O table not only updates the 1992 table by including the latest data on the various aspects of Hawaii's economy, but it also introduces several changes and improvements in the previous table. For example, the 1997 detailed I-O table has a total of 131 sectors compared to 118 sectors in the 1992 table. The value added component of the economy is analyzed in a greater detail in the 1997 table. It is broken down to four sub-components, namely compensation of employees, proprietors' income, indirect business taxes, and other capital costs. In the 1992 table, indirect business taxes and other capital costs were aggregated to one component as other value added. The detailed treatment of value added in the 1997 table has permitted the derivation of state tax multipliers that can be used in estimating impacts of new public- and private- sector projects and programs on state tax revenues.

Final demand sectors are also reported in a greater detail in the 1997 table. In the 1992 table the general government expenditures were analyzed in terms of three sectors, namely state and local government, Federal military government, and Federal civilian government. In the 1997 detailed table, each of these three sectors is further broken down to investment and consumption, thus yielding six general government expenditures sectors in final demand. In the 1992 table, changes in business inventories and private investment were combined to form a single private investment sector. In the 1997 table, they are treated as two separate final demand sectors. The government enterprises are also analyzed in more detail in the 1997 table. There are three state and local government enterprises (water and sewer, transit, and other) and two Federal government enterprises (postal services and other) in the 1997 table, compared to one state and local government enterprise and one Federal government enterprise sector in the 1992 table.

Another change is the migration from the U.S. Standard Industry Classification (SIC) codes, to the North American Industry Classification System (NAICS) for classifying establishments into industries. This has permitted the addition of new industries in the 1997 table, but has also required changes in definitions of some industries. The NAICS groups establishments into industries based on the activities in which they are primarily engaged. In other words, it is based on the economic principle that the producing units within an industry share the same production processes or production functions. One interesting result of the change is a new sightseeing transportation sector in the 1997 detailed table, which includes the establishments engaged in providing land, water and other sightseeing activities. In the 1992 table, according to the SIC convention, they were included either in one of the transportation (ground, water, air, and transportation services) sectors or in the amusement and recreation services sector.

The 1997 table also represents an improvement over the 1992 table in terms of the range of data on which it is based. The 1992 Economic Census data were incorporated in the 1992 table, but not as extensively as the 1997 Census in the 1997 table. For example, the 1997 Economic Censuses provide several supplementary data sets, such as Class of Client, Sources of Receipts, and Merchandise Line Sales that provided useful information in the construction of the 1997 table. Such information was not used in the 1992 table. There are approximately three times the number of data sources used in the 1997 table as in the 1992 table.

The procedure used in calculating income and Type II multipliers has also changed. Income and Type II multipliers in the 1997 table follow the RIMS II (Regional Input-Output Modeling System) methodology of the Bureau of Economic Analysis (BEA, 1997). The BEA procedure is explained in Section II of this report.

The remainder of this report is organized as follows. Section II provides a brief description of I-O analysis, followed by the derivation of the direct and total requirements tables and multipliers using the condensed version of the 1997 Hawaii I-O table. Section III provides a description of industries, data sources, and estimation

procedures. Section IV describes the estimation of the inter-industry matrix and its balancing procedure. Section V presents the multipliers derived from the 1997 detailed I-O table for Hawaii. The corresponding transactions table as well as the direct and total requirements tables are available at the DBEDT Web site cited earlier. Section VI provides a few examples of economic impact analyses using the I-O model, followed by some cautionary notes in using I-O multipliers.

II. THE INPUT-OUTPUT MODEL

Basic Framework

An input-output (I-O) model depicts a comprehensive and detailed set of accounts of sales and purchases of goods and services among the producing industries, final consumers (households, visitors, exports, and government), and resource owners (labor, capital, and land) during a particular time period (usually a year) for a specific economy or region. The information from the I-O model is presented in a format called the I-O table. This framework was developed by Wassily Leontief in the 1930's, for which he was awarded the 1973 Nobel Prize in Economics.[1]

A very general and simplified overview of an industry-by-industry I-O table is presented in Figure 2.1. The standard I-O table can be viewed as consisting of three major components (also known as blocks or quadrants). These are inter-industry transactions (block A), final demand (block B), and value added (block C). Each of these blocks consists of a series of rows and columns. The producing or selling sectors are shown in rows and they are often called the "row" sectors. Similarly, the purchasing or buying sectors are shown in columns and hence they are called the "column" sectors.

Block A, the inter-industry transactions portion of the table accounts for intermediate sales and purchases of goods and services among the producing industries in the economy. Reading across a row of the transactions table shows the inter-industry sales by the row sector to the various column sectors. Similarly, reading down a column shows the inter-industry purchases by the column sector from the various row sectors.

Block B shows the sales of commodities and services by each row industry to final users, namely households (personal consumption expenditures or PCEs), Federal, state and local government units (government expenditures), visitors (visitor expenditures), investors (private investment), and exports. The elements in Block B are final demands of goods and services produced within the economy.

Block C shows primary payments to the owners of factors production. These include payments to the primary factors of production (labor, land, and capital), business tax payments to government, interest payments for business loans, and payments for imported goods and services for intermediate use.

The I-O model follows an accounting framework in which the total receipts of sellers must balance the total expenditures of buyers. By that convention, total output (sales, including final demands) is equal to total input (purchases, including final payments) for each producing sector in the economy.

[1] Miller and Blair (1985), p. 1. Analytical details of input-output analysis can be found in Miller and Blair and other publications (*see* References)

Figure 2.1 An Overview of an Input-Output Table

	I N D U S T R I E S 1,2,3,……..,131	**Final Demand Sectors**	**Total**
I 1, N 2, D 3, U .. S .. T .. R .. I .. E .. S 131	**Block A** Inter-Industry Transactions	**Block B** Final demand (sales to households, visitors, government, investment, and exports)	**Total industry output (sales)**
Final payments Sectors	**Block C** Primary payments (payments for labor, capital, land, loans, taxes, and imported goods)		**Total payments**
Total	**Total industry input (purchases)**	**Total expenditures**	

The derivation of the direct and total requirements tables as well as output, earnings, and employment multipliers is illustrated below using a condensed version of the 1997 Hawaii I-O table. Mathematical representation of the I-O model and related procedures are presented in Appendix B.

Illustration

Transactions Table

For illustrative purposes, a condensed version of the 1997 Hawaii State I-O transactions table is shown in Table 2.1. The condensed table has 20 industry sectors, seven final demand sectors, and four final payment sectors. Table 2.1 summarizes transactions (sales and purchases) among the various aggregated sectors of Hawaii's economy in 1997. Except for the last row, the data in the table are expressed in millions of current dollars. In the I-O framework, industry sales and purchases are valued at producers' prices. Thus, wholesale and retail transactions are broken down into the producers' value, transportation costs, and wholesale trade and retail trade margins and assigned to the relevant producing industry and transportation and trade sectors.

Although it is not a necessary component of the I-O transactions table, the last row shows employment by industry, which is used at a later stage to calculate employment multipliers. Employment is defined as the total number of wage and salary jobs plus self-employed jobs in the industry, including both full-time and part-time jobs.

Table 2.1 1997 Condensed Input-Output Transactions Table for Hawaii (in $million)

	Industry	Agriculture	Mining and construction	Food processing	Other manu-facturing	Trans-portation	Information	Utilities
1	Agriculture	83.4	10.8	203.4	0.6	1.0	0.6	0.1
2	Mining and construction	4.8	21.2	1.7	29.5	5.6	9.2	20.5
3	Food processing	7.7	0.0	31.0	0.1	3.4	0.5	4.9
4	Manufacturing	44.4	200.9	50.7	92.4	316.6	30.8	332.2
5	Transportation	12.3	39.0	19.2	28.1	249.6	20.4	12.0
6	Information	2.7	19.9	15.7	13.4	53.6	148.4	4.6
7	Utilities	7.0	13.3	8.6	27.8	13.9	8.4	0.2
8	Wholesale trade	33.8	159.7	55.1	41.1	69.1	17.1	6.7
9	Retail trade	7.9	193.5	15.7	15.9	11.3	20.2	8.6
10	Finance and insurance	16.6	46.8	5.9	12.7	61.5	26.2	17.4
11	Real estate and rentals	20.1	74.1	11.2	25.2	65.3	41.7	10.5
12	Professional services	3.5	253.4	9.2	18.6	55.8	46.4	16.9
13	Business services	3.2	36.1	17.6	28.6	86.7	9.9	2.8
14	Educational services	0.2	0.0	0.0	1.5	1.9	2.5	5.7
15	Health services	0.0	0.0	0.0	0.0	0.2	0.0	0.0
16	Arts and entertainment	0.0	0.0	0.0	0.0	0.0	4.6	0.0
17	Accommodations	0.4	0.6	0.7	0.9	4.8	1.5	0.7
18	Eating and drinking	1.1	2.7	3.4	4.9	22.9	4.4	2.5
19	Other services	5.4	30.3	7.4	12.3	28.3	14.1	1.9
20	Government	3.4	3.0	2.5	3.6	134.3	5.9	2.1
	Total intermediate input	257.7	1,105.3	459.1	357.1	1,186.0	412.7	450.1
	Labor income	323.6	1,490.0	200.8	361.0	1,057.8	533.1	199.2
	Indirect business taxes	39.6	154.3	11.7	16.1	162.6	90.1	121.5
	Other capital costs	112.3	105.2	131.8	196.1	599.5	538.6	326.2
	Total value added	475.5	1,749.6	344.2	573.1	1,819.9	1,161.8	647.0
	Imports	90.3	669.4	251.2	1,431.8	580.0	365.8	123.2
	Output	823.5	3,524.3	1,054.5	2,361.9	3,585.8	1,940.3	1,220.3
	Total jobs (no. of jobs)	21,196	33,364	7,020	11,025	27,748	12,848	2,765

Table 2.1 1997 Condensed Input-Output Transactions Table for Hawaii (in $million) - Continued

	Industry	Wholesale trade	Retail trade	Finance and insurance	Real estate and rentals	Professional services	Business services	Educational services
1	Agriculture	1.2	5.5	1.1	67.6	1.0	0.3	0.8
2	Mining and construction	2.5	10.4	6.4	166.8	3.4	2.9	1.1
3	Food processing	2.7	2.4	0.0	0.0	0.0	0.0	0.0
4	Manufacturing	24.8	29.5	11.5	33.9	7.3	16.6	2.9
5	Transportation	10.9	23.6	20.4	30.3	24.9	10.8	1.7
6	Information	42.7	89.6	129.4	78.2	47.2	36.8	14.4
7	Utilities	9.0	45.2	10.5	65.7	11.0	8.9	4.2
8	Wholesale trade	34.8	17.7	13.8	30.9	15.9	14.9	3.1
9	Retail trade	15.2	50.6	4.9	29.7	28.2	19.1	2.0
10	Finance and insurance	36.3	82.3	590.1	385.7	26.6	21.0	3.5
11	Real estate and rentals	84.4	458.5	173.7	597.0	164.4	32.2	71.3
12	Professional services	35.7	75.4	115.8	87.9	147.0	54.0	6.0
13	Business services	35.4	84.9	31.7	133.1	17.6	51.5	3.5
14	Educational services	0.0	0.0	0.4	0.1	3.4	3.6	0.2
15	Health services	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	Arts and entertainment	0.0	0.0	0.0	0.0	0.0	0.0	0.2
17	Accommodations	1.9	4.7	2.5	5.4	2.0	0.8	0.2
18	Eating and drinking	2.6	4.9	7.7	12.2	5.0	2.7	6.1
19	Other services	14.1	14.4	17.0	339.7	17.6	9.3	3.3
20	Government	9.5	126.8	20.4	61.3	10.6	30.4	1.3
	Total intermediate input	363.7	1,126.2	1,157.3	2,125.3	532.8	315.8	125.6
	Labor income	776.5	1,825.7	1,065.3	825.5	1,262.2	773.0	323.1
	Indirect business taxes	393.5	516.7	133.9	690.9	97.3	68.6	18.2
	Other capital costs	218.0	497.3	955.7	5,545.7	84.5	188.3	3.9
	Total value added	1,388.0	2,839.7	2,154.9	7,062.1	1,444.1	1,029.9	345.2
	Imports	187.3	407.0	323.4	245.7	190.0	76.8	6.6
	Output	1,939.0	4,372.8	3,635.7	9,433.1	2,166.9	1,422.6	477.5
	Total jobs (no. of jobs)	23,146	87,374	31,427	31,737	35,278	35,481	14,371

Table1 2.1 1997 Condensed Input-Output Transactions Table for Hawaii (in $million) - Continued

	Industry	Health services	Arts and entertainment	Accommodations	Eating and drinking	Other services	Government	Total inter-industry demand
1	Agriculture	9.8	3.5	23.3	41.7	2.6	2.9	461.1
2	Mining and construction	9.0	6.2	18.6	12.3	15.3	24.4	371.8
3	Food processing	3.7	6.0	36.8	156.9	0.0	3.9	259.9
4	Manufacturing	22.6	3.6	13.6	8.0	23.0	22.0	1,287.0
5	Transportation	28.1	6.0	22.3	14.5	14.4	33.1	621.5
6	Information	57.2	12.0	77.7	16.8	30.9	14.6	905.7
7	Utilities	62.7	24.1	126.0	52.5	55.8	31.3	586.0
8	Wholesale trade	56.8	7.0	46.0	93.1	22.3	23.3	762.3
9	Retail trade	41.0	11.8	65.9	30.5	28.1	3.9	604.1
10	Finance and insurance	56.6	10.0	156.9	32.6	25.4	25.9	1,639.9
11	Real estate and rentals	411.7	73.7	187.2	170.5	221.0	20.6	2,914.2
12	Professional services	105.0	21.0	64.5	31.9	59.3	32.1	1,239.3
13	Business services	55.3	15.0	124.1	24.9	41.1	33.0	836.1
14	Educational services	4.4	0.0	0.0	0.0	4.3	0.5	28.8
15	Health services	109.7	0.0	0.0	0.0	0.0	0.0	109.9
16	Arts and entertainment	0.1	26.8	9.3	5.8	0.8	0.0	47.6
17	Accommodations	2.3	0.7	1.2	0.5	1.4	0.3	33.4
18	Eating and drinking	10.6	2.1	11.7	8.4	4.1	1.2	121.1
19	Other services	22.8	10.4	39.9	13.5	20.4	5.5	627.5
20	Government	26.5	4.3	38.2	32.9	12.7	5.5	535.0
	Total intermediate input	1,096.0	244.3	1,063.1	747.2	582.9	284.0	13,992.2
	Labor income	2,108.6	322.0	1,318.3	849.2	755.2	7,344.0	23,714.2
	Indirect business taxes	106.0	34.4	336.2	96.9	71.1	0.0	3,159.5
	Other capital costs	152.5	71.2	508.2	240.8	61.5	1,126.0	11,663.3
	Total value added	2,367.1	427.6	2,162.7	1,186.9	887.7	8,470.0	38,537.0
	Imports	396.3	98.5	230.6	340.6	200.7	123.4	6,338.5
	Output	3,859.3	770.3	3,456.4	2,274.7	1,671.4	8,877.4	58,867.6
	Total jobs (no. of jobs)	52,473	18,570	41,219	50,509	37,930	166,750	742,231

Table 2.1 1997 Condensed Input-Output Transactions Table for Hawaii (in $million) - Continued

	Industry	PCE	Visitor's expenditures	Gross private investment	State and local government	Federal government: military	Federal government: civilian	Exports	Output
1	Agriculture	131.5	18.4	5.2	5.1	12.1	0.3	189.9	823.5
2	Mining and construction	0.0	0.0	1,846.0	859.0	405.0	42.4	0.0	3,524.3
3	Food processing	419.5	52.3	1.2	14.4	0.0	3.8	303.3	1,054.5
4	Manufacturing	266.3	49.0	67.0	73.6	69.0	0.2	549.7	2,361.9
5	Transportation	644.7	2,060.7	63.5	37.6	34.5	1.8	121.5	3,585.8
6	Information	778.9	33.4	0.0	37.0	44.7	3.9	136.6	1,940.3
7	Utilities	407.4	0.0	0.0	113.9	106.2	6.7	0.0	1,220.3
8	Wholesale trade	687.9	210.0	152.3	53.7	14.6	0.4	57.9	1,939.0
9	Retail trade	2,292.0	1,254.8	183.7	23.4	0.9	0.2	13.9	4,372.8
10	Finance and insurance	1,626.2	0.0	0.0	3.4	0.0	0.1	366.1	3,635.7
11	Real estate and rentals	5,310.6	935.7	46.2	64.5	1.6	6.8	153.5	9,433.1
12	Professional services	385.7	38.1	118.6	83.4	141.3	18.4	142.0	2,166.9
13	Business services	112.4	225.4	0.0	62.1	90.6	1.2	94.9	1,422.6
14	Educational services	431.7	140.7	0.0	-123.8	0.2	0.0	0.0	477.5
15	Health services	3,780.5	83.3	0.0	-137.9	4.9	18.6	0.0	3,859.3
16	Arts and entertainment	327.9	425.2	0.0	-47.2	0.2	0.0	16.7	770.3
17	Accommodations	146.1	3,271.3	0.0	3.3	2.3	0.0	0.0	3,456.4
18	Eating and drinking	1,036.5	1,126.2	0.0	-19.5	5.1	0.4	5.0	2,274.7
19	Other services	962.2	63.0	0.0	14.6	4.0	0.0	0.0	1,671.4
20	Government	478.0	46.0	0.0	3,227.3	4,181.3	366.8	43.0	8,877.4
	Total intermediate input	20,225.9	10,033.5	2,483.7	4,348.0	5,118.4	471.9	2,194.1	58,867.6
	Labor income								23,714.2
	Indirect business taxes								3,159.5
	Other capital costs								11,663.3
	Total value added								38,537.0
	Imports	4,939.8	1,672.6	1,017.0	236.8	265.6	23.5	461.0	14,954.7
	Output	25,165.7	11,706.1	3,500.7	4,584.8	5,384.0	495.4	2,655.1	112,359.3
	Total jobs (no. of jobs)								742,231

Reading across a row of the transaction table shows sales by the row sector to the various column sectors in the economy. For example, in 1997, total output for agriculture amounted to $823.5 million. Of total agricultural sales, total inter-industry sales to agriculture itself and other industries amounted to $461.1 million. Food processing accounted for the largest share ($203.4 million or 44%) of total inter-industry sales of agriculture. Agricultural sales to final demand sectors totaled $362.4 million, including $131.5 million to Hawaii residents and $231 million to other final demand sectors (government, visitors, private investment, and exports).

