THE HAWAII STATE INPUT-OUTPUT STUDY: 2012 BENCHMARK REPORT

Research and Economic Analysis Division
Department of Business, Economic Development, and Tourism
STATE OF HAWAII

August 2016

TABLE OF CONTENTS

LIST OF APPENDIXES

LIST OF FIGURES AND TABLES

PREFACE

This report is the tenth in a series of benchmark input-output (I-O) studies of Hawaii's economy prepared by the Department of Business, Economic Development & Tourism (DBEDT). It succeeds benchmark studies conducted for 1967, 1972, 1977, 1982, 1987, 1992, 1997, 2002, and 2007. 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 prepared at the Research and Economic Analysis Division (READ) of DBEDT by Dr. Binsheng Li, under the supervision of Dr. Eugene Tian, Division Head.

I. INTRODUCTION

This report presents the 2012 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 assessing 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 industry aggregation. One is composed of 68 industry sectors, while the other one is more condensed, containing 20 sectors. A list of sectors included in the 2012 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 68 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 2012 I-O table mainly updated the 2007 table by including the latest data on the various aspects of Hawaii's economy.

The remainder of this report is organized as follows. Section 2 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 2012 Hawaii I-O table. Section 3 provides a description of industries, data sources, and estimation procedures. Section 4 describes the estimation of the inter-industry matrix and its balancing procedure. Section 5 presents the multipliers derived from the 2012 detailed I-O table for Hawaii. Section 6 shows 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 as "row" sectors. Similarly, the purchasing or buying sectors are shown in columns and hence they are called as "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

	Industries	**Final Demand Sectors**	**Total**
Industries	**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 the condensed version of the 2012 Hawaii I-O table. Mathematical details of the I-O model and related procedures are presented in Appendix B.

Illustration

Transactions Table

For illustrative purposes, a condensed version of the 2012 Hawaii State I-O transactions table is shown in Table 2.1. The condensed table has 20 industry sectors, seven final demand sectors, and five final payment sectors. Table 2.1 summarizes transactions (sales and purchases) among the various aggregated sectors of Hawaii's economy in 2012. Except for the job data, 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, Table 2.1 also shows wage and salary jobs, proprietor's jobs, and total jobs by industry, which are used at a later stage to calculate wage and salary job and total job multipliers. Total job 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. In addition, Table 2.1 also shows earnings and state taxes by industry, which are used at a later stage to calculate earnings and state tax multipliers.

Table 2.1. 2012 Condensed Input-Output Transactions Table for Hawaii (in $million)

Industry	Agriculture	Mining and Construction	Food processing	Other manufacturing	Transportation
1 Agriculture	77.6	8.5	172.5	24.0	0.1
2 Mining and construction	15.5	12.4	10.0	11.0	56.8
3 Food processing	5.9	0.0	62.5	33.2	2.4
4 Other manufacturing	82.7	442.9	85.3	426.9	507.1
5 Transportation	20.4	102.2	16.4	92.9	243.7
6 Information	1.3	20.8	4.3	28.4	25.6
7 Utilities	17.8	100.5	30.9	132.7	32.6
8 Wholesale trade	43.8	373.6	82.6	228.6	85.9
9 Retail trade	11.7	395.2	21.6	77.9	7.1
10 Finance and insurance	12.1	65.5	3.7	42.2	37.5
11 Real estate and rentals	47.2	226.9	27.7	98.1	89.8
12 Professional services	3.8	492.7	14.0	62.1	64.5
13 Business services	7.4	108.5	105.8	189.5	253.4
14 Educational services	0.0	1.0	0.4	12.5	13.7
15 Health services	0.0	0.0	0.0	0.0	0.9
16 Arts and entertainment	0.2	2.1	1.2	2.7	0.6
17 Accommodation	1.6	26.7	17.3	41.6	7.8
18 Eating and drinking	1.1	42.1	23.9	44.3	48.8
19 Other services	5.2	34.4	14.4	55.2	32.3
20 Government	11.0	19.9	15.7	91.1	453.7
Total intermediate input	366.4	2,475.9	710.1	1,694.9	1,964.4
Imports	151.8	1,176.8	329.1	5,995.7	648.1
Labor income	305.6	3,098.5	249.8	560.4	1,613.0
Compensation of employees	327.0	2,413.0	243.5	499.5	1,508.0
Proprietor's income	-21.4	685.5	6.3	60.9	105.0
TOPILS	-9.0	75.0	15.2	28.8	508.0
Other capital costs	127.4	828.5	56.6	484.1	958.0
Total Value added	424.0	4,002.0	321.7	1,073.3	3,079.0
Output	942.2	7,654.7	1,361.0	8,763.9	5,691.5
Wage and salary jobs	7,572	30,364	6,070	7,278	25,107
Proprietors' jobs	8,237	11,138	657	3,456	4,276
Total jobs	15,809	41,502	6,727	10,734	29,383
Earnings	269.8	2,770.5	193.8	438.9	1,293.4
State total taxes	25.5	554.2	26.0	91.0	222.1
State individual income tax	7.9	113.0	8.9	21.8	59.3
State GET	10.7	380.2	8.5	19.3	95.8
State TAT	0.0	0.0	0.0	0.0	0.0
State other taxes	6.9	61.1	8.6	49.9	66.9