Reading down a column shows the purchases by the column sector from the various row sectors. For example, in 1997, total agriculture's purchases included $257.7 million from Hawaii's industries (including $83.4 million from agriculture itself and $172.8 million from other industries), $323.6 million as payments to households (i.e. compensation of employees plus proprietors' income), $151.9 million as other value added (indirect business taxes plus capital costs), and $90.3 million worth of imported inputs. In 1997, there were 21,196 wage and salary plus self-employed jobs in Hawaii's agricultural sector.

Direct Requirements Table

The next step in I-O analysis after the construction of the transactions table is the derivation of a direct requirements table, also known as the technology coefficient matrix or the A matrix. Such a table gives a comprehensive picture of the interdependence among the various producing sectors of the economy. Elements in each column of the direct requirements table are obtained by expressing each column entry of the transactions table as a proportion (coefficient) of the corresponding column total. The coefficients of the direct requirements table show the amounts of inputs (purchases) required by a column sector from each of the row sectors in order to produce $1 of output from that column sector. Each column of the direct requirements table represents a production function for the corresponding producing sector. Because the technical coefficients are fixed, this production function is characterized by constant returns to scale. Each industry's production process is described in terms of the average technology being used by that particular industry.

The computation of the direct requirements coefficients is usually limited to the columns representing the producing sectors. Thus, the columns representing the final demand sectors are usually omitted. However, the personal consumption expenditures (PCEs) sector may be treated as an additional producing sector since a substantial portion of household earnings is injected to the economy in the form of household purchases from industries for final consumption. The sectors that are included in the direct requirements matrix are referred to as the "endogenous sectors" or are said to be "endogenous to the model."

The direct requirements table for 20 producing sectors is presented in Table 2.2. The agriculture column of the direct requirements table shows input purchases from the various producing sectors to produce $1 of agricultural output. For example, agriculture purchased about 31 cents worth of inputs from Hawaii's industries, including 10 cents worth of inputs from agriculture itself, about 5 cents worth of inputs from other manufacturing, 4 cents worth of wholesale services, and about 2 cents each from finance and insurance and real estate/rentals. Labor costs, other value added, and imported commodities accounted for remaining 69 cents.

Table 2.2 1997 Condensed Direct Requirements Table for Hawaii

	Industry	Agriculture	Mining and construction	Food processing	Other manufacturing	Trans-portation
1	Agriculture	0.1013	0.0031	0.1929	0.0003	0.0003
2	Mining and construction	0.0058	0.0060	0.0016	0.0125	0.0016
3	Food processing	0.0093	0.0000	0.0294	0.0000	0.0009
4	Other manufacturing	0.0539	0.0570	0.0480	0.0391	0.0883
5	Transportation	0.0149	0.0111	0.0182	0.0119	0.0696
6	Information	0.0033	0.0056	0.0149	0.0057	0.0149
7	Utilities	0.0085	0.0038	0.0082	0.0118	0.0039
8	Wholesale trade	0.0410	0.0453	0.0522	0.0174	0.0193
9	Retail trade	0.0096	0.0549	0.0149	0.0067	0.0031
10	Finance and insurance	0.0202	0.0133	0.0056	0.0054	0.0171
11	Real estate and rentals	0.0244	0.0210	0.0106	0.0107	0.0182
12	Professional services	0.0042	0.0719	0.0088	0.0079	0.0156
13	Business services	0.0039	0.0102	0.0167	0.0121	0.0242
14	Educational services	0.0003	0.0000	0.0000	0.0006	0.0005
15	Health services	0.0000	0.0000	0.0000	0.0000	0.0001
16	Arts and entertainment	0.0000	0.0000	0.0000	0.0000	0.0000
17	Accommodations	0.0005	0.0002	0.0007	0.0004	0.0014
18	Eating and drinking	0.0013	0.0008	0.0032	0.0021	0.0064
19	Other services	0.0065	0.0086	0.0070	0.0052	0.0079
20	Government	0.0042	0.0009	0.0024	0.0015	0.0374

	Industry	Information	Utilities	Wholesale trade	Retail trade	Finance and insurance
1	Agriculture	0.0003	0.0001	0.0006	0.0013	0.0003
2	Mining and construction	0.0047	0.0168	0.0013	0.0024	0.0017
3	Food processing	0.0002	0.0040	0.0014	0.0005	0.0000
4	Other manufacturing	0.0159	0.2722	0.0128	0.0068	0.0031
5	Transportation	0.0105	0.0098	0.0056	0.0054	0.0056
6	Information	0.0765	0.0038	0.0220	0.0205	0.0356
7	Utilities	0.0043	0.0002	0.0046	0.0103	0.0029
8	Wholesale trade	0.0088	0.0055	0.0180	0.0041	0.0038
9	Retail trade	0.0104	0.0070	0.0079	0.0116	0.0014
10	Finance and insurance	0.0135	0.0143	0.0187	0.0188	0.1623
11	Real estate and rentals	0.0215	0.0086	0.0435	0.1048	0.0478
12	Professional services	0.0239	0.0138	0.0184	0.0172	0.0319
13	Business services	0.0051	0.0023	0.0183	0.0194	0.0087
14	Educational services	0.0013	0.0046	0.0000	0.0000	0.0001
15	Health services	0.0000	0.0000	0.0000	0.0000	0.0000
16	Arts and entertainment	0.0024	0.0000	0.0000	0.0000	0.0000
17	Accommodations	0.0008	0.0006	0.0010	0.0011	0.0007
18	Eating and drinking	0.0022	0.0021	0.0013	0.0011	0.0021
19	Other services	0.0073	0.0015	0.0073	0.0033	0.0047
20	Government	0.0030	0.0017	0.0049	0.0290	0.0056

Table 2.2 1997 Condensed Direct Requirements Table for Hawaii - Continued

	Industry	Real estate and rentals	Professional services	Business services	Educational services	Health services
1	Agriculture	0.0072	0.0004	0.0002	0.0016	0.0025
2	Mining and construction	0.0177	0.0016	0.0020	0.0022	0.0023
3	Food processing	0.0000	0.0000	0.0000	0.0000	0.0010
4	Other manufacturing	0.0036	0.0034	0.0117	0.0061	0.0059
5	Transportation	0.0032	0.0115	0.0076	0.0036	0.0073
6	Information	0.0083	0.0218	0.0259	0.0302	0.0148
7	Utilities	0.0070	0.0051	0.0062	0.0088	0.0162
8	Wholesale trade	0.0033	0.0073	0.0105	0.0066	0.0147
9	Retail trade	0.0032	0.0130	0.0134	0.0041	0.0106
10	Finance and insurance	0.0409	0.0123	0.0148	0.0074	0.0147
11	Real estate and rentals	0.0633	0.0759	0.0227	0.1493	0.1067
12	Professional services	0.0093	0.0678	0.0380	0.0126	0.0272
13	Business services	0.0141	0.0081	0.0362	0.0073	0.0143
14	Educational services	0.0000	0.0016	0.0026	0.0003	0.0011
15	Health services	0.0000	0.0000	0.0000	0.0000	0.0284
16	Arts and entertainment	0.0000	0.0000	0.0000	0.0004	0.0000
17	Accommodations	0.0006	0.0009	0.0006	0.0004	0.0006
18	Eating and drinking	0.0013	0.0023	0.0019	0.0127	0.0027
19	Other services	0.0360	0.0081	0.0065	0.0069	0.0059
20	Government	0.0065	0.0049	0.0214	0.0027	0.0069

	Industry	Arts and entertainment	Accommodations	Eating and drinking	Other services	Government
1	Agriculture	0.0045	0.0067	0.0183	0.0015	0.0003
2	Mining and construction	0.0081	0.0054	0.0054	0.0092	0.0028
3	Food processing	0.0078	0.0106	0.0690	0.0000	0.0004
4	Other manufacturing	0.0047	0.0039	0.0035	0.0138	0.0025
5	Transportation	0.0078	0.0065	0.0064	0.0086	0.0037
6	Information	0.0156	0.0225	0.0074	0.0185	0.0016
7	Utilities	0.0313	0.0365	0.0231	0.0334	0.0035
8	Wholesale trade	0.0091	0.0133	0.0409	0.0134	0.0026
9	Retail trade	0.0153	0.0191	0.0134	0.0168	0.0004
10	Finance and insurance	0.0130	0.0454	0.0143	0.0152	0.0029
11	Real estate and rentals	0.0957	0.0542	0.0750	0.1322	0.0023
12	Professional services	0.0273	0.0187	0.0140	0.0355	0.0036
13	Business services	0.0194	0.0359	0.0109	0.0246	0.0037
14	Educational services	0.0000	0.0000	0.0000	0.0026	0.0001
15	Health services	0.0000	0.0000	0.0000	0.0000	0.0000
16	Arts and entertainment	0.0348	0.0027	0.0025	0.0005	0.0000
17	Accommodations	0.0009	0.0003	0.0002	0.0008	0.0000
18	Eating and drinking	0.0027	0.0034	0.0037	0.0024	0.0001
19	Other services	0.0135	0.0115	0.0059	0.0122	0.0006
20	Government	0.0056	0.0111	0.0144	0.0076	0.0006

Table 2.3 1997 Condensed Total Requirements Table (Type I) for Hawaii

	Industry	Agriculture	Mining and construction	Food processing	Other Manu-facturing	Trans-portation
1	Agriculture	1.1156	0.0041	0.2222	0.0007	0.0013
2	Mining and construction	0.0087	1.0084	0.0052	0.0140	0.0043
3	Food processing	0.0110	0.0003	1.0330	0.0003	0.0017
4	Other manufacturing	0.0703	0.0657	0.0727	1.0476	0.1032
5	Transportation	0.0204	0.0154	0.0264	0.0145	1.0779
6	Information	0.0089	0.0134	0.0228	0.0090	0.0221
7	Utilities	0.0118	0.0070	0.0130	0.0133	0.0071
8	Wholesale trade	0.0501	0.0499	0.0676	0.0203	0.0249
9	Retail trade	0.0133	0.0589	0.0204	0.0089	0.0061
10	Finance and insurance	0.0322	0.0235	0.0184	0.0098	0.0270
11	Real estate and rentals	0.0391	0.0434	0.0300	0.0181	0.0313
12	Professional services	0.0107	0.0836	0.0171	0.0126	0.0237
13	Business services	0.0088	0.0161	0.0235	0.0150	0.0307
14	Educational services	0.0005	0.0003	0.0004	0.0008	0.0008
15	Health services	0.0000	0.0000	0.0000	0.0000	0.0001
16	Arts and entertainment	0.0000	0.0000	0.0001	0.0000	0.0001
17	Accommodations	0.0007	0.0005	0.0011	0.0005	0.0016
18	Eating and drinking	0.0021	0.0016	0.0044	0.0025	0.0075
19	Other services	0.0103	0.0124	0.0117	0.0070	0.0114
20	Government	0.0070	0.0049	0.0066	0.0032	0.0423
	Total	1.42	1.41	1.60	1.20	1.42

	Industry	Information	Utilities	Wholesale trade	Retail trade	Finance and insurance
1	Agriculture	0.0010	0.0015	0.0017	0.0027	0.0012
2	Mining and construction	0.0065	0.0213	0.0031	0.0054	0.0040
3	Food processing	0.0006	0.0044	0.0017	0.0008	0.0003
4	Other manufacturing	0.0223	0.2884	0.0178	0.0136	0.0082
5	Transportation	0.0138	0.0155	0.0079	0.0080	0.0091
6	Information	1.0862	0.0090	0.0279	0.0268	0.0491
7	Utilities	0.0063	1.0047	0.0064	0.0126	0.0052
8	Wholesale trade	0.0117	0.0131	1.0203	0.0066	0.0067
9	Retail trade	0.0131	0.0113	0.0099	1.0139	0.0038
10	Finance and insurance	0.0213	0.0221	0.0277	0.0310	1.1998
11	Real estate and rentals	0.0338	0.0203	0.0554	0.1207	0.0692
12	Professional services	0.0313	0.0216	0.0245	0.0242	0.0448
13	Business services	0.0083	0.0081	0.0218	0.0238	0.0135
14	Educational services	0.0015	0.0049	0.0002	0.0002	0.0004
15	Health services	0.0000	0.0000	0.0000	0.0000	0.0000
16	Arts and entertainment	0.0027	0.0000	0.0001	0.0001	0.0001
17	Accommodations	0.0010	0.0008	0.0012	0.0013	0.0010
18	Eating and drinking	0.0029	0.0031	0.0018	0.0017	0.0030
19	Other services	0.0101	0.0048	0.0105	0.0088	0.0093
20	Government	0.0051	0.0038	0.0069	0.0316	0.0085
	Total	1.28	1.46	1.25	1.33	1.44

Table 2.3 1997 Condensed Total Requirements Table (Type I) for Hawaii - Continued

	Industry	Real estate and rentals	Professional services	Business services	Educational services	Health services
1	Agriculture	0.0089	0.0015	0.0007	0.0037	0.0044
2	Mining and construction	0.0203	0.0041	0.0036	0.0061	0.0057
3	Food processing	0.0003	0.0003	0.0003	0.0011	0.0015
4	Other manufacturing	0.0105	0.0091	0.0176	0.0128	0.0152
5	Transportation	0.0057	0.0148	0.0104	0.0061	0.0105
6	Information	0.0143	0.0288	0.0328	0.0369	0.0216
7	Utilities	0.0098	0.0074	0.0082	0.0116	0.0192
8	Wholesale trade	0.0066	0.0100	0.0131	0.0097	0.0182
9	Retail trade	0.0063	0.0158	0.0160	0.0066	0.0136
10	Finance and insurance	0.0556	0.0226	0.0229	0.0196	0.0274
11	Real estate and rentals	1.0806	0.0947	0.0359	0.1681	0.1279
12	Professional services	0.0176	1.0776	0.0462	0.0193	0.0359
13	Business services	0.0185	0.0123	1.0404	0.0119	0.0195
14	Educational services	0.0003	0.0019	0.0029	1.0005	0.0014
15	Health services	0.0000	0.0000	0.0000	0.0000	1.0293
16	Arts and entertainment	0.0001	0.0001	0.0001	0.0005	0.0001
17	Accommodations	0.0008	0.0011	0.0007	0.0006	0.0008
18	Eating and drinking	0.0019	0.0030	0.0025	0.0133	0.0035
19	Other services	0.0405	0.0131	0.0094	0.0142	0.0120
20	Government	0.0087	0.0076	0.0240	0.0052	0.0098
	Total	1.31	1.33	1.29	1.35	1.38