Note. TOPILS = Taxes on Production and Imports less Subsidies.

Table 2.1. 2012 Condensed Input-Output Transactions Table for Hawaii (in $million) - Continued

Industry	Information	Utilities	Wholesale trade	Retail trade	Finance and insurance	Real estate and rentals
1 Agriculture	0.0	0.0	0.5	0.2	0.0	8.3
2 Mining and construction	7.5	65.5	21.3	30.6	34.9	302.3
3 Food processing	0.8	0.0	2.3	0.6	0.0	0.0
4 Other manufacturing	12.5	1,484.2	162.6	122.7	45.8	97.4
5 Transportation	27.9	9.7	34.0	24.8	36.1	27.0
6 Information	138.9	2.2	117.9	58.4	145.4	42.5
7 Utilities	14.4	85.0	62.8	124.2	34.2	74.2
8 Wholesale trade	34.0	12.3	197.9	28.3	10.9	25.0
9 Retail trade	30.6	5.9	81.5	85.9	8.8	78.1
10 Finance and insurance	27.9	11.7	79.9	78.6	891.1	265.4
11 Real estate and rentals	81.0	10.9	294.6	781.0	359.8	603.8
12 Professional services	61.4	28.2	129.5	95.8	241.8	120.3
13 Business services	58.1	22.0	327.1	194.7	228.4	170.4
14 Educational services	10.9	17.0	10.8	8.1	20.1	0.9
15 Health services	0.0	0.0	0.0	0.0	0.0	0.0
16 Arts and entertainment	2.8	0.1	0.0	0.0	0.0	0.0
17 Accommodation	19.0	6.6	68.4	43.8	99.6	43.5
18 Eating and drinking	22.8	8.3	60.8	36.5	93.6	15.0
19 Other services	22.2	1.3	65.9	34.2	82.8	595.1
20 Government	23.6	15.2	80.1	178.1	130.9	71.2
Total intermediate input	596.2	1,786.3	1,797.9	1,926.5	2,464.4	2,540.3
Imports	360.0	212.4	856.4	695.3	537.9	246.9
Labor income	684.7	488.1	1,202.9	2,673.5	1,376.3	1,758.3
Compensation of employees	666.0	451.0	1,131.0	2,421.0	1,265.0	632.0
Proprietor's income	18.7	37.1	71.9	252.5	111.3	1,126.3
TOPILS	90.0	305.0	592.0	1,715.0	243.0	1,263.0
Other capital costs	780.3	813.9	510.1	691.5	624.7	11,354.7
Total Value added	1,555.0	1,607.0	2,305.0	5,080.0	2,244.0	14,376.0
Output	2,511.3	3,605.7	4,959.3	7,701.8	5,246.3	17,163.2
Wage and salary jobs	8,459	3,567	17,745	69,456	16,035	11,794
Proprietors' jobs	1,857	262	3,820	16,919	13,373	34,881
Total jobs	10,316	3,829	21,565	86,375	29,408	46,675
Earnings	543.8	378.1	1,035.6	2,336.6	1,182.4	1,675.6
State total taxes	140.5	142.0	94.3	536.7	236.7	668.0
State individual income tax	26.5	16.5	45.8	93.9	54.0	63.1
State GET	64.3	0.0	21.3	383.7	5.0	467.6
State TAT	0.0	0.0	0.0	0.0	0.0	0.0
State other taxes	49.7	125.5	27.3	59.2	177.8	137.3

Note. TOPILS = Taxes on Production and Imports less Subsidies.