	Industry	Arts and entertainment	Accommodations	Eating and drinking	Other services	Government
1	Agriculture	0.0083	0.0109	0.0367	0.0033	0.0005
2	Mining and construction	0.0120	0.0084	0.0086	0.0136	0.0030
3	Food processing	0.0088	0.0116	0.0717	0.0005	0.0005
4	Other manufacturing	0.0188	0.0194	0.0193	0.0282	0.0042
5	Transportation	0.0116	0.0102	0.0111	0.0126	0.0044
6	Information	0.0229	0.0312	0.0144	0.0264	0.0025
7	Utilities	0.0352	0.0393	0.0262	0.0366	0.0038
8	Wholesale trade	0.0134	0.0177	0.0491	0.0173	0.0032
9	Retail trade	0.0190	0.0224	0.0174	0.0203	0.0009
10	Finance and insurance	0.0257	0.0620	0.0266	0.0300	0.0042
11	Real estate and rentals	0.1190	0.0732	0.0933	0.1563	0.0039
12	Professional services	0.0372	0.0285	0.0220	0.0460	0.0048
13	Business services	0.0253	0.0411	0.0169	0.0308	0.0043
14	Educational services	0.0004	0.0004	0.0003	0.0030	0.0001
15	Health services	0.0000	0.0000	0.0000	0.0000	0.0000
16	Arts and entertainment	1.0361	0.0029	0.0027	0.0006	0.0000
17	Accommodations	0.0012	1.0006	0.0005	0.0011	0.0001
18	Eating and drinking	0.0035	0.0041	1.0045	0.0032	0.0002
19	Other services	0.0198	0.0161	0.0114	1.0196	0.0010
20	Government	0.0089	0.0145	0.0174	0.0112	1.0010
	Total	1.43	1.41	1.45	1.46	1.04

Total Requirements Table

The direct requirements table (Table 2.2) shows the direct or initial effects on all producing sectors due to a change in final demand by one dollar. These direct effects lead to a series of successive or indirect impacts on the producing sectors. For example, agriculture supplies about 20 cents worth of agricultural commodities to produce every $1 of food processing output. Agriculture has to purchase inputs from various suppliers to produce 20 cents of agricultural products required by food processing. These suppliers, in turn, would need to purchase inputs to meet the demands for their commodities. The indirect impacts would continue through each of the various industries that supply an input to food processing, although each successive transaction will be smaller than the preceding one due to the leakage of purchasing power from the economy in the form of imports. To capture all indirect effects of a $1 increase in food processing output, this analysis needs to be applied to all sectors that provide inputs to food processing.

Measuring total requirements this way would be exceedingly tedious, especially when the number of producing sectors is large. Fortunately, total requirements can be estimated easily using matrix algebra. The direct requirements table is subtracted from an identity matrix and then inverted. The resultant matrix is called the total requirements table or the Leontief inverse matrix, which gives the direct and indirect effects of $1 change in final demand. Mathematical details for this procedure are given in Appendix B.

The total requirements table (Type I) for the 20-industry I-O model is presented in Table 2.3. Each column of the total requirements table indicates the direct and indirect impacts on producing sectors of a $1 change in the column sector's final demand. For example, $1 increase in agriculture's final demand increases output in the economy by about $1.42, of which $1.12 (including the initial $1 increase) comes from agriculture itself and the remaining 30 cents from other endogenous sectors. The column totals of the Type I total requirements table are final-demand output multipliers for the corresponding column sector.

Input-Output Multipliers

One of the most important functions of I-O analysis is to assess the effects of an exogenous (external) change on an economy. Under I-O framework, sectoral outputs are demand-determined. Various multipliers can be derived from the I-O table to estimate the various types of economic impacts of a change in an industry's final demand. Three of the most commonly used I-O multipliers are output, earnings, and employment (job) multipliers.

Multipliers are derived based on direct and indirect effects arising from an exogenous change in an industry's final demand. The direct effect measures the initial effect attributable to the exogenous change, while the indirect effect measures the subsequent intra- and inter-industry purchases of inputs as a result of the initial change in output of the directly affected industry. If earnings and personal consumption expenditures (PCEs) are also included in the model as endogenous sectors, the resultant multipliers can measure the effects of demand changes on household spending (PCEs) that result from changes in earnings through direct and indirect effects. These additional effects are known as the induced effects.

Thus, depending upon whether the household sector is included as an industry in the model or not, there are two types of multipliers, namely Type I and Type II. They are calculated as follows:

$$\text{Type I multiplier} = \frac{\text{Direct effect} + \text{Indirect effect}}{\text{Direct effect}}$$

$$\text{Type II multiplier} = \frac{\text{Direct effect} + \text{Indirect effect} + \text{Induced effect}}{\text{Direct effect}}$$

Type II multipliers are larger than Type I multipliers. Because of the induced effect of household spending, Type II multipliers are more widely used in real-world applications.

As multipliers are the ratios of various total effects to various direct effects, one could derive many multipliers under each type. The two most popular multipliers are the final-demand and direct-effect multipliers. The final-demand multiplier for an industry measures the total change in a variable (e.g., output, earnings, or employment) that results from a change in that industry's final demand. An industry's direct-effect multiplier measures the total change in a variable that results from an additional unit change in the same variable in that industry.

Output Multipliers

The final-demand output multipliers for each column sector are derived by summing the corresponding column entries of the total requirements table (Appendix B). The output multipliers for the 20 endogenous sectors are shown in the last row of Table 2.3. For example, the output multiplier for agriculture is $1.42, which means that every $1 change in agriculture's final demand results in a change in the economy's total output by $1.42. This includes the initial dollar change ($1.00) in agriculture's final demand (direct effect) and changes in the outputs of the endogenous sectors to support the initial dollar change in agricultural output (indirect effect) ($0.42). The output multipliers computed based on the total requirements table (Table 2.3) are called Type I output multipliers, as the household sector is not included in calculations.

Earnings Multipliers

Final-demand earnings multipliers measure the economic impact of changes in an industry's final demand in terms of changes in the industry's payments to households' earnings. Following the RIMS II (Regional Input-Output Modeling System) methodology of the Bureau of Economic Analysis (BEA) (BEA, 1997), earnings are defined as the income that is received by households from the production of regional goods and services and that are available for spending on goods and services. Accordingly, earnings for each industry are calculated as follows:

Earnings = Wage and salary income + Proprietors' income + Director's fees +
Employer contributions to health insurance - Personal contributions to social insurance

By calculating earnings this way, certain components of labor income that cannot be spent are excluded. These include employer and employee's contributions to social insurance (i.e. social security taxes) and employer's contributions to private pensions. Because of this, earnings figures will be somewhat smaller than those in the labor income row of the transactions table (Table 2.1).[2]

The Type I earnings multipliers are derived using earnings-to-output ratios and the Type I total requirements table. Earnings-to-output ratios are also called direct earnings coefficients, which are used to convert the total requirements in Table 2.3 to earnings equivalents by multiplying each row of the total requirements table by the corresponding sector's direct earnings coefficient. See Appendix B for calculation of income multipliers in matrix notations. The column total of the resultant matrix is the final-demand earnings multiplier, which gives the total earnings effects of a $1 change in the column sector's final demand. The Type I final-demand earnings multiplier for agriculture is 0.45 (Table 2.4). Accordingly, a $1 increase in agriculture's final demand would increase the earnings in the economy by 45 cents.

The direct-effect earnings multiplier is derived by calculating the ratio between the final-demand earnings multiplier and the direct earnings coefficient. The direct earnings coefficient for agriculture is 0.334. Thus, the Type I direct-effect earnings multiplier for agriculture is 1.34 (0.448 ÷ 0.334). That means a $1 change in household earnings in agriculture will change total earnings in the economy by $1.34.

Employment Multipliers

Final-demand employment multipliers can be derived in a similar fashion as final-demand earnings multipliers, except that the direct earnings coefficients are replaced by direct employment coefficients (employment-to-output ratios). In other words, the entries in the total requirements table is transformed to employment equivalents by multiplying each row of the total requirements table by the corresponding sector's direct employment coefficient. The other way is to use the final-demand earnings multiplier table in conjunction with employment-to-earnings ratios. The employment-to-output ratio is obtained by dividing industry's employment by its output and the employment-to-earnings ratio is obtained by dividing employment by earnings. Mathematical details involved in calculating the employment multipliers are presented in Appendix B.

The final-demand employment multiplier indicates the change in the number of jobs for one million dollar change in final demand. For example, the Type I final-demand employment multiplier for agriculture is 31.55. In words, one million dollars of additional demand for Hawaii's agricultural products would create about 32 new jobs in Hawaii's economy. The direct-effect employment multiplier is computed as the ratio between the final-demand employment multiplier and direct employment coefficient. The direct employment coefficient for agriculture is 25.74 (21,196 ÷ 823.50). Thus, the Type I direct-effect employment multiplier for agriculture is 1.23 (31.55 ÷ 25.74).

[2] For information on earnings by industry, refer to the detailed table at the DBEDT Web site.

The employment final-demand multipliers tend to decrease over time due to increases in worker productivity and inflation. The employment multipliers presented in Table 2.4 are for 1997. Although this report is released in 2002, using the 1997 final-demand employment-multipliers for subsequent years would overestimate the employment impacts. Therefore, the employment final-demand multipliers were also computed for each year from 1998 to 2007 by adjusting the 1997 multiplier for productivity growth and inflation. They are not included in this report due to space limitations, but are available at the DBEDT Web site.

Type II Multipliers

In computing the Type II multipliers, households are treated both as suppliers of labor inputs to industries and as purchasers of goods and services produced in the economy. Thus, both a household row and a household column are added to the direct requirements table to account for the effects of changes in household earnings and expenditures.

For the 1997 I-O table, Type II multipliers are derived by adopting BEA's RIMS II methodology on calculating regional multipliers instead of the traditional "textbook" approach. The textbook method is criticized for overstating the induced impact because it does not account for leakages due to taxes and savings and household spending from other incomes such as transfer payments.[3]

According to BEA's RIMS II methodology, entries in the household row are the earnings to output ratios, as described previously.[4] Entries in the household column are obtained by dividing each industry's PCEs by total PCEs and then by multiplying the PCE shares by the ratio of personal income less taxes and savings to personal income in order to account for the dampening effects of taxes and savings on expenditures.[5] This procedure is analogous to IMPLAN's disposable income method for calculating Type II input-output multipliers (MIG, Inc., 2000).

The rest of the conceptual procedures involved in Type II multipliers are the same as those for Type I multipliers. Using the total requirements table with the household sector (also called as Type II total requirements table), Type II output, earnings, and employment multipliers can be computed in the same manner as their Type I counterparts. Entries in the household row of the Type II total requirements table are the final-demand earnings multipliers. Due to induced effects, Type II multipliers are higher than Type I multipliers. For comparison purposes, Type I and Type II output, earnings, and employment multipliers from the 1997 condensed table are presented in Table 2.4.

[3] MIG, Inc., 2000, p. 170.

[4] For details, *see* BEA (1997). *Regional Multipliers: A User Handbook for the Regional Input-Output Modeling System (RIMS II),* pp. 21-22.

[5] In the textbook approach, the entries in the household row are the ratios between industry's labor income (compensation of employees plus proprietors' income) and output, and the entries in the household column are household expenditures per dollar of total labor income.

Table 2.4 1997 Condensed Type I and Type II Output, Earnings, and Employment Multipliers for Hawaii

		Final-demand multipliers						Direct-effect multipliers			
		Output		Earnings		Employment		Earnings		Employment	
	Industry	Type I	Type II	Type I	Type II	Type I	Type II	Type I	Type II	Type I	Type II
1	Agriculture	1.42	1.94	0.45	0.59	31.5	37.6	1.34	1.78	1.23	1.46
2	Mining and construction	1.41	1.98	0.49	0.65	14.5	21.1	1.35	1.79	1.53	2.23
3	Food processing	1.60	1.98	0.33	0.44	16.2	20.7	2.08	2.76	2.44	3.11
4	Other manufacturing	1.20	1.41	0.18	0.24	6.7	9.1	1.41	1.87	1.43	1.96
5	Transportation	1.42	1.85	0.37	0.49	12.2	17.2	1.50	1.99	1.58	2.22
6	Information	1.28	1.64	0.31	0.41	9.4	13.6	1.33	1.77	1.43	2.05
7	Utilities	1.46	1.73	0.23	0.30	5.7	8.8	1.67	2.21	2.50	3.86
8	Wholesale trade	1.25	1.72	0.41	0.54	14.6	20.1	1.20	1.59	1.22	1.68
9	Retail trade	1.33	1.85	0.44	0.59	23.3	29.3	1.25	1.66	1.17	1.46
10	Finance and insurance	1.44	1.86	0.36	0.48	12.8	17.7	1.47	1.95	1.48	2.05
11	Real estate and rentals	1.31	1.49	0.16	0.21	6.8	9.0	2.06	2.74	2.03	2.68
12	Professional services	1.33	2.03	0.61	0.80	19.8	28.0	1.18	1.57	1.22	1.72
13	Business services	1.29	1.95	0.56	0.75	28.8	36.4	1.21	1.61	1.15	1.46
14	Educational services	1.35	2.10	0.64	0.85	33.0	41.6	1.12	1.49	1.10	1.38
15	Health services	1.38	2.03	0.56	0.74	17.3	24.9	1.21	1.61	1.27	1.83
16	Arts and entertainment	1.43	1.98	0.47	0.62	28.9	35.3	1.31	1.74	1.20	1.46
17	Accommodations	1.42	1.93	0.44	0.58	16.6	22.5	1.35	1.80	1.39	1.89
18	Eating and drinking	1.45	1.95	0.43	0.57	27.1	32.9	1.36	1.81	1.22	1.48
19	Other services	1.46	2.05	0.51	0.67	27.2	34.0	1.29	1.71	1.20	1.50
20	Government	1.04	1.81	0.66	0.87	19.3	28.1	1.02	1.35	1.03	1.50

III. INDUSTRY CLASSIFICATION, DATA SOURCES, AND ESTIMATING PROCEDURES

Industry Classification

One of the changes in the 1997 I-O table over the 1992 table is the replacement of the SIC (Standard Industry Classification) system with the NAICS (North American Industry Classification System) in grouping industries. However, several data sources used in the 1997 I-O table are still reported in the SIC format, while others are available in the NAICS format. For example, the output estimates mostly came from the 1997 Economic Census that follows the NAICS, while the gross state product (GSP), labor income (earnings), and employment data came in the SIC format.

SIC to NAICS Bridge

The bridge between SIC to NAICS provided in the NAICS manual was the major tool used to transform SIC-based data into NAICS format. The data in SIC format were disaggregated into as much detail as possible using various sources and then bridged into the NAICS-based industries in the 1997 I-O table. The components of compensation of employees and jobs were disaggregated using the detailed Hawaii's Department of Labor and Industrial Relations (DLIR) ES-202 jobs and income data. Similarly, proprietors' jobs and income were disaggregated using the 1997 nonemployer statistics from the Economic Census. Indirect business taxes and other capital costs were disaggregated using the 1997 528-industry IMPLAN I-O model for Hawaii.

Output

The main data source for industries' outputs for the 1997 I-O table is the 1997 Economic Census of Hawaii's industries. The Economic Census discloses output estimates for most of the industries included in the 1997 I-O table. Following the 1997 U.S. national I-O table, industry's output is generally measured as follows:

Output = Revenue of for-profit establishments
+ Expenses of non-profit establishments*
- Cost of merchandise resales*
+ Adjustment for underreporting*
+ Change in inventory*
+ Sales taxes*
+ Employee tips*

* = if applicable (every industry may only have some of the components).

The above definition applies to most of the manufacturing and service industries. However, there are several industries for which output measures and sources are different from those presented in the 1997 Economic Census.

Agriculture, Aquaculture, and Commercial Fishing

The output for the agricultural sectors was based on the value of agricultural sales as published in *Statistics of Hawaii Agriculture*, with adjustments made for changes in inventories and inter-farm sales. Agricultural outputs are commodity-based. The output of aquaculture was based on data in *Statistics of Hawaii Agriculture* and that of commercial fishing was based on information from the National Marine Fisheries Services (NMFS) Web site.

Agricultural and Landscape Services

The agricultural and landscape services are not covered in either the *Statistics of Hawaii Agriculture* or the Economic Census. Outputs were estimated by applying the valued added to output ratios for these sectors in the 1997 U.S. table to their Hawaii's valued added obtained from the Bureau of Economic Analysis (BEA).

Construction

Output equals the net revenue (total value of construction less subcontracting) plus architectural and engineering services included in the value of construction. Construction output came from the 1997 Economic Census of Construction.

Sugar Processing

Sugar processing output was based on data in *Statistics of Hawaii Agriculture*.

Petroleum Processing

Petroleum processing output was not disclosed in the Economic Census. This was estimated using the ratio of value of petroleum as an input to total petroleum output from the 1997 U.S. national I-O table. The value of petroleum input was based on an estimate of value of petroleum imports to Hawaii. The figure thus obtained was consistent with the petroleum processing output from the Hawaii Department of Taxation.

Transportation

Measuring output of transportation sectors in a regional economy can be quite difficult. Since transportation industries cross regional boundaries, it is difficult to determine what activity should be considered part of a regional economy.

In principle, the output of air and water transportation is measured in terms of the operating revenue generated by the resources (labor and capital) within the region (Chase, 1996). Conceptually, output for transportation sectors are derived from revenue from the movement of goods and people:

- **i.** from outside the region into the region
- **ii.** from inside the region to out of the region
- **iii.** within the region
- **iv.** transshipped through the region

Thus, transportation output is associated with imports and exports, intra-regional movement, and transshipments.

Air Transportation

For air transportation, output was defined to be the sum of (i) half of the round-trip transpacific passenger revenue of domestic flights of all U.S. carriers (including Aloha and Hawaiian) between Hawaii and the domestic port, (ii) all passenger revenue of international flights of all US carriers between Hawaii and the immediate foreign port, (iii) inter-island passenger and cargo revenue of Hawaii's carriers, and (iv) half of the air cargo revenue from shipments to and from Hawaii. The transpacific passenger revenue was estimated based on the number of passengers and the average air fares between Honolulu and the domestic ports and international revenue was estimated based on international passengers and air fares between Honolulu and the foreign ports. The inter-island passenger revenue was estimated as the difference between total passenger revenue of Hawaii's carriers estimated based on information obtained from the *State of Hawaii Data Book 1998* (Table 18.37) and the estimates of their transpacific and international revenue. Given the lack of information, air cargo revenue was estimated based on the value of total cargo tonnage.

Water Transportation

Water transportation output was defined as the half of the revenue earned from shipping goods to Hawaii plus half of the revenue earned from shipping good from Hawaii, plus inter-island shipping and cruise ship revenue. The Economic Census does not disclose all of this information. The transpacific value of shipping was estimated based on interviews with industry experts, company financial reports, and the Economic Census.

Telecommunications

The output for telecommunications was based on communications output from the 1997 IMPLAN I-O model for Hawaii, with some adjustments to account for the differences in Hawaii's compensation of employees between the IMPLAN model and BEA.

Wholesale and Retail Trade

For wholesale and retail trade industries, outputs are measured as the wholesale or retail margins. The margins were based on the U.S. wholesale and retail margins, with slight adjustments to more closely reflect wholesale and retail trade patterns in Hawaii. The margins were based on types of commodities sold, and applied to the industries selling those commodities.

Typical wholesale and retail margins are listed in Appendix C. One should be aware that not all retail goods are purchased from wholesalers in Hawaii. Some are purchased directly from the manufacturers, while others are purchased from mainland wholesalers. The same procedure is also applied to merchandise resales of service sectors.

Banking

In accordance with the U.S. I-O methodology, banking output was defined to be monetary service charges and fees plus imputed service charges earned. Monetary interest and investment incomes are not considered part of output in the I-O framework. There is no source of receipts dataset available for banks operating in Hawaii. Ratios from the NIPA's and other BEA data sources were used to estimate the monetary and imputed service charges.

Insurance

In accordance with the 1997 U.S. I-O table, insurance output was defined as premiums minus claims for all property and casualty insurance, plus expenses of life insurance companies, plus revenue earned by insurance agents and brokers in Hawaii. The information on premiums and claims came from the 1997 Report of Hawaii's Insurance Commissioner of Hawaii's Department of Commerce and Consumer Affairs and the revenue of agents and brokers came from the 1997 Economic Census of Finance and Insurance.

Real Estate

Real estate output was defined as the revenue of all rental activity in the state (regardless of which industry earned the revenue), plus the revenue of real estate brokers and agents, plus the imputed rental value of buildings owned by non-profit establishments serving individuals, plus the imputed value of new home sales by the construction industry. The 1997 Hawaii Housing Policy Study Update (Locations, Inc., 1997) and the Economic Census were major sources of data for this industry.

Owner-Occupied Housing

Owner-occupied housing output was defined as the revenue that would be generated if all of the owner-occupied housing units were rented. This was estimated based on the number of owner-occupied housing units and average rent paid to rental units. This information was obtained from the 1997 Housing Policy Study for Hawaii.

Education

The Economic Census does not cover private primary and secondary schools and universities. Since they are non-profit institutions, their output was based on expenses instead of revenue. This information came from the issue of Hawaii's Economy on education and the economy (DBEDT, 1998). The output of other educational services from the 1997 Economic Census of Educational Services was added to this to derive the total output for the sector.

Hospitals

Hospitals output from the 1997 Economic Census of Health Care and Social Assistance was based on their expenses instead of their revenues, since they are considered non-profit institutions serving individuals. Government-run hospitals are included in the Economic Census, but were removed from the output estimate, since the hospitals industry by definition includes private hospitals. Government hospitals are included in government expenditures in final demand.

Government Enterprises

State and local government enterprises are analyzed in terms of three sectors, namely water and sewer, public transit, and other government enterprises (airports, harbors, housing, parking, etc.). There are two Federal government enterprises, namely postal service and others, which consist of military exchanges, commissaries, restaurants, and hotels. Government enterprise output was defined as their operating revenue, except for military exchanges and commissaries for which output was defined as their operating margins.

Value Added

Value added is the income side of the Hawaii GSP account. For the 1997 I-O table, value added is divided into its four components: (i) compensation of employees, (ii) proprietors' income, (iii) indirect business taxes (IBT), and (iv) other capital costs.[6] The Bureau of Economic Analysis (BEA) provides the following data by industry at the 2-digit SIC level.

Total GSP (compensation of employees + property type income + IBT);

Total income (wages and salary income + proprietors' income + other labor income);

Total compensation of employees (wage and salary income + other labor income + employer contribution to social insurance); and

Property type income (proprietors' income + other capital costs).

Note that some value added components, such as proprietors' income, other labor income, and other capital costs do not exist by industry; hence they were estimated using the relations among the various GSP components as above. Once all these individual components were calculated at the 2-digit SIC level, they were allocated to and bridged into NAICS-based industries in the 1997 I-O table.

Labor Income

Labor income is defined as the sum of compensation of employees and proprietors' income.

Compensation of Employees

Compensation of employees consists of wage and salary income, other labor income, and employer's contribution to social insurance. Other labor income is composed mainly of health benefits, directors' fees, and employer's contributions to private pensions. The BEA's estimate of compensation of employees at the 2-digit SIC level was bridged into the NAICS-based industries in the 1997 I-O table based on detailed ES-202 income.

Proprietors' Income

Proprietors' income was estimated from the BEA's personal income series. The proprietors' income was bridged from 2 digit SIC into the 1997 NAICS based I-O industries based on the nonemployer statistics from the 1997 Economic Census. There were a few cases where other relevant information conflicted with the BEA estimate of proprietors' income by industry, and in those cases proprietors' income was adjusted.

Indirect Business Taxes

Indirect Business Taxes (IBTs) consist of business taxes and fees paid to the Federal, state, and local governments. Components of IBT include general excise taxes (GET), transient accommodations taxes

[6] For the condensed table, compensation of employees and proprietors' income are combined to form labor income.

(TAT), fuel taxes, property taxes, customs duties, and certain types of non-tax fees. IBTs were estimated using two methods. For most industries, BEA's IBT estimates at the 2-digit SIC level were bridged to the I-O industries using IBT shares by industry from IMPLAN. Also, IBT was estimated from the ground up for each industry by adding different relevant types of taxes and fees paid by each industry. The most representative estimate of IBT for each industry from the two methods was used.

Other Capital Costs

Other capital costs consist of several components, including corporate profits, consumption of fixed capital (i.e. depreciation), net interest paid, net rental income of individuals, and business transfers. Other capital costs at the 2-digit levels were computed as BEA's estimate of property type income less proprietors' income. These estimates were bridged into the NAICS-based I-O industries based on IMPLAN. There were a few cases where other relevant information conflicted with the BEA estimate of other capital costs by industry, and in those cases other capital costs were adjusted.

Final Demand

Final demand reflects the expenditure side of the GSP account. It consists of personal consumption expenditures (PCEs), state and local government consumption and investment, Federal government consumption and investment, gross private investment, change in inventories, visitor's expenditures, and exports. For more detailed information regarding the concepts and definitions of final demand, readers may want to refer to BEA's National Income and Product Accounts (NIPAs).

Personal Consumption Expenditures

Personal consumption expenditures (PCEs) were based primarily on the Consumer Expenditure Survey (CES) from the U.S. Bureau of Labor Statistics, merchandise lines sales from the Economic Census of retail industries, and source of receipts datasets by industry from the Economic Census.

Using the consumer and visitor expenditures surveys, merchandise line sales from each retail sector were allocated to PCEs, visitor expenditures, and other components of final demand. Consumption expenditures and merchandise sales are valued at purchasers' prices. They were broken down to producers' prices, transportation costs, and wholesale and retail margins using the 1992 benchmark I-O composition of U.S. NIPA final demand and assigned to relevant sectors. The U.S. transportation margins were adjusted to account for differences in transportation services in Hawaii.

Typical wholesale trade, retail trade, and transportation margins are presented in Appendix C. Also presented in Appendix C is an example describing purchasers' prices, trade and transportation margins and producers' prices.

Visitor Expenditures

Visitor's expenditures were estimated and allocated into I-O industries based on information obtained from DBEDT historical visitor data series and the Hawaii Visitors and Convention Bureau's (HVCB) annual report. As was done for PCEs, visitor expenditures were also adjusted to account for transportation costs and trade margins.

Gross Private Investment

Gross private investment consists of private sector spending on construction and producers' durable equipment (PDE). The value of private construction was estimated as total value of new construction (excluding repairs and maintenance construction) minus the value of government construction. Spending on producers' durable equipment was based on retail and wholesale data on durable equipment sales as well as on equipment imports. Margins were computed for PDE and allocated to relevant industries.

Change in Inventories

Changes in inventories were estimated based on three sources: BEA data on farm incomes and expenses, and the 1997 Economic Censuses of Manufacturing and Wholesale Trade. Margins were applied to changes in inventories.

State and Local Government Consumption and Investment

State and local government consumption and investment were based on the Census Bureau's Census of Governments, the state and county annual financial reports, and a special report on state expenditures prepared by the Hawaii's Department of Accounting and General Services (DAGS). Unlike previous I-O tables, state and local government consumption and investment are separated into two final demand sectors.

Government consumption consists of compensation of employees, consumption of fixed capital, and operating expenses, less current charges for services provided. The compensation of employees and capital consumption were based on their BEA estimates for local and state governments adjusted for local and state government enterprises. Operating expenses were based on the Census of Governments and the special DAGS report. Investment is the value of new construction and expenditures on durable equipment. State and local government consumption and investment exclude the operating expenses of state and local state government enterprises (water supply and sewer, transit, airports, harbors, etc.) but include their investment. This is consistent with the NIPA definition of final demand.

Federal Military Government Consumption and Investment

The value of Federal military government consumption and investment was based primarily on procurement data from the Department of Defense for Hawaii, and the compensation of employees and the consumption of fixed capital from BEA. Investment components of procurement were separated from consumption.

Federal Civilian Government Consumption and Investment

The value of Federal civilian government consumption and investment was based primarily on procurement data from the Federal Procurement Data Center (FPDC) for Hawaii, and the compensation of employees and the consumption of fixed capital from BEA. The investment components of procurement were separated from consumption and adjusted for government enterprises. Expenses of Federal government enterprises were extracted from the total Federal government to yield Federal civilian government consumption and investment.

Exports

Exports consist of the commodities and services that are sold to people and businesses outside the State of Hawaii. The value of commodity exports were estimated using the waterborne commerce data from the US Army Corps of Engineers, which disclose the tonnage of cargo by type of commodity being shipped to and out of Hawaii. Also used were the U.S. Customs data, which disclose the foreign exports through the port of Honolulu. The 1997 Commodity Flow Survey by the U.S. Bureau of the Census was also used to estimate the tonnage leaving the state and its value. Values of exported services were estimated by using the exported services dataset by industry from the 1997 Economic Census.

Imports

Imports consist of the commodities and services purchased by industries as inputs to production and by final users for consumption and investment. Total imports by industries were computed as a residual between the income and expenditure sides of Hawaii's GSP accounts and allocated to individual industries in balancing the inter-industry transactions table. The value of imports of final demand sectors was estimated as the total expenditures on final goods and services at producers' prices less final sales of goods and services by domestic industries. Various transportation and trade margins attributable to imports for final use were included in final demands of the corresponding transportation and trade sectors. Imports were also estimated independently using the same data sources as exports. Both procedures yielded comparable results.

Employment

Both wage and salary employment and proprietors' employment numbers are based on BEA employment data by industry. Like GSP, BEA employment data are available at the 2-digit SIC level, so they were bridged from SIC into NAICS. The wage and salary jobs were bridged in a similar fashion as the wage and salary income, and proprietors' jobs were bridged similarly to proprietors' income, with further adjustments for several industries.

IV. INTER-INDUSTRY MATRIX AND BALANCING PROCEDURE

Inter-Industry Matrix

The core of an I-O model is the inter-industry matrix or inter-industry transactions table, which shows the flows of sales and purchases of commodities and services among the producing industries in the economy. Detailed data on these commodity and service flows are generally not available. Conducting a full survey of industries would be a time consuming and costly proposition. Thus, I-O models at the regional level are mostly based on non-survey or partial-survey methods.

The individual cells in the 1997 inter-industry matrix were estimated using several sources. First, any cells for which reliable estimates could be found were filled in. These estimates came from the 1997 Economic Census, industries' annual reports, the *Statistics of Hawaii Agriculture*, and the state and country government annual reports. Values for the rest of the cells were estimated using the production functions from the 1992 Hawaii I-O table, the 1997 U.S. I-O table, or the 1997 Hawaii I-O table from IMPLAN.

Production functions for construction industries were estimated using the data from the Economic Census of Construction. The *Statistics of Hawaii Agriculture* and BEA's report on farm incomes and expenses provided values for inter-industry commodity flows of various agricultural and food processing sectors. Information from a recent survey on cost of production of vegetables was used to estimate input purchases from the vegetables sector (Peterson et al., 1999). The production function for commercial fishing was estimated based on the 1992 I-O Hawaii table modified by University of Hawaii economists to estimate the economic contributions of Hawaii's pelagic fisheries (Sharma et al. 1999). The supplemental Census data on the purchases of certain goods and services by manufacturing were used to estimate the input requirements for some manufacturing sectors.

The 1997 U.S. table was used to estimate the production functions of most of the service sectors. The U.S. I-O table has only one retail sector, but the Hawaii table has several retail sectors. Given the lack of other information, their production functions were based on IMPLAN and the 1992 I-O table for Hawaii. Production functions for the government enterprises were based on the 1997 U.S. I-O table as well as data received from DAGS and the source of receipts datasets for various industries. Columns and rows in the inter-industry matrix were first adjusted manually so that the row totals and column totals were close to their control totals. Then, a bi-proportional balancing procedure was used to balance the matrix.

Balancing Procedure

In theory, total output (sales) should equal to total input (purchases) for each industry. Because of the lack of information on inter-industry transactions, industries' sales (row totals) usually do not initially add up to their total purchases (column totals). Therefore, rows and columns of the transactions table need to be adjusted using a balancing procedure such that they add up to the same total or other desired control totals.