Table 2.1. 2012 Condensed Input-Output Transactions Table for Hawaii (in $million) - Continued

	Industry	Professional services	Business services	Educational services	Health services	Arts and entertainment
1	Agriculture	0.5	0.8	0.0	4.6	0.8
2	Mining and construction	14.7	16.4	40.9	39.7	8.4
3	Food processing	1.3	0.0	0.0	41.7	0.6
4	Other manufacturing	62.9	79.7	17.0	132.1	8.8
5	Transportation	98.8	38.3	9.3	88.0	10.1
6	Information	78.7	54.0	17.5	77.4	10.6
7	Utilities	33.0	48.5	12.0	185.6	33.2
8	Wholesale trade	46.2	35.7	7.6	143.5	8.0
9	Retail trade	74.8	61.6	1.2	59.4	1.7
10	Finance and insurance	37.6	30.8	4.2	58.4	6.4
11	Real estate and rentals	392.1	161.3	103.1	654.4	55.8
12	Professional services	266.3	179.1	16.5	242.7	28.9
13	Business services	80.8	140.7	31.9	457.7	25.8
14	Educational services	14.3	5.1	9.2	28.1	6.4
15	Health services	0.5	0.1	1.1	102.6	0.4
16	Arts and entertainment	0.0	0.0	0.3	0.3	18.2
17	Accommodation	85.8	22.0	4.5	97.0	3.3
18	Eating and drinking	36.4	23.0	17.0	116.3	15.4
19	Other services	42.4	33.8	4.2	42.1	13.4
20	Government	41.6	75.1	5.5	166.9	39.7
	Total intermediate input	1,408.6	1,005.7	302.9	2,738.7	295.8
	Imports	312.2	163.1	36.3	883.0	67.5
	Labor income	2,605.4	2,686.1	718.3	4,144.3	441.4
	Compensation of employees	1,975.0	2,535.0	691.0	3,714.0	386.0
	Proprietor's income	630.4	151.1	27.3	430.3	55.4
	TOPILS	157.0	114.0	56.0	212.0	81.0
	Other capital costs	322.6	521.9	23.7	207.7	140.6
	Total Value added	3,085.0	3,322.0	798.0	4,564.0	663.0
	Output	4,805.8	4,490.9	1,137.2	8,185.7	1,026.4
	Wage and salary jobs	24,603	53,057	16,284	62,827	11,451
	Proprietors' jobs	20,056	13,303	3,476	11,257	10,231
	Total jobs	44,659	66,360	19,760	74,084	21,682
	Earnings	2,344.1	2,301.9	613.5	3,615.1	388.8
	State total taxes	386.1	373.4	95.9	612.9	70.8
	State individual income tax	101.7	101.7	28.8	157.7	13.7
	State GET	240.6	226.3	55.3	380.2	49.2
	State TAT	0.0	0.0	0.0	0.0	0.0
	State other taxes	43.8	45.4	11.8	75.0	8.0

Note. TOPILS = Taxes on Production and Imports less Subsidies.

Table 2.1. 2012 Condensed Input-Output Transactions Table for Hawaii (in $million) - Continued