One of the most popular techniques in balancing an I-O transactions table is the bi-proportional balancing procedure, also called the RAS procedure. Traditionally, RAS is used to balance the direct requirements table. This study uses a modified RAS procedure to balance the inter-industry portion of

the transactions table, because it is faster than balancing the direct requirements table. See Appendix D for the mathematical details. Final demand and final payment sectors are not changed in the balancing process.

The modified RAS procedure used in the 1997 Hawaii I-O table involves the following pieces of information.

i. Total sales or output by sector for 1997
ii. Total sales to final users by sector for 1997
iii. Total purchases or input by sector for 1997
iv. Total value added by sector for 1997
v. Inter-industry matrix, as mentioned earlier

Since only the inter-industry portion of the transactions table is unbalanced, instead of using the total industry sales (output) and purchases (input) as control totals, the difference between industry's total output and value added was used as the control total for columns and the difference between total output and total final sales was used as the control total for rows. This calculated control total for columns includes both an industry's total purchases from Hawaii's industries and an industry's total imports for intermediate use. This allowed the estimation of industry imports during the balancing procedure rather than estimating them separately.

After balancing the inter-industry transaction matrix, final demand and final payment sections were added back to the matrix to arrive at the complete the 1997 Hawaii I-O transactions table. Direct and total requirements tables were then derived to estimate the various I-O multipliers, which are presented in the next section.

V. MULTIPLIERS FROM THE 1997 DETAILED I-O TABLE FOR HAWAII

1997 Detailed I-O Table for Hawaii

The 1997 detailed I-O transactions table for the State of Hawaii includes the following.[7]

One hundred thirty-one (131) producing sectors (see Table 5.1 or Appendix A)
Eleven (11) final demand sectors
- Personal consumption expenditures (PCEs)
- Visitor expenditures
- Change in inventories
- Gross private investment
- Six (6) government sub-sectors
  - State and local government investment
  - State and local government consumption
  - Federal government military investment
  - Federal government military consumption
  - Federal government civilian investment
  - Federal government civilian consumption
- Export Sector

Four (4) final payments sectors
- Compensation of employees
- Proprietors' income
- Indirect business taxes
- Other capital costs

Imports
Employment
- Wage and salary jobs
- Proprietors' jobs
- Total jobs

Earnings (used in earnings and Type II multiplier calculations)
State tax revenue (used in state tax multiplier calculations)

1997 Detailed I-O Multipliers

Using the procedures described in Section 2 and Appendix B, the following multipliers were derived for each industry in the 1997 detailed I-O table and the results are presented in Table 5.1.[8]

[7] For details, refer to the 1997 Input-Output Study for Hawaii at the DBEDT Web site. The study presents the 1997 transactions table and various I-O multipliers for each of the 131 industry sectors in the 1997 detailed I-O table.

[8] Although not presented in Table 5.1 due to space limitations, final-demand and direct-effect multipliers were also derived for wage and salary employment. Estimates for wage and salary multipliers are provided with the detailed 1997 I-O transactions table at the DBEDT Web site. Also presented at the DBEDT Web site are final-demand wage and salary employment and total employment multipliers for 1998 to 2007. Employment multipliers for subsequent years are adjusted for projected inflation and productivity growth.

Final-demand multipliers (Type I and Type II)
- Output multiplier
- Earnings multiplier
- Total employment multiplier
- State tax multipliers

Direct-effect multipliers (Type I and Type II)
- Earnings multiplier
- Total employment multiplier

The final-demand employment multipliers presented in this report are for 1997. As discussed previously, final-demand employment multipliers change over time due to inflation and labor productivity growth. The final-demand wage and salary and total employment multipliers for 1998-2007 are available at the DBEDT Web site.

Note that the state tax multipliers are new to the 1997 I-O table for Hawaii. These were generated because one of the most common impact analyses conducted is the impact of new policies on state tax revenues. The taxes included in calculations are state taxes that are part of the indirect business tax (IBT) components of value added plus personal state income taxes on household earnings.[9] The GET (general excise tax), transient accommodations tax (TAT), state fuel taxes, state alcohol taxes, and other state taxes and fees are IBT components included in state taxes. Excluded are property taxes, other city and county taxes, and Federal taxes. The calculation of the state tax multiplier is analogous to calculating earnings and employment multipliers. Entries in the total requirements table (Leontief's inverse) are converted to state tax equivalents by multiplying each row of the total requirements table by the ratio of state taxes to output for the corresponding row industry.

The interpretation of each of the above multipliers is provided at the end of Table 5.1. As mentioned earlier, when the household sector is assumed to be exogenous (external) to the model we get Type I multipliers. Type II multipliers are obtained by including the household sector to the direct requirements table as one of the producing sectors.

Table 5.1 presents the 1997 I-O multipliers for Hawaii's 131 producing sectors. Included in the table are both Type I and Type II final-demand output, earnings, total employment and state tax multipliers as well as Type I and Type II direct-effect earnings and total employment multipliers. Some general observations from the table are summarized below.

The Type I output multipliers vary from a minimum of 1.0 for general government sectors to a maximum of 2.20 for state and local government transit.[10] In general, agricultural processing industries (especially sugar processing, fruit and vegetable processing, and meat processing) have higher Type I output multipliers, while non-agricultural manufacturing sectors (notably petroleum and transportation equipment) have lower Type I multipliers. This is because agricultural processing sectors are mostly based on inputs produced from Hawaii's industries, while non-agricultural manufacturing inputs are mostly imported. Several service-oriented industries that are labor-intensive and use limited material inputs also have lower Type I output multipliers, such as employment services, legal services, investigation and security services, and other personal and household services.

[9] For information on state tax revenues by industry for 1997, refer to the 1997 detailed I-O table at the DBEDT Web site.

[10] For an explanation of large output multiplier for state and local government transit., see Footnote 8 at the end of Table 5.1.

As expected, Type II output multipliers are higher than their Type I counterparts due to induced effects. Relative to Type I multipliers, increments in Type II output multipliers are highest among the labor-intensive sectors, including general government sectors, other personal and household services, legal services, and employment services. The reason is that a large portion of purchases of these industries goes to households as earnings, which is injected back to the economy in the form of increased spending on goods and services produced in the economy.

Type I final-demand earnings multipliers show substantial variations across industries, ranging from 0.05 for petroleum manufacturing to 2.27 for state and local government transit. Other industries that have smaller Type I final-demand earnings multipliers include owner-occupied dwellings, real estate, electricity production, and other local and state government enterprises. Labor-intensive sectors, such as general government and service sectors have relatively higher Type I final-demand earnings multipliers. This pattern also holds for Type II final-demand earnings multipliers.

The Type I direct-effect earnings multipliers vary from 1.0 for general government sectors to 4.22 for sugar processing and Type II direct-effect multipliers vary from 1.31 to 5.55 for the same industries. For labor-intensive sectors, final-demand earnings multipliers are higher and so are direct-earnings coefficients. So the direct-effect multipliers that show the total effect relative to direct-earnings coefficients are lower.

Final-demand employment multipliers, showing number of total jobs (wage and salary plus proprietors' jobs) per $1 million change in industry's final demand, vary from 1.3 for petroleum manufacturing to 86.9 for non-store retailers for Type I and from 2.0 to 94.5 for the same industries for Type II. In general, agricultural and services sectors have higher and manufacturing, communications and utilities sectors have lower final-demand employment multipliers. The opposite pattern is observed for the direct-effect employment multipliers. This is mainly due to differences in jobs-to-output ratios. Agricultural and services sectors have higher and manufacturing, communications and utilities sectors have lower jobs-to-output ratios.

Also presented in Table 5.1 are final-demand state tax multipliers. As described at the end of Table 5.1, state tax multipliers show the changes in state tax revenues that result from a $1 change in an industry's final demand. State taxes include part of industries' indirect business taxes and state income taxes on households' earnings originated from producing sectors.

Table 5.1 1997 Detailed Type I and Type II Output, Earnings, Employment, and Tax Multipliers for Hawaii

		Final-demand multipliers								Direct-effect multipliers			
		Output[1] (dollars)		Earnings[2] (dollars)		Employment[3] (total jobs)		State tax[4] (dollars)		Earnings[5] (dollars)		Employment[6] (total jobs)	
	Industry	Type I	Type II	Type I	Type II	Type I	Type II	Type I	Type II	Type I	Type II	Type I	Type II
1	Sugarcane	1.31	1.96	0.56	0.74	19.8	27.2	0.051	0.083	1.15	1.51	1.15	1.58
2	Vegetables	1.59	1.96	0.33	0.43	35.0	39.2	0.045	0.064	2.11	2.77	1.32	1.48
3	Macadamia nuts	1.40	1.86	0.39	0.52	35.2	40.3	0.043	0.066	1.38	1.81	1.17	1.34
4	Pineapples	1.53	2.10	0.50	0.66	25.2	31.7	0.050	0.079	1.50	1.98	1.58	1.98
5	Other fruits	1.61	2.15	0.47	0.62	62.7	68.9	0.051	0.079	1.70	2.24	1.21	1.33
6	Coffee	1.46	1.85	0.34	0.45	30.9	35.3	0.039	0.059	1.43	1.88	1.14	1.31
7	Greenhouse and nursery products	1.27	1.69	0.37	0.48	31.0	35.7	0.035	0.057	1.23	1.62	1.13	1.30
8	Dairy cattle and milk production	1.37	1.64	0.24	0.31	12.3	15.4	0.032	0.045	1.68	2.22	1.59	1.99
9	Poultry and eggs	1.48	1.79	0.27	0.36	21.1	24.6	0.038	0.054	2.17	2.85	1.57	1.84
10	Cattle Ranching	1.57	2.11	0.47	0.62	59.4	65.5	0.045	0.073	1.56	2.06	1.37	1.51
11	Hog and pig farming	1.71	2.02	0.28	0.36	45.2	48.8	0.043	0.059	2.25	2.96	1.37	1.48
12	Misc. livestock	1.69	2.16	0.40	0.53	25.1	30.3	0.048	0.071	1.76	2.32	1.59	1.92
13	Aquaculture	1.33	1.76	0.37	0.49	17.4	22.3	0.040	0.061	1.26	1.66	1.21	1.54
14	Other agricultural products	1.49	1.84	0.30	0.40	18.2	22.2	0.042	0.060	1.73	2.28	1.47	1.79
15	Commercial fishing	1.57	2.01	0.38	0.51	35.8	40.8	0.046	0.068	1.49	1.96	1.16	1.32
16	Support activities for agriculture	1.34	1.90	0.49	0.64	30.0	36.4	0.065	0.093	1.24	1.63	1.12	1.36
17	Landscape services	1.33	2.00	0.59	0.77	37.3	44.9	0.088	0.122	1.21	1.59	1.16	1.40
18	Mining	1.31	1.71	0.34	0.45	11.9	16.3	0.041	0.061	1.31	1.72	1.31	1.81
19	Single family housing construction	1.42	1.97	0.47	0.62	16.4	22.6	0.087	0.115	1.38	1.82	1.46	2.01
20	Multiple family housing construction	1.43	1.96	0.46	0.61	13.5	19.5	0.086	0.113	1.42	1.86	1.63	2.36
21	Commercial building construction	1.46	2.06	0.52	0.68	14.1	20.9	0.087	0.117	1.41	1.85	1.63	2.40
22	Hotel construction	1.49	2.06	0.50	0.66	13.7	20.2	0.086	0.115	1.46	1.92	1.70	2.52
23	Road construction	1.52	2.12	0.51	0.68	14.0	20.7	0.084	0.114	1.46	1.92	1.71	2.52
24	Other construction	1.47	2.09	0.54	0.71	14.2	21.3	0.088	0.119	1.41	1.85	1.66	2.49
25	Maintenance and repair construction	1.35	1.94	0.51	0.67	15.1	21.7	0.084	0.114	1.28	1.68	1.41	2.03
26	Fruit and vegetable product manufacturing[7]	1.80	2.31	0.44	0.58	19.8	25.6	0.048	0.074	2.18	2.86	2.46	3.17
27	Sugar manufacturing	1.97	2.58	0.53	0.69	18.3	25.2	0.051	0.082	4.22	5.55	4.88	6.71
28	Confectionery product manufacturing	1.45	1.89	0.38	0.51	21.1	26.1	0.049	0.071	1.55	2.03	1.48	1.83
29	Meat product manufacturing	2.00	2.46	0.40	0.52	33.3	38.5	0.053	0.076	2.62	3.45	3.90	4.50
30	Dairy product manufacturing	1.56	1.86	0.26	0.34	10.0	13.4	0.035	0.050	1.87	2.45	2.28	3.06

Table 5.1 1997 Detailed Type I and Type II Output, Earnings, Employment and Tax Multipliers for Hawaii - Continued

		Final-demand multipliers								Direct-effect multipliers			
		Output[1] (dollars)		Earnings[2] (dollars)		Employment[3] (total jobs)		State tax[4] (dollars)		Earnings[5] (dollars)		Employment[6] (total jobs)	
	Industry	Type I	Type II	Type I	Type II	Type I	Type II	Type I	Type II	Type I	Type II	Type I	Type II
31	Bakeries and grain product manufacturing	1.39	1.82	0.37	0.49	17.6	22.5	0.043	0.064	1.38	1.81	1.34	1.72
32	Beverage manufacturing	1.48	1.79	0.27	0.35	9.0	12.4	0.040	0.056	2.07	2.73	2.48	3.45
33	Snack food manufacturing	1.46	1.79	0.28	0.37	14.6	18.2	0.038	0.054	1.91	2.51	2.30	2.88
34	Coffee and tea manufacturing	1.56	1.83	0.23	0.30	15.1	18.1	0.031	0.044	2.58	3.40	3.86	4.63
35	Other food product manufacturing	1.47	1.75	0.24	0.32	12.2	15.4	0.039	0.053	2.17	2.85	2.00	2.52
36	Apparel and textile manufacturing	1.30	1.69	0.34	0.45	21.7	26.2	0.038	0.058	1.35	1.77	1.25	1.51
37	Wood product manufacturing	1.28	1.72	0.38	0.50	18.8	23.7	0.042	0.064	1.29	1.70	1.24	1.57
38	Furniture manufacturing	1.25	1.80	0.47	0.62	18.5	24.7	0.045	0.072	1.20	1.58	1.24	1.65
39	Paper manufacturing	1.26	1.59	0.29	0.38	7.9	11.6	0.035	0.052	1.35	1.78	1.65	2.43
40	Printing	1.30	1.84	0.47	0.62	15.8	22.0	0.047	0.074	1.24	1.63	1.30	1.81
41	Chemical manufacturing	1.29	1.63	0.29	0.38	9.2	13.0	0.035	0.052	1.42	1.86	1.58	2.23
42	Petroleum manufacturing	1.10	1.17	0.05	0.07	1.3	2.0	0.007	0.010	1.75	2.30	3.05	4.63
43	Rubber and plastic product manufacturing	1.36	1.77	0.35	0.46	13.1	17.7	0.042	0.063	1.41	1.85	1.45	1.96
44	Non-metallic mineral product manufacturing	1.68	2.21	0.47	0.61	13.9	20.0	0.054	0.081	1.66	2.18	1.94	2.78
45	Metal product manufacturing	1.29	1.65	0.31	0.41	11.0	15.1	0.037	0.055	1.36	1.79	1.44	1.97
46	Electrical product manufacturing	1.28	1.60	0.28	0.37	7.5	11.1	0.036	0.052	1.48	1.95	2.03	3.01
47	Transportation equipment manufacturing	1.18	1.68	0.43	0.57	13.7	19.4	0.037	0.062	1.16	1.52	1.23	1.73
48	Miscellaneous product manufacturing	1.22	1.62	0.35	0.46	15.4	20.0	0.037	0.057	1.26	1.65	1.25	1.61
49	Truck transportation	1.52	2.07	0.48	0.62	17.2	23.4	0.089	0.117	1.39	1.83	1.44	1.95
50	Warehousing	1.71	2.06	0.31	0.41	14.2	18.2	0.088	0.105	2.32	3.05	2.37	3.04
51	Water transportation	1.61	1.96	0.30	0.40	9.2	13.1	0.042	0.060	2.82	3.71	3.47	4.96
52	Air transportation	1.41	1.76	0.30	0.40	8.2	12.2	0.035	0.053	1.40	1.85	1.62	2.41
53	Ground passenger transportation	1.33	1.88	0.47	0.62	33.7	39.9	0.083	0.110	1.21	1.59	1.11	1.31
54	Support activities for transportation	1.29	1.92	0.54	0.72	14.9	22.0	0.050	0.082	1.21	1.59	1.27	1.88
55	Couriers	1.34	1.86	0.46	0.60	18.0	24.0	0.043	0.069	1.19	1.56	1.17	1.56
56	Sightseeing transportation	1.34	1.85	0.45	0.59	19.4	25.2	0.077	0.102	1.21	1.60	1.18	1.53
57	Publishing	1.30	1.78	0.42	0.55	12.3	17.8	0.074	0.099	1.31	1.72	1.42	2.04
58	Software and information services	1.28	1.88	0.52	0.68	17.9	24.7	0.082	0.112	1.17	1.54	1.20	1.66
59	Motion picture and sound production	1.22	1.86	0.55	0.72	28.2	35.4	0.084	0.116	1.17	1.53	1.14	1.44
60	Motion picture exhibition	1.27	1.56	0.25	0.33	20.5	23.8	0.066	0.081	1.53	2.01	1.22	1.41

Table 5.1 1997 Detailed Type I and Type II Output, Earnings, Employment and Tax Multipliers for Hawaii - Continued

		Final-demand multipliers								Direct-effect multipliers			
		Output[1] (dollars)		Earnings[2] (dollars)		Employment[3] (total jobs)		State tax[4] (dollars)		Earnings[5] (dollars)		Employment[6] (total jobs)	
	Industry	Type I	Type II	Type I	Type II	Type I	Type II	Type I	Type II	Type I	Type II	Type I	Type II
61	Radio and TV broadcasting	1.26	1.70	0.38	0.51	12.8	17.8	0.071	0.093	1.28	1.68	1.44	2.01
62	Cable TV	1.24	1.53	0.25	0.33	7.6	10.9	0.065	0.080	1.45	1.91	1.76	2.53
63	Telecommunications	1.29	1.60	0.27	0.36	7.3	10.8	0.046	0.062	1.42	1.86	1.66	2.46
64	Electricity	1.44	1.65	0.19	0.24	4.1	6.5	0.083	0.093	1.47	1.93	1.95	3.10
65	Gas production and distribution	1.41	1.92	0.44	0.57	7.9	13.6	0.066	0.092	1.14	1.50	1.26	2.18
66	Wholesale trade	1.25	1.72	0.41	0.54	14.7	20.0	0.135	0.159	1.20	1.58	1.23	1.68
67	Motor vehicle and parts dealers	1.32	1.83	0.44	0.58	14.6	20.3	0.179	0.204	1.21	1.59	1.25	1.75
68	Furniture and home furnishing stores	1.19	1.75	0.49	0.64	20.4	26.8	0.134	0.162	1.10	1.45	1.10	1.44
69	Electronics and appliance stores	1.27	1.77	0.43	0.57	20.8	26.4	0.153	0.178	1.18	1.55	1.15	1.46
70	Building materials & gardening equipment dealers	1.27	1.74	0.41	0.54	16.8	22.1	0.144	0.168	1.21	1.59	1.20	1.58
71	Food stores	1.23	1.77	0.47	0.62	23.9	30.0	0.173	0.201	1.14	1.50	1.11	1.39
72	Health and personal care stores	1.25	1.78	0.46	0.61	19.8	25.8	0.163	0.190	1.15	1.51	1.13	1.48
73	Gas stations	1.34	1.78	0.38	0.50	21.5	26.5	0.074	0.096	1.26	1.65	1.16	1.43
74	Apparel and accessory stores	1.43	1.92	0.42	0.56	21.4	27.0	0.138	0.163	1.33	1.75	1.26	1.58
75	Sporting goods, hobby, book, and music stores	1.19	1.77	0.50	0.66	35.5	42.1	0.155	0.184	1.10	1.44	1.05	1.25
76	Department stores	1.34	1.83	0.43	0.56	26.1	31.7	0.144	0.169	1.27	1.67	1.18	1.43
77	Other general merchandise stores	1.69	2.09	0.35	0.46	15.0	19.6	0.117	0.138	1.73	2.27	1.64	2.15
78	Misc. store retailers	1.16	1.77	0.52	0.69	42.6	49.4	0.148	0.179	1.08	1.42	1.04	1.20
79	Nonstore retailers	1.25	1.93	0.58	0.76	86.9	94.5	0.143	0.176	1.12	1.47	1.03	1.12
80	Banking and credit intermediation	1.33	1.71	0.33	0.43	11.1	15.4	0.036	0.056	1.44	1.90	1.59	2.21
81	Securities and investment activities	1.40	1.99	0.51	0.67	25.2	31.8	0.091	0.120	1.32	1.73	1.25	1.58
82	Insurance	1.67	2.15	0.42	0.55	14.5	20.0	0.097	0.121	1.75	2.31	1.84	2.53
83	Owner-occupied dwellings	1.25	1.35	0.08	0.11	3.2	4.3	0.012	0.016	NA	NA	NA	NA
84	Real estate	1.34	1.58	0.20	0.27	8.7	11.4	0.058	0.070	1.75	2.30	1.74	2.28
85	Equipment rental	1.37	1.82	0.39	0.52	17.4	22.5	0.077	0.100	1.33	1.74	1.27	1.64
86	Automobile rental	1.60	1.92	0.28	0.37	12.0	15.6	0.137	0.154	2.01	2.65	1.77	2.31
87	Legal services	1.21	2.04	0.72	0.95	13.0	22.4	0.091	0.133	1.09	1.44	1.20	2.08
88	Accounting services	1.37	2.03	0.57	0.75	28.5	35.9	0.088	0.121	1.24	1.63	1.20	1.51
89	Architectural and engineering services	1.45	2.09	0.55	0.72	17.2	24.4	0.090	0.122	1.32	1.73	1.46	2.06
90	Computer systems design services	1.26	1.98	0.62	0.82	21.0	29.1	0.089	0.125	1.13	1.49	1.15	1.60

Table 5.1 1997 Detailed Type I and Type II Output, Earnings, Employment and Tax Multipliers for Hawaii - Continued

		Final-demand multipliers								Direct-effect multipliers			
		Output[1] (dollars)		Earnings[2] (dollars)		Employment[3] (total jobs)		State tax[4] (dollars)		Earnings[5] (dollars)		Employment[6] (total jobs)	
	Industry	Type I	Type II	Type I	Type II	Type I	Type II	Type I	Type II	Type I	Type II	Type I	Type II
91	Management, scientific, and consulting services	1.30	1.99	0.59	0.78	30.3	38.1	0.087	0.122	1.18	1.55	1.14	1.43
92	Research and development services	1.37	1.88	0.44	0.57	14.1	19.7	0.055	0.080	1.36	1.78	1.45	2.03
93	Advertising	1.32	2.01	0.60	0.78	21.2	29.0	0.089	0.124	1.20	1.58	1.27	1.74
94	Photographic services	1.36	2.00	0.55	0.73	31.4	38.6	0.088	0.120	1.23	1.62	1.16	1.43
95	Other professional services	1.43	2.20	0.67	0.88	37.0	45.8	0.099	0.138	1.24	1.63	1.17	1.45
96	Administrative and facilities support services	1.34	2.03	0.60	0.78	21.4	29.2	0.089	0.124	1.23	1.62	1.31	1.79
97	Employment services	1.10	1.96	0.74	0.98	46.3	56.0	0.088	0.131	1.06	1.39	1.05	1.26
98	Business support services	1.28	1.88	0.52	0.68	25.1	31.8	0.083	0.113	1.23	1.62	1.21	1.54
99	Travel arrangement and reservation services	1.34	1.93	0.52	0.68	19.9	26.7	0.083	0.113	1.31	1.73	1.29	1.72
100	Investigation and security services	1.12	1.91	0.69	0.90	47.4	56.3	0.086	0.126	1.06	1.40	1.04	1.24
101	Services to buildings and dwellings	1.15	1.87	0.63	0.82	47.3	55.5	0.085	0.121	1.09	1.43	1.05	1.23
102	Waste management and remediation services	1.60	2.04	0.39	0.51	11.8	16.8	0.082	0.104	1.63	2.14	1.83	2.61
103	Educational services	1.35	2.11	0.65	0.86	33.4	42.0	0.089	0.127	1.14	1.50	1.11	1.39
104	Doctors and dentists	1.27	2.04	0.67	0.88	14.7	23.3	0.089	0.128	1.13	1.49	1.23	1.97
105	Nursing and residential care facilities	1.33	1.99	0.58	0.76	24.6	32.1	0.047	0.081	1.15	1.51	1.14	1.49
106	Hospitals	1.49	2.08	0.51	0.67	16.1	22.8	0.059	0.089	1.33	1.75	1.50	2.12
107	Other medical services	1.40	1.91	0.45	0.59	14.9	20.7	0.070	0.096	1.29	1.69	1.33	1.85
108	Social assistance	1.35	2.08	0.63	0.82	37.4	45.5	0.049	0.086	1.17	1.54	1.11	1.35
109	Performing arts and related services	1.45	2.18	0.63	0.83	50.8	59.0	0.096	0.133	1.35	1.77	1.26	1.46
110	Amusement services	1.39	1.80	0.36	0.47	21.2	25.9	0.078	0.099	1.43	1.89	1.31	1.61
111	Recreation services	1.46	2.01	0.48	0.63	32.8	39.0	0.086	0.114	1.30	1.71	1.17	1.39
112	Golf courses	1.45	1.97	0.45	0.59	20.2	26.0	0.084	0.110	1.32	1.73	1.30	1.67
113	Museums and historical sites	1.38	1.97	0.51	0.67	30.2	36.8	0.087	0.116	1.28	1.68	1.20	1.46
114	Accommodations[8]	1.42	1.92	0.44	0.57	16.8	22.4	0.113	0.139	1.35	1.77	1.41	1.88
115	Eating and drinking places	1.46	1.95	0.42	0.56	27.0	32.6	0.078	0.103	1.35	1.77	1.22	1.47
116	Dry-cleaning and laundry services	1.39	1.96	0.49	0.65	28.3	34.8	0.086	0.114	1.25	1.65	1.16	1.43
117	Automotive repair services	1.35	1.83	0.42	0.56	20.0	25.6	0.081	0.106	1.26	1.65	1.22	1.55
118	Other repair services	1.24	1.83	0.51	0.67	23.7	30.3	0.081	0.111	1.15	1.52	1.13	1.45
119	Personal care services	1.31	1.98	0.58	0.76	43.0	50.5	0.087	0.121	1.16	1.52	1.09	1.29
120	Death care services	1.25	1.70	0.39	0.51	15.7	20.7	0.058	0.081	1.21	1.59	1.21	1.61

Table 5.1 1997 Detailed Type I and Type II Output, Earnings, Employment and Tax Multipliers for Hawaii - Continued

	Industry	Final-demand multipliers: Output[1] (dollars) Type I	Output[1] (dollars) Type II	Earnings[2] (dollars) Type I	Earnings[2] (dollars) Type II	Employment[3] (total jobs) Type I	Employment[3] (total jobs) Type II	State tax[4] (dollars) Type I	State tax[4] (dollars) Type II	Direct-effect multipliers: Earnings[5] (dollars) Type I	Earnings[5] (dollars) Type II	Employment[6] (total jobs) Type I	Employment[6] (total jobs) Type II
121	Parking lots and garages	1.59	1.96	0.32	0.42	19.6	23.8	0.083	0.102	1.71	2.25	1.40	1.70
122	Other personal services and households	1.17	1.97	0.69	0.91	68.5	77.5	0.089	0.130	1.06	1.40	1.02	1.16
123	Organizations	1.68	2.32	0.55	0.72	23.8	30.9	0.058	0.090	1.46	1.92	1.41	1.83
124	Other state and local gov't enterprises	1.44	1.71	0.23	0.30	7.6	10.6	0.030	0.044	2.10	2.76	2.17	3.03
125	State and local gov't enterprises: Water and sewer	1.25	1.63	0.33	0.44	9.0	13.4	0.029	0.049	1.23	1.62	1.28	1.90
126	State and local gov't enterprises: Transit[9]	2.20	4.82	2.27	2.99	59.2	88.9	0.187	0.320	1.16	1.52	1.26	1.89
127	Federal gov't enterprises: Postal service	1.34	2.27	0.81	1.07	19.6	30.2	0.056	0.103	1.12	1.47	1.18	1.82
128	Other Federal gov't enterprises	1.17	1.79	0.54	0.71	27.7	34.8	0.038	0.069	1.10	1.44	1.07	1.34
129	Federal gov't: Military	1.00	1.75	0.65	0.85	17.5	26.0	0.038	0.075	1.00	1.31	1.00	1.48
130	Federal gov't: Civilian	1.00	1.76	0.66	0.87	14.6	23.3	0.038	0.077	1.00	1.31	1.00	1.59
131	State and local government	1.00	1.85	0.74	0.97	23.4	33.1	0.043	0.086	1.00	1.31	1.00	1.41

Notes:

[1] Each entry in the final-demand output multiplier column shows the total dollar change in output in all row industries that results from a $1 change in final demand in the corresponding row industry.

[2] Each entry in the final-demand earnings multiplier column shows the total change in earnings received by households from all row industries that results from a $1 change in final demand in the corresponding row industry.

[3] Each entry in the final-demand employment multiplier column shows the total change in number of jobs in all row industries that results from a $1 million change in final demand in the corresponding row industry.

[4] Each entry in the final-demand state tax multiplier column shows the total change in state tax revenues from households and all row industries that results from a $1 change in final demand in the corresponding row industry.

[5] Each entry in the direct-effect earnings multiplier column shows the total change in earnings received by households from all row industries that results from a $1 change in earnings received by households directly from the corresponding row industry.

[6] Each entry in the direct-effect employment multiplier column shows the total change in number of jobs in all row industries that results from a change of one job in the corresponding row industry.

7 Includes pineapple canning, which cannot be shown separately due to disclosure constraints.

[8] The Accommodations industry state tax multiplier (0.14) consists mainly of Hotel operations, of which room revenue is only part. To estimate the impact of a change in room revenue only, the state tax multiplier of 0.169 is suggested.

[9] The state and local government enterprise: transit industry has large final-demand multipliers because final demand for this sector is in terms of its revenue, which is only about one-fourth of its expenditures.

VI. EXAMPLES AND CONSIDERATIONS IN USING I-O MODELS IN IMPACT ANALYSIS

The I-O table and the multipliers generated from it are a major tool used in economic impact analysis. Unfortunately, multipliers are often used incorrectly. The following are a few hypothetical examples showing the correct use of I-O multipliers.[11]

Economic Impacts of Visitor Spending

Visitor spending contributes significantly to Hawaii's economy. In 1997, visitor spending on goods and services produced in Hawaii totaled more than $10 billion, contributing to about one-fourth each of total output and employment and about one-fifth of total household earnings for the state. Thus, estimating impacts of changes in visitor expenditures due to various factors (such as unforeseen events or changes in economic conditions in Hawaii's visitor markets) is an important task. For example, the terrorist attacks of September 11, 2001 and ongoing recession in Japanese and the U.S. economies resulted in a significant decline in visitor arrivals and hence visitor spending in late 2001 and into 2002.

Let us hypothesize a decline in visitor spending of $1 billion in 2002. To estimate its impact on the economy, this $1 billion needs to be allocated to the various industries producing the goods and services purchased by visitors. Unless the analyst has information on which to base the allocation of purchases, an acceptable technique is to allocate visitor purchases based on the industries' shares in total visitor expenditure in the 1997 I-O table. Then, the value of the decrease in visitor spending for each industry is multiplied by the final-demand output, earnings and job multipliers for that industry and the results are added up to obtain the total output, earnings and job impacts of the decline in visitor expenditures. The results, shown in Table 6.1, indicate that a hypothetical decrease in visitor expenditures of $1 billion could potentially cost Hawaii's economy about $1.6 billion in output (sales), $460 million in earnings, and about 18,600 jobs.

Purchasers' Prices vs. Producers' Prices

All transactions in the I-O framework are valued at producers' prices rather than the consumer's price. In order to do impact analysis correctly, the value of the direct impact should be broken down into the producers' prices for the good (or service), as well as the transportation costs , wholesale and retail trade margins and other costs that are imbedded in the consumer's price. These costs are then attributed to the respective producing industries, e.g. transportation, wholesale and trade sectors.