	Industry	Accommodation	Eating and drinking	Other services	Government	Total Interindustry demand
1	Agriculture	0.1	50.6	1.4	1.3	351.8
2	Mining and construction	226.4	94.2	34.8	147.3	1,190.4
3	Food processing	4.4	244.2	3.9	3.0	407.0
4	Other manufacturing	54.0	125.5	107.3	134.2	4,191.6
5	Transportation	79.5	52.6	47.9	54.7	1,114.6
6	Information	72.7	31.2	52.9	39.5	1,020.4
7	Utilities	355.2	143.8	184.8	172.4	1,877.7
8	Wholesale trade	103.9	202.5	51.2	81.7	1,803.0
9	Retail trade	25.8	22.6	46.1	0.2	1,098.0
10	Finance and insurance	153.1	41.1	27.6	16.5	1,891.3
11	Real estate and rentals	294.4	274.8	368.1	91.1	5,015.8
12	Professional services	178.9	109.4	138.3	139.1	2,613.3
13	Business services	567.5	110.5	201.1	131.3	3,412.5
14	Educational services	2.5	1.1	11.3	22.1	195.2
15	Health services	0.0	0.0	1.7	6.8	114.1
16	Arts and entertainment	3.3	6.6	1.1	0.1	39.5
17	Accommodation	50.7	32.9	32.0	53.1	757.3
18	Eating and drinking	67.2	55.0	14.1	44.3	785.8
19	Other services	82.3	31.4	23.7	52.4	1,268.8
20	Government	192.2	61.9	44.7	95.1	1,813.3
	Total intermediate input	2,514.1	1,692.0	1,394.1	1,286.1	30,961.3
	Imports	440.5	638.8	377.8	974.7	15,104.6
	Labor income	2,130.6	1,601.0	1,688.6	14,235.0	44,261.8
	Compensation of employees	2,092.0	1,479.0	1,197.0	14,235.0	39,861.0
	Proprietor's income	38.6	122.0	491.6	0.0	4,400.8
	TOPILS	776.0	114.0	73.0	-90.0	6,319.0
	Other capital costs	837.4	271.0	-114.6	2,286.0	21,726.2
	Total Value added	3,744.0	1,986.0	1,647.0	16,431.0	72,307.0
	Output	6,698.6	4,316.8	3,418.9	18,691.7	118,372.9
	Wage and salary jobs	37,633	58,846	30,021	183,078	681,247
	Proprietors' jobs	1,031	3,041	15,771	0	177,042
	Total jobs	38,664	61,887	45,792	183,078	858,289
	Earnings	1,959.5	1,446.9	1,551.8	10,515.7	36,855.7
	State total taxes	779.0	304.7	168.5	769.6	6,298.05
	State individual income tax	61.8	55.6	61.1	558.5	1,651.21
	State GET	325.2	214.7	78.4	0.0	3,026.32
	State TAT	343.8	0.0	0.0	0.0	343.80
	State other taxes	48.2	34.3	28.9	211.1	1,276.71

Note. TOPILS = Taxes on Production and Imports less Subsidies.

Table 2.1. 2012 Condensed Input-Output Transactions Table for Hawaii (in $million) - Continued

Industry	PCE	Visitor expenditures	Gross private investment*	State and local government
1 Agriculture	332.7	22.0	0.0	2.0
2 Mining and construction	0.0	0.0	4,388.3	1,457.0
3 Food processing	374.3	54.9	0.8	7.6
4 Other manufacturing	2,574.6	53.2	181.4	49.5
5 Transportation	1,155.0	2,899.8	120.7	56.4
6 Information	1,201.2	18.2	0.0	23.0
7 Utilities	1,556.5	0.0	0.0	141.5
8 Wholesale trade	2,457.5	105.5	385.2	60.1
9 Retail trade	4,082.4	2,023.1	415.4	45.8
10 Finance and insurance	2,395.3	0.0	0.0	19.8
11 Real estate and rentals	10,275.5	1,408.7	42.1	80.2
12 Professional services	867.5	120.8	542.2	14.4
13 Business services	499.2	313.8	0.0	0.0
14 Educational services	801.3	137.4	0.0	0.0
15 Health services	7,895.5	145.4	0.0	0.0
16 Arts and entertainment	442.9	510.7	0.0	0.0
17 Accommodation	476.6	5,454.9	0.0	6.9
18 Eating and drinking	1,948.3	1,565.6	0.0	0.0
19 Other services	1,928.6	128.5	0.0	84.2
20 Government	1,780.6	81.7	0.0	6,278.5
Total Hawaii produced	43,045.4	15,044.0	6,076.1	8,326.9
Imports	8,399.3	1,065.2	5,017.9	329.5
Total	51,444.7	16,109.2	11,094.1	8,656.4

Table 2.1. 2012 Condensed Input-Output Transactions Table for Hawaii (in $million) - Continued

Industry	Federal government: military	Federal government: civilian	Exports	Total Output
1 Agriculture	1.0	0.3	232.4	942.2
2 Mining and construction	530.2	8.1	80.7	7,654.7
3 Food processing	43.3	0.0	473.0	1,361.0
4 Other manufacturing	540.9	3.7	1,169.0	8,763.9
5 Transportation	10.3	3.3	331.4	5,691.5
6 Information	21.7	1.8	225.0	2,511.3
7 Utilities	19.1	10.9	0.0	3,605.7
8 Wholesale trade	8.4	3.5	136.0	4,959.3
9 Retail trade	4.2	0.5	32.3	7,701.8
10 Finance and insurance	0.0	10.7	929.2	5,246.3
11 Real estate and rentals	1.9	0.2	338.8	17,163.2
12 Professional services	187.9	37.5	422.2	4,805.8
13 Business services	156.3	11.7	97.4	4,490.9
14 Educational services	3.0	0.3	0.0	1,137.2
15 Health services	20.6	10.1	0.0	8,185.7
16 Arts and entertainment	1.3	0.0	32.1	1,026.4
17 Accommodation	2.3	0.6	0.0	6,698.6
18 Eating and drinking	5.2	0.4	11.6	4,316.8
19 Other services	7.7	1.2	0.0	3,418.9
20 Government	7,883.9	853.7	0.0	18,691.7
Total Hawaii produced	9,449.3	958.6	4,511.3	118,372.9
Imports	343.5	29.1	773.1	31,062.3
Total	9,792.8	987.7	5,284.3	

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 2012, total output for agriculture amounted to $942.2 million. Of total agricultural sales, total inter-industry sales to agriculture itself and other industries amounted to $351.8 million. Food processing accounted for the largest share ($172.5 million or 49%) of total inter-industry sales of agriculture. Agricultural sales to final demand sectors totaled $590.5 million, including $332.7 million to Hawaii residents and $257.7 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 2012, total agriculture's purchases included $366.4 million from Hawaii's industries (including $77.6 million from agriculture itself and $288.8 million from other industries), $305.6 million as payments to households (i.e. compensation of employees plus proprietors' income), $118.4 million as other value added (taxes on production and imports less subsidies plus other capital costs), and $151.8 million worth of imported inputs. In 2012, there were 7,572 wage and salary jobs and 8,237 self-employed jobs in Hawaii's agricultural sector. Total earnings and state taxes generated from Hawaii's agricultural sector were $269.8 million and $27.0 million, respectively, in 2012.

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.

The direct requirements table for 20 producing sectors is presented in Table 2.2. 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 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 38.9 cents worth of inputs from Hawaii's industries, including 8.2 cents worth of inputs from agriculture itself, about 8.8 cents worth of inputs from other manufacturing, about 5.0 cents worth of inputs from real estate and rentals, and about 4.7 cents worth of inputs from wholesale services. Value added, and imported commodities accounted for remaining 61.1 cents.

Table 2.2. 2012 Condensed Direct Requirements Table for Hawaii

	Industry	Agriculture	Mining and Construction	Food processing	Other manufacturing	Transportation
1	Agriculture	0.0823	0.0011	0.1268	0.0027	0.0000
2	Mining and construction	0.0164	0.0016	0.0073	0.0013	0.0100
3	Food processing	0.0063	0.0000	0.0459	0.0038	0.0004
4	Other manufacturing	0.0878	0.0579	0.0627	0.0487	0.0891
5	Transportation	0.0216	0.0134	0.0121	0.0106	0.0428
6	Information	0.0014	0.0027	0.0031	0.0032	0.0045
7	Utilities	0.0189	0.0131	0.0227	0.0151	0.0057
8	Wholesale trade	0.0465	0.0488	0.0607	0.0261	0.0151
9	Retail trade	0.0125	0.0516	0.0159	0.0089	0.0012
10	Finance and insurance	0.0129	0.0086	0.0027	0.0048	0.0066
11	Real estate and rentals	0.0501	0.0296	0.0203	0.0112	0.0158
12	Professional services	0.0040	0.0644	0.0103	0.0071	0.0113
13	Business services	0.0079	0.0142	0.0777	0.0216	0.0445
14	Educational services	0.0000	0.0001	0.0003	0.0014	0.0024
15	Health services	0.0000	0.0000	0.0000	0.0000	0.0002
16	Arts and entertainment	0.0002	0.0003	0.0009	0.0003	0.0001
17	Accommodation	0.0017	0.0035	0.0127	0.0047	0.0014
18	Eating and drinking	0.0011	0.0055	0.0175	0.0051	0.0086
19	Other services	0.0055	0.0045	0.0106	0.0063	0.0057
20	Government	0.0117	0.0026	0.0115	0.0104	0.0797
	Total intermediate input	0.3888	0.3234	0.5218	0.1934	0.3451
	Imports	0.1612	0.1537	0.2418	0.6841	0.1139
	Value added	0.4500	0.5228	0.2364	0.1225	0.5410
	Total	1.0000	1.0000	1.0000	1.0000	1.0000