As an example, let us consider the impact of a $100 million increase in sales of clothing to Tourists (Table 6.2). It would be incorrect to apply the multipliers of the retail Apparel and Accessory Stores directly to the $100 million, because output for Apparel and Accessory Stores is not the total revenue (sales) for the industry, but rather its margin or retail markup.

[11] Also see the 1992 Input-Output Study for Hawaii for an example of using of I-O model in impact analysis.

Table 6.1 Economic Impacts of Decline in Visitor Spending by $1 Billion

	Visitor expenditures shares (%)	Decline in visitor expenditures ($ mil.)	Type II final-demand multipliers (from Table 2.4)			Economic impacts		
			Output	Earnings	Job*	Output	Earnings	Job
Agriculture	0.16	1.6	1.94	0.59	34.8	3.1	0.9	55
Mining and construction	0.00	0.0	1.98	0.65	19.7	0.0	0.0	0
Food processing	0.45	4.5	1.98	0.44	19.3	8.9	2.0	86
Other manufacturing	0.42	4.2	1.41	0.24	8.5	5.9	1.0	36
Transportation	17.60	176.0	1.85	0.49	16.0	326.4	86.0	2,819
Information	0.29	2.9	1.64	0.41	12.6	4.7	1.2	36
Utilities	0.00	0.0	1.73	0.30	8.1	0.0	0.0	0
Wholesale trade	1.79	17.9	1.72	0.54	18.7	30.9	9.7	336
Retail trade	10.72	107.2	1.85	0.59	27.3	198.2	62.9	2,925
Finance and insurance	0.00	0.0	1.86	0.48	16.5	0.0	0.0	0
Real estate and rentals	7.99	79.9	1.49	0.21	8.4	119.4	17.0	670
Professional services	0.33	3.3	2.03	0.80	26.1	6.6	2.6	85
Business services	1.93	19.3	1.95	0.75	33.8	37.5	14.4	651
Educational services	1.20	12.0	2.10	0.85	38.6	25.2	10.3	464
Health services	0.71	7.1	2.03	0.74	23.2	14.5	5.3	165
Arts and entertainment	3.63	36.3	1.98	0.62	32.8	71.8	22.7	1,192
Accommodations	27.95	279.5	1.93	0.58	20.9	538.5	162.4	5,837
Eating and drinking	9.62	96.2	1.95	0.57	30.7	188.0	54.9	2,957
Other services	0.54	5.4	2.05	0.67	31.7	11.1	3.6	171
Government	0.39	3.9	1.81	0.87	26.1	7.1	3.4	103
Industries' total	85.71	857.1				1,597.6	460.2	18,585
Imports	14.29	142.9				0.0	0.0	0
Total	100.0	1,000.0				1,597.6	460.2	18,585

*Note that these employment (job) multipliers are slightly different from those presented in Table 2.4 because of adjustment for inflation and worker productivity.

Table 6.2 Output Impact of an Increase in Clothing Sales by $100 Million

	Margin %	Allocation ($ million)	Type II output multipliers (from Table 5.1)	Total output impact ($ million)
Margins				
Truck transportation	0.80	0.80	2.07	1.66
Air transportation	0.30	0.30	1.76	0.53
Water transportation	1.75	1.75	1.96	3.43
Wholesale trade	6.00	6.00	1.72	10.32
Retail apparel stores	42.00	42.00	1.92	80.64
Producers' prices	49.15	49.15		
Hawaii's apparel manufacturing (7%)		3.44	1.69	5.81
Imports (93%)		45.71		0.00
Total		100.00		102.39

In order to do the impact analysis correctly, the $100 million needs to be broken down into the value of the clothing at the producers' prices, the transportation costs, and the trade margins. As shown in Appendix C, the retail margin for clothing is 42%, the wholesale margin is 6%, the truck transportation margin is 0.8%, the air transportation margin is 0.3%, and the water transportation margin is 1.75%. Thus, as shown in Table 6.2, the $100 million in clothing expenditures should be distributed into various sectors representing the contribution of the transportation industry, the wholesale and retail trade services provided, as well as garment manufacturing. This yields $49.2 million as the value of clothing at producers' prices.

Note also in Table 6.2 that the producers' value of clothing ($49.2 million) is further distributed into what is contributed through the manufacturing process in Hawaii and what is imported. This type of estimate is often judgmental, but according to the 1997 I-O table, Hawaii's apparel manufacturing industry had about $200 million in sales, most of which was exported. According to the 1997 Economic Census, the merchandise line sales for apparel was over $2 billion for Hawaii. Thus, one would conclude that most of the clothing purchased in Hawaii is imported. Based on this information, the percentage of total clothing sales that is made and sold in Hawaii was estimated to be about 7%. Accordingly, of the 49.2 million of clothing sales in producers' prices, $3.4 million is allocated to Hawaii's apparel manufacturing and $45.7 million to imports. Of course, if visitors bought primarily Hawaiian wear, the value of manufacturing in Hawaii would likely rise and the corresponding value of imports fall. This reemphasizes the need to be very careful about thinking through the appropriate breakdown of the direct expenditure so that the appropriate values and corresponding multipliers are used.

After the allocation, values attributed to various trade and distribution sectors and Hawaii's apparel manufacturing are then multiplied by their respective output multipliers and the results are added up to arrive at the total impact. As shown in Table 6.2, an increase in clothing sales to visitors of $100 million would generate about $102 million of new output in Hawaii's economy, with most of the impact coming from the wholesale and retail margins on imported goods. Earnings and employment impacts can be estimated by replacing the output multipliers with Type II final-demand earnings and employment multipliers.

Gross Impact vs. Net Impact: Government Spending

I-O analysis is often used to calculate the impact of government spending. For example, consider a hypothetical proposal for a new $10 million government program to provide early childhood health screening for low-income families. The program will not be funded by a reduction of government spending elsewhere. Assuming that the program has broad-based support on its merits, will the expenditure itself also have a net economic impact on the economy (not counting the actual value of healthier children)? The Type II output multiplier for government spending from Table 2.4 is 1.81. That suggests that the $10 million expenditure will ultimately generate more than $18 million in output -- $8 million more than the actual expenditures on the program.

However, this conclusion ignores an important factor. The $10 million in program funds had to have come from somewhere and consequently there may be up to $10 million less spending elsewhere. This lack of spending elsewhere will offset the gross economic impact of the

government program spending. What will the net impact of the program be on the economy, if any? The answer depends on how the funds would have been utilized otherwise. There are many ways such a program could be funded, but let us assume for simplicity of the example that the entire program will be funded by a small increase in the personal income tax rate. Let us also assume for simplicity that households will absorb the slight increase in taxes by a comparable reduction in personal consumption expenditures. That is, the amount of income households save will not be affected. The net economic impact in this situation will be the difference between the lost economic impact of $10 million in consumer spending, balanced against the impact of the $10 million increase in government spending for the new program.

The calculation is shown in Table 6.3. Since the direct spending involved is the same for both households and government ($10 million) any net benefit will depend on the differences in the multiplier effects. As the table shows, the Type II output multiplier for household spending (PCE) is lower than the same multiplier for government spending. Thus, in this case there will be as small net economic impact with respect to total output in the economy.

Table 6.3 Net Impact of Government Spending

	Direct Effect ($ million)	Type II Output Multiplier (from Table 2.4)*	Total Output Impact ($ million)
Government	10.0	1.81	18.1
Households (PCE)	-10.0	1.45	-14.5
Net impact			3.6

*Note that the household or PCE multipliers are not shown in Table 2.4. The Type II PCE output multiplier is derived by post-multiplying the Type II total requirements table by the PCE shares and then adding up the results. The PCE earnings and employment multipliers are derived similarly using the final-demand earnings and employment multiplier tables and the PCE shares.

Of course, in the real world the many options of funding government programs would complicate the analysis. However, the point is still the same. The economic impact of any expenditure or use of funds is a gross impact of that particular expenditure only. The net economic impact must be balanced against the alternative use of these funds and what the economic impact of that use would have been.

Gross Impact vs. Net Impact: Business Operation

Another area where impact is often overstated by failing to consider gross and net impacts is in analyzing the operation of new businesses. Just because a new hotel, restaurant, or movie theater is built and operated does not mean that there will be increased demand for hotels or dinners or movies unless there exists insufficient capacity in these businesses. In reality, a new hotel might simply be taking business from other existing hotels. Visitors who stay in this new hotel might have stayed in other existing hotels if the new hotel had not been built. So the impact of the operation of the new hotel will be overstated unless its impact on other hotels is netted out.

Final-Demand vs. Direct-Effect Multipliers

The multipliers presented in Tables 2.4 and 5.1 permit the user to choose between final-demand and direct-effect multipliers to estimate earnings and employment impacts. If the question is to estimate the earnings and employment impacts of a change in an industry's final demand, final-demand earnings and employment multipliers are the correct multipliers to use. On the other hand, if information is available about an income or employment change in an industry, direct-effect income/employment multipliers should be used. It is often also of interest to calculate the impact of an industry's earnings or employment change on the total output of the economy. In that case, initial earnings and employment change should be translated into output change by using the industry's direct-earnings coefficient (income-to-output ratio) and direct-employment coefficient (employment-to-output ratio). Then, the output change should be multiplied by the industry's final-demand output multiplier. To illustrate this, let us examine the total output, earnings and employment impacts of the creation of 500 new jobs in Hawaii's information sector.

The calculation of total job impact is quite straightforward. This is obtained by multiplying direct or initial increase in jobs by Type II direct-effect job multiplier for information sector. This gives total job impact of 1,025 jobs (2.05 x 500 = 1,025), including the initial changed of 500 jobs plus 525 jobs created due to indirect and induced effects of the initial change. To compute the earnings and output impacts, the initial change in the number of jobs should be transformed to changes in earnings and output. This is done by multiplying the number of jobs by earnings-to-job and output-to-job ratios. This gives the initial (direct) earnings change of $17.4 million and initial output change of $75.5 million. The total earnings effect of $30.7 million is obtained by multiplying the direct earnings effect by the direct-effect earnings multiplier for the information sector (17.4 x 1.77 = 30.7). The total output effect of $123.8 million is obtained based on the direct output effect and output multiplier. Alternatively, the total job and earnings effects can also be derived using the direct output effect and final-demand job and earnings multipliers. These results are presented in Table 6.4.

Table 6.4 Impacts of 500 New Jobs in Hawaii's Information Sector

	Direct effect	Final-demand multipliers (from Table 2.4)	Direct-effect multipliers from Table 2.4)	Total impact
Employment (no. of jobs)	500	13.6*	2.05	1,025.0
Income ($ million)	17.4	0.41	1.77	30.7
Output ($ million)	75.5	1.64	1.64	123.8

*This multiplier may be interpreted as the number of jobs per $1 million of final demand output for 1997. Note that final-demand employment multipliers will change from year to year due to worker productivity growth and inflation-driven wage changes. The base, 1997 multipliers are used in this illustration for simplicity and clarity. For actual impact estimations the current year employment multipliers should be used.

Considerations in Using I-O Models in Impact Analysis

When conducting an impact analysis using I-O models, the following considerations and cautions should be kept in mind.

1. There is no single multiplier for an entire economy. The question is often asked: What is the multiplier for Hawaii's Economy? This question makes little sense, since there are different multipliers (output, earning, employment and tax) and there are many industries. For example, Table 5.1 contains 1,572 multipliers and many more multipliers can be derived from an I-O table.

2. One potential misuse of the I-O model is to add output and earnings impacts together. Output, income and employment impacts are three different measures of impacts of the same project. When describing the size of an industry, we often use the total sales of the industry, or the number of people the industry employs, or the amount of earnings the industry generates. But we would not add any of these measures together.

3. Output in several industries is measured not in terms of their total sales (revenues), but their trade margins. These industries include retail trade and wholesale trade. Similarly, output of several other industries is measured in terms of their net operating revenues instead of total revenues, such as finance, insurance, and real estate. When calculating economic impacts of these industries, caution needs to be exercised in calculating the direct output correctly. For example, a new duty-free store may have sales of $100 million in a year. This amount includes the cost of the merchandise imported from out-of-state as well as transportation costs, and the mark-up value of the store. But in I-O analysis, only the "mark-up" value is counted as the output of the store.

4. Output of general government sectors (Federal military, Federal civilian, and state and local government) is measured in terms of their *value-added* (employee compensation plus other capital costs). "General" government refers to non-enterprise activities. It is standard practice to include general governments as industries in I-O models in order to balance the government transactions. General government expenditures are treated as final demands. Employee compensation is part of their spending. When conducting an impact analysis of a government spending, care needs to be taken in defining direct output. For example, impact analysis of an increase in state and local government spending may be conducted under three cases. (i) Spending is industry-specific or product-specific. In this case, the multipliers of the industry that produces the product should be used to calculate the impacts. (ii) Spending is not industry- or product-specific. In this case, assumptions need to be made on the spending pattern. It is usually assumed that government expenditures are spent on the various industries in the same proportion as the base-year model. After assigning the new spending to individual industries according to the share of state and local government spending in the base-year model, the multipliers of respective industries should be used to calculate the impact. (iii) Spending is an increase in payroll. In this case the multipliers of the State and Local Government sector should be used to calculate the economic impacts.

5. A change in an industry's final demand would usually result in changes in final demands of other industries. Impact analysis should be done for all the changes, and then calculate the net effect. For example, a decrease in state government spending by lowering income tax rate may, at the same time, increase personal consumption expenditures. The

appropriate economic impact of the new tax policy would be the net effect of the decrease in government spending and the increase in personal consumption expenditures.

6. The values of multipliers depend upon the restrictive behavioral assumptions underlying the I-O model. Users of I-O multipliers should be aware of these assumptions: (i) the relationships that exist between industries and final demand sectors are linear, implying fixed prices and no substitution among different inputs; (ii) the direct purchase coefficients are assumed to be fixed, reflecting the average input-output relationship in each industry as opposed to a marginal unit of production; (iii) consumption is a simple linear function of household income; and (iv) the effects of induced state and local government spending and capital investment are assumed to be zero. Therefore, for analyses that require alternative assumptions, other economic tools may be required.

7. High multipliers are not necessary "good", and low multipliers are not necessary "bad". When evaluating the relative benefits of alternative projects, it is sometimes suggested that the development with the highest multiplier be promoted. This may not be appropriate for two reasons. First, the results would depend on the types of multiplier being compared. A project with a high earnings multiplier may have a low employment multiplier or have a high energy requirement, resulting in inconsistencies when ranking projects by the magnitude of their multipliers. Second, limiting the evaluation to the size of the multipliers neglects the relative costs of the proposed developments. Such things as capital costs, public investment, and tax incentives should also be considered.

8. Impact assessments are only the estimates of economic impacts of an anticipated external change. Impact analysis is a forecasting exercise and forecasts may be wrong. Inaccurate impact estimates can occur for a number of reasons, including the misuse of multipliers, model misspecification, incorrect projections of the direct impact, and measurement errors in the base-year input-output coefficients. It is, therefore, inappropriate to calculate the income impacts of a multi-million dollar project down to the last dollar. The analyst should recognize the limitations on the tool being used.