	Industry	Information	Utilities	Wholesale trade	Retail trade	Finance and insurance
1	Agriculture	0.0000	0.0000	0.0001	0.0000	0.0000
2	Mining and construction	0.0030	0.0182	0.0043	0.0040	0.0067
3	Food processing	0.0003	0.0000	0.0005	0.0001	0.0000
4	Other manufacturing	0.0050	0.4116	0.0328	0.0159	0.0087
5	Transportation	0.0111	0.0027	0.0069	0.0032	0.0069
6	Information	0.0553	0.0006	0.0238	0.0076	0.0277
7	Utilities	0.0057	0.0236	0.0127	0.0161	0.0065
8	Wholesale trade	0.0135	0.0034	0.0399	0.0037	0.0021
9	Retail trade	0.0122	0.0016	0.0164	0.0112	0.0017
10	Finance and insurance	0.0111	0.0032	0.0161	0.0102	0.1699
11	Real estate and rentals	0.0323	0.0030	0.0594	0.1014	0.0686
12	Professional services	0.0244	0.0078	0.0261	0.0124	0.0461
13	Business services	0.0231	0.0061	0.0660	0.0253	0.0435
14	Educational services	0.0043	0.0047	0.0022	0.0010	0.0038
15	Health services	0.0000	0.0000	0.0000	0.0000	0.0000
16	Arts and entertainment	0.0011	0.0000	0.0000	0.0000	0.0000
17	Accommodation	0.0076	0.0018	0.0138	0.0057	0.0190
18	Eating and drinking	0.0091	0.0023	0.0123	0.0047	0.0178
19	Other services	0.0089	0.0004	0.0133	0.0044	0.0158
20	Government	0.0094	0.0042	0.0161	0.0231	0.0249
	Total intermediate input	0.2374	0.4954	0.3625	0.2501	0.4697
	Imports	0.1434	0.0589	0.1727	0.0903	0.1025
	Value added	0.6192	0.4457	0.4648	0.6596	0.4277
	Total	1.0000	1.0000	1.0000	1.0000	1.0000

Table 2.2. 2012 Condensed Direct Requirements Table for Hawaii - Continued

	Industry	Real estate and rentals	Professional services	Business services	Educational services	Health services
1	Agriculture	0.0005	0.0001	0.0002	0.0000	0.0006
2	Mining and construction	0.0176	0.0031	0.0036	0.0359	0.0048
3	Food processing	0.0000	0.0003	0.0000	0.0000	0.0051
4	Other manufacturing	0.0057	0.0131	0.0177	0.0149	0.0161
5	Transportation	0.0016	0.0206	0.0085	0.0082	0.0108
6	Information	0.0025	0.0164	0.0120	0.0154	0.0095
7	Utilities	0.0043	0.0069	0.0108	0.0106	0.0227
8	Wholesale trade	0.0015	0.0096	0.0079	0.0066	0.0175
9	Retail trade	0.0046	0.0156	0.0137	0.0011	0.0073
10	Finance and insurance	0.0155	0.0078	0.0069	0.0037	0.0071
11	Real estate and rentals	0.0352	0.0816	0.0359	0.0907	0.0799
12	Professional services	0.0070	0.0554	0.0399	0.0145	0.0296
13	Business services	0.0099	0.0168	0.0313	0.0280	0.0559
14	Educational services	0.0001	0.0030	0.0011	0.0080	0.0034
15	Health services	0.0000	0.0001	0.0000	0.0010	0.0125
16	Arts and entertainment	0.0000	0.0000	0.0000	0.0002	0.0000
17	Accommodation	0.0025	0.0179	0.0049	0.0039	0.0118
18	Eating and drinking	0.0009	0.0076	0.0051	0.0150	0.0142
19	Other services	0.0347	0.0088	0.0075	0.0037	0.0051
20	Government	0.0041	0.0087	0.0167	0.0049	0.0204
	Total intermediate input	0.1480	0.2931	0.2239	0.2663	0.3346
	Imports	0.0144	0.0650	0.0363	0.0319	0.1079
	Value added	0.8376	0.6419	0.7397	0.7017	0.5576
	Total	1.0000	1.0000	1.0000	1.0000	1.0000