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Appendix A. NAICS Codes for Industries in the 1997 I-O Table for Hawaii

Detailed table		NAICS industry code	Condensed table	
	Sector			Sector
1	Sugarcane	11193	1	Agriculture
2	Vegetables	1112	1	
3	Macadamia nuts	111335, 111336	1	
4	Pineapples	part of 111339	1	
5	Other fruits	11131-4, part of 111339	1	
6	Coffee	part of 111339	1	
7	Greenhouse and nursery products	1114	1	
8	Dairy cattle and milk production	11212	1	
9	Poultry and eggs	1123	1	
10	Cattle Ranching	11211, 11213	1	
11	Hog and pig farming	1122	1	
12	Misc. livestock	1124, 1129	1	
13	Aquaculture	1125, part of 111998	1	
14	Other agricultural products	113, 1111, 1119 except 11193 and part of 111998	1	
15	Commercial fishing	114	1	
16	Support activities for agriculture	115, 54194, 81291	1	
17	Landscape services	54132, 56173	1	
18	Mining	21	2	Mining and construction
19	Single family housing construction	part of 23	2	
20	Multiple family housing construction	part of 23	2	
21	Commercial building construction	part of 23	2	
22	Hotel construction	part of 23	2	
23	Road construction	part of 23	2	
24	Other construction	part of 23	2	
25	Maintenance and repair construction	part of 23	2	
26	Fruit and vegetable product manufacturing	3114	3	Food processing
27	Sugar manufacturing	31131	3	
28	Confectionery product manufacturing	3113 except 31131	3	
29	Meat product manufacturing	3116	3	
30	Dairy product manufacturing	3115	3	
31	Bakeries and grain product manufacturing	3118	3	
32	Beverage manufacturing	312	3	
33	Snack food manufacturing	31191	3	
34	Coffee and tea manufacturing	31192	3	
35	Other food product manufacturing	3111, 3112, 3117, 31193-9	3	
36	Apparel and textile manufacturing	313-315	4	Other manufacturing
37	Wood product manufacturing	321	4	
38	Furniture manufacturing	337	4	
39	Paper manufacturing	322	4	
40	Printing	323	4	
41	Chemical manufacturing	325	4	
42	Petroleum manufacturing	324	4	
43	Rubber & plastic product manufacturing	326	4	
44	Non-metallic mineral product manufacturing	327	4	
45	Metal product manufacturing	331, 332	4	
46	Electrical product manufacturing	334-335	4	

Appendix A. NAICS Codes for Industries in the 1997 I-O Table for Hawaii - Continued

Detailed table		NAICS industry code	Condensed table	
	Sector			Sector
47	Transportation equipment manufacturing	336	4	Other manufacturing
48	Misc. product manufacturing	316, 333, 339	4	
49	Truck transportation	484	5	Transportation
50	Warehousing	493	5	
51	Water transportation	483, part of 4885	5	
52	Air transportation	481, part of 4885	5	
53	Ground passenger transportation	485	5	
54	Support activities for transportation	488 except 4885	5	
55	Couriers	492	5	
56	Sightseeing transportation	487	5	
57	Publishing	511 except 5112	6	Information
58	Software & information services	5112, 514	6	
59	Motion picture and sound production	512 except 51213	6	
60	Motion picture exhibition	51213	6	
61	Radio and TV broadcasting	5131	6	
62	Cable TV	5132	6	
63	Telecommunications	5133	6	
64	Electricity	2211	7	Utilities
65	Gas production & distribution	2212	7	
66	Wholesale trade	42	8	Wholesale trade
67	Motor vehicle and parts dealers	441	9	Retail trade
68	Furniture and home furnishing stores	442	9	
69	Electronics and appliance stores	443	9	
70	Building materials & gardening equipment dealers	444	9	
71	Food stores	445	9	
72	Health and personal care stores	446	9	
73	Gas stations	447	9	
74	Apparel & accessory stores	448	9	
75	Sporting goods, hobby, book, and music stores	451	9	
76	Department stores	4521	9	
77	Other general merchandise stores	4529	9	
78	Misc. store retailers	453	9	
79	Nonstore retailers	454	9	
80	Banking and credit intermediation	522	10	Finance and insurance
81	Securities and investment activities	523, 525, 533, 55	10	
82	Insurance	524	10	
83	Owner-occupied dwellings		10	
84	Real estate	531	11	Real estate and rentals
85	Equipment rental	532 except 5321	11	
86	Automobile rental	5321	11	
87	Legal services	5411	12	Professional services
88	Accounting services	5412	12	
89	Architectural and engineering services	5413 except 54132	12	
90	Computer systems design services	5415	12	
91	Management, scientific, and consulting services	5416	12	
92	Research and development services	5417	12	

Appendix A. NAICS Codes for Industries in the 1997 I-O Table for Hawaii - Continued

Detailed table		NAICS code	Condensed table	
	Sector			Sector
93	Advertising	5418	12	Professional services
94	Photographic services	54192	12	
95	Other professional services	5414, 5419 except 54192, 3	12	
96	Administrative and facilities support services	5611, 5612	13	Business services
97	Employment services	5613	13	
98	Business support services	5614, 5619	13	
99	Travel arrangement & reservation services	5615	13	
100	Investigation & security services	5616	13	
101	Services to buildings & dwellings	5617 except 56173	13	
102	Waste management & remediation services	2213, 562	13	
103	Educational services	61	14	Educational services
104	Doctors and dentists	6211 - 6213	15	Health services
105	Nursing and residential care facilities	623	15	
106	Hospitals	622	15	
107	Other medical services	6214-9	15	
108	Social assistance	624	15	
109	Performing arts and related services	7111, 7113-5	16	Arts and entertainment
110	Amusement services	7112, 713 except 7139	16	
111	Recreation services	7139 except 71391	16	
112	Golf courses	71391	16	
113	Museums and historical sites	712	16	
114	Hotels and other lodging places	721	17	Accommodations
115	Eating and drinking places	722	18	Eating and drinking
116	Dry-cleaning and laundry services	8123	19	Other services
117	Automotive repair services	8111	19	
118	Other repair services	8112 - 8114	19	
119	Personal care services	8121	19	
120	Death care services	8122	19	
121	Parking lots and garages	81293	19	
122	Other personal services and households	8129 except 81291, 3; 814	19	
123	Organizations	813	19	
124	Other state and local gov't enterprises	part of state and local gov't	20	Government
125	State and local gov't enterprises: Water and sewer	part of state and local gov't	20	
126	State and local gov't enterprises: Transit	part of state and local gov't	20	
127	Federal gov't enterprises: Postal service	part of Federal gov't	20	
128	Other Federal gov't enterprises	part of Federal gov't	20	
129	Federal gov't: Military	part of Federal gov't	20	
130	Federal gov't: Civilian	part of Federal gov't	20	
131	State and local government	part of state and local gov't	20	

Appendix B. Mathematics of Input-Output Models

The flow of inter-industry sales in the transaction table (Table 2.1) can be expressed as a system of equations, representing the distribution of each industry's total output (sales) to industries and final demand sectors as follows:

$$X_i = \sum_{j=1}^{n} Z_{ij} + \sum_{k=1}^{m} Y_{ik} \qquad \text{(B.1)}$$

where:

$i, j =$ 1, 2, …, n industries;
$k =$ 1, 2, …, m final demand sectors;
$X_i =$ total output (sales) of the ith industry, including the total inter-industry sales (the first term in the equation) and total final sales (the second term in the equation);
$Z_{ij} =$ ith industry's inter-industry sales to the jth industry; and
$Y_{ik} =$ ith industry's final sales to the kth final demand sector.

Similarly, the flow of inter-industry purchases can be expressed as a system of another set of n equations, showing the distribution of industry j's total input (purchases) from n industries and imports, and payments to s final payments sectors as follows:

$$X_j = \sum_{i=1}^{n} Z_{ij} + M_j + \sum_{r=1}^{s} W_{rj} \qquad \text{(B.2)}$$

where:

$i, j =$ 1, 2, …, n industries;
$r =$ 1, 2, …, s final payment sectors, including imports;
$X_j =$ total input (purchases) of the jth industry, including the total inter-industry purchases (the first term in the equation) and total final payments (the second term in the equation);
$Z_{ij} =$ jth industry's inter-industry purchases from the ith industry;
$M_j =$ imports of industry j as intermediate input; and
$W_{rj} =$ jth industry's payments to the rth final payment sector.

The next step in I-O analysis is to derive the direct requirements table. Each coefficient of the direct requirements table, usually designated as a_{ij}, represents the purchase of column sector j from row sector i to produce a dollar of output in sector j. The $a_{ij}s$ are derived by dividing each column entry of the transactions table, $Z_{ij}s$ by the corresponding column total, X_j, i.e.

$$a_{ij} = Z_{ij} / X_j \qquad \text{(B.3)}$$

Using equation (B.3), the system of inter-industry equations (B.1) can be rewritten as:

$$X_i = \sum_{j=1}^{n} a_{ij} X_j + \sum_{k=1}^{m} Y_{ik} \qquad \text{(B.4)}$$

For notational convenience, let us combine the various final demand sectors to one sector ($Y = \sum_{k=1}^{s} Y_{ik}$) and rewrite the above system of equations (B.4) in a compact form using matrix algebra as follows:

$$X = AX + Y \tag{B.5}$$

where X represents the n by 1 vector of industry total outputs, A represents the n by n matrix of direct requirements coefficients (also known as the technology matrix), and Y is the n by 1 vector of total final demands.

The last expression of the inter-industry equations (B.5) can be rewritten as:

$$X(I - A) = Y \tag{B.6}$$

where I is the n by n identity matrix, which has ones on its diagonal and zeros elsewhere else. Thus, the vector of total industry outputs can be solved as:

$$X = (I - A)^{-1} Y = BY \tag{B.7}$$

where $(I - A)^{-1} = B$ is the total requirements table, or Leontief inverse matrix. B is also referred to as the final-demand output multiplier table.

If the household sector is exogenous, the Type I final-demand output multiplier for the jth sector (O_j) can be obtained by summing down the jth column of the Leontief matrix as:

$$O_j = \sum_{i=1}^{n} b_{ij} \tag{B.8}$$

where $b_{ij}s$ are the elements of the final-demand output multiplier table, representing the change in output of sector i due to a one dollar change in final demand of sector j.

The final-demand earnings multipliers are obtained using the total requirements table and direct earnings coefficients as:

$$C = L \cdot B \tag{B.9}$$

where C is the final-demand income multiplier table, L is the n by n matrix containing the ith sector's direct earnings coefficient in its ith diagonal and zeros elsewhere. The Type I final-demand earnings multiplier for sector j (I_j^{FD}) is computed as:

$$I_j^{FD} = \sum_{i=1}^{n} c_{ij} \tag{B.10}$$

The Type I direct-effect earnings multiplier for sector j (I_j^{DE}) is derived as:

$$I_j^{DE} = I_j^{FD} / l_j \tag{B.11}$$

where l_j is the direct earnings coefficient for the sector j, obtained as the ratio of earnings to total output of the jth sector.

Using the Leontief matrix and employment-to-output ratios, the final-demand employment multiplier table is computed as:

$$D = E \cdot B \tag{B.12}$$

where D is the final-demand employment multiplier table, E is the n by n matrix containing the ith sector's direct employment coefficient in its ith diagonal and zeros elsewhere. The final-demand employment multiplier for sector j (E_j^{FD}) is computed as:

$$E_j^{FD} = \sum_{i=1}^{n} d_{ij} \tag{B.13}$$

The Type I direct-effect employment multiplier for sector j (I_j^{DE}) is derived as:

$$E_j^{DE} = E_j^{FD} / e_j \tag{B.14}$$

where e_j is the employment-to-output ratio for sector j. Type II multipliers are obtained in exactly the same fashion except that the household sector is chosen to be endogenous.

Appendix C. Various Retail, Wholesale and Transportation Margins

Retail and Wholesale Margins for PCEs (as a proportion of retail prices)

Commodity	Retail	Wholesale
Groceries	.264	.090
Clothing	.420	.060
Drugs, health aids, and beauty aids	.301	.078
Soaps and detergents	.242	.148
Electrical appliances	.290	.066
Computers	.286	.077
Furniture	.425	.016
Home furnishings	.347	.037
Jewelry	.464	.024
Toys and hobbies	.329	.154
Sporting goods	.350	.123
Hardware and supplies	.409	.070
Lumber	.444	.032
Automobiles	.165	.015
Gasoline	.206	.315
Auto parts	.362	.067
All other merchandise	.331	.063
Average	.353	.076

Transportation Margins for PCEs
(as a proportion of retail prices)

Type	Margin
Truck transportation	.008
Air transportation	.003
Water transportation	.017

Wholesale Margins
(as a proportion of wholesale prices)

Commodity	Margin
Durable equipment	.251
Automotive	.225
Furniture	.320
Lumber	.222
Commercial equipment	.260
Metals and minerals	.216
Electrical equipment	.220
Hardware	.260
Machinery	.299
Misc. durable equipment	.259
Non-durable equipment	.181
Paper	.215
Drugs	.148
Apparel	.308
Groceries	.161
Chemicals	.239
Petroleum	.100
Alcohol	.243
Misc. non-durable goods	.239

Note. The wholesale margin for PCEs is the average of all PCE purchases of that type of commodity, which includes purchases made from retailers who did not purchase the goods through Hawaii wholesalers. That is why some of them are rather low. The transportation margins are estimates for all commodities.

Source: 1992 Benchmark I-O Composition of U.S. NIPA Final Demand.

All transactions in an I-O model are valued at producer's prices. In other words, only the margin on a merchandise resale is considered the output of the selling industry. Here is an example:

A grocery store sells vegetables to a household for $100. In the I-O table, the purchase would not show up as a PCE purchase of $100 from the food store retail sector. The retail markup for groceries is around 26.4% of the purchasers' price, so $26.40 of the $100 would be a household purchase from the retail food store sector. A wholesaler sells the good to the retail, and the wholesale margin is around 9% of the purchaser's price, so $9.00 would be a household purchase from the wholesale sector. Transportation costs (air, water, and truck transportation) associated with the shipping of the goods from the producer to the wholesaler and retailer account for about 2.8% of the purchasers' cost, so $2.80 would be a household purchase from the three transportation sectors. The remaining $61.60 is the producer value, the value that the vegetable producer received

when he/she sold the product. Thus, there is also a household purchase from the vegetable producing sector of $61.60, assuming all of the vegetables are produced locally and not imported.

Typical margins are listed above in this Appendix. One needs to be aware that not all retail goods are purchased from wholesalers in Hawaii. Some are purchased directly from the manufacturer, and others are purchased from mainland wholesalers.

Appendix D. Mathematics of the Modified RAS Procedure

Using equation (B.1), theoretically total intermediate sales of sector *i* (U_i) is calculated as:

$$U_i = \sum_{j=1}^{i} Z_{ij} = X_i - Y_i \qquad \text{(D.1)}$$

and total inter-industry input (including intermediate import (M_j)) for sector *j* (V_j) is calculated from equation (B.2) as:

$$V_j = \sum_{i=1}^{n} Z_{ij} + M_j = X_j - W_j \qquad \text{(D.2)}$$

where X_i is total sales or output for industry *i*, X_j is total purchases or input for industry *j*, Y_i is total final demand for industry *i*, W_j is total final payments of industry *j*, Z_{ij} is industry *i's* (*j's*) inter-industry sales (purchases) to (from) the industry j (i), and M_j is imports of industry *j* as intermediate input. Note that $X_i = X_j$ for $i = j$.

The import row for intermediate use is represented as follows:

$$\sum_{j=1}^{n} M_j = M \qquad \text{(D.3)}$$

where M is the control total for intermediate imports computed based on relations between the value added and expenditure sides of the GSP account (i.e. total final demand less total value added gives total imports for intermediate use).

Although true theoretically, the last three equations (equations D.1 – D.3) do not hold in practice. Thus, $Z_{ij}s$ and M_js need to be adjusted until each of the three equations is satisfied simultaneously.

Let

$$U_i^0 = \sum_{j=1}^{n} Z_{ij}^0,\ r_i^0 = \frac{U_i^0}{U_i},\ \ M^0 = \sum_{j=1}^{n} M_j^0, \text{ and } r_m^0 = \frac{M^0}{M} \qquad \text{(D.4)}$$

where $Z_{ij}^0 s$ and $M_j^0 s$ are the elements from the pre-balanced inter-industry matrix. Then we get

$$U_i = \sum_{j=1}^{n} Z_{ij}^0 \cdot r_i^0 \text{ and } M = \sum_{j=1}^{n} M_j^0 \cdot r_m^0 \qquad \text{(D.5)}$$

This balances the rows but the columns are still unbalanced. To balance the columns, let

$$V_j^1 = \sum_{i=1}^{n} Z_{ij}^1 + M_j^1 \text{ and } q_j^1 = \frac{V_j^1}{V_j} \tag{D.6}$$

where $Z_{ij}^1 s$ and M_j^1 are the elements from the row-balanced inter-industry matrix. Then, we have

$$V_j = \sum_{i=1}^{n} Z_{ij}^1 \cdot q_j^1 + M_j^1 \cdot q_j^1 \tag{D.7}$$

Now the columns are balanced, but the rows are no longer in balance. The above procedures must be repeated iteratively until a set threshold of minimum deviation between the column and row control totals is reached. The balancing procedure was implemented using specifically designed macros in Microsoft Excel.