	Industry	Arts and entertainment	Accommodation	Eating and drinking	Other services	Government
1	Agriculture	0.0007	0.0000	0.0117	0.0004	0.0001
2	Mining and construction	0.0082	0.0338	0.0218	0.0102	0.0079
3	Food processing	0.0005	0.0007	0.0566	0.0012	0.0002
4	Other manufacturing	0.0086	0.0081	0.0291	0.0314	0.0072
5	Transportation	0.0099	0.0119	0.0122	0.0140	0.0029
6	Information	0.0103	0.0109	0.0072	0.0155	0.0021
7	Utilities	0.0323	0.0530	0.0333	0.0541	0.0092
8	Wholesale trade	0.0078	0.0155	0.0469	0.0150	0.0044
9	Retail trade	0.0017	0.0039	0.0052	0.0135	0.0000
10	Finance and insurance	0.0062	0.0229	0.0095	0.0081	0.0009
11	Real estate and rentals	0.0544	0.0439	0.0637	0.1077	0.0049
12	Professional services	0.0282	0.0267	0.0254	0.0405	0.0074
13	Business services	0.0251	0.0847	0.0256	0.0588	0.0070
14	Educational services	0.0062	0.0004	0.0002	0.0033	0.0012
15	Health services	0.0004	0.0000	0.0000	0.0005	0.0004
16	Arts and entertainment	0.0177	0.0005	0.0015	0.0003	0.0000
17	Accommodation	0.0032	0.0076	0.0076	0.0094	0.0028
18	Eating and drinking	0.0150	0.0100	0.0128	0.0041	0.0024
19	Other services	0.0130	0.0123	0.0073	0.0069	0.0028
20	Government	0.0387	0.0287	0.0143	0.0131	0.0051
	Total intermediate input	0.2882	0.3753	0.3919	0.4078	0.0688
	Imports	0.0658	0.0658	0.1480	0.1105	0.0521
	Value added	0.6460	0.5589	0.4601	0.4817	0.8791
	Total	1.0000	1.0000	1.0000	1.0000	1.0000

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 13 cents worth of agricultural commodities to produce every $1 of food processing output. Agriculture has to purchase inputs from various suppliers to produce 13 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 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 $1.55, of which $1.09 (including initial $1 increase) comes from agriculture itself and the remaining 36 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 an additional endogenous sector, 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.

Table 2.3. 2012 Condensed Total Requirements Table (Type I) for Hawaii

	Industry	Agriculture	Mining and construction	Food processing	Other manufacturing	Transportation
1	Agriculture	1.0913	0.0017	0.1459	0.0039	0.0008
2	Mining and construction	0.0213	1.0048	0.0145	0.0033	0.0131
3	Food processing	0.0080	0.0009	1.0510	0.0047	0.0016
4	Other manufacturing	0.1211	0.0769	0.1083	1.0646	0.1080
5	Transportation	0.0281	0.0181	0.0213	0.0134	1.0481
6	Information	0.0056	0.0077	0.0094	0.0059	0.0080
7	Utilities	0.0268	0.0190	0.0353	0.0193	0.0114
8	Wholesale trade	0.0594	0.0558	0.0808	0.0311	0.0223
9	Retail trade	0.0183	0.0563	0.0245	0.0114	0.0049
10	Finance and insurance	0.0216	0.0152	0.0118	0.0084	0.0114
11	Real estate and rentals	0.0706	0.0524	0.0509	0.0211	0.0284
12	Professional services	0.0131	0.0751	0.0245	0.0125	0.0200
13	Business services	0.0220	0.0270	0.1006	0.0298	0.0559
14	Educational services	0.0008	0.0010	0.0013	0.0019	0.0032
15	Health services	0.0000	0.0000	0.0000	0.0000	0.0002
16	Arts and entertainment	0.0003	0.0003	0.0010	0.0004	0.0002
17	Accommodation	0.0049	0.0072	0.0174	0.0065	0.0038
18	Eating and drinking	0.0042	0.0084	0.0222	0.0068	0.0112
19	Other services	0.0113	0.0094	0.0176	0.0088	0.0093
20	Government	0.0197	0.0095	0.0224	0.0145	0.0877
	Type I output multipliers	1.55	1.45	1.76	1.27	1.45

	Industry	Information	Utilities	Wholesale trade	Retail trade	Finance and insurance
1	Agriculture	0.0004	0.0018	0.0008	0.0004	0.0007
2	Mining and construction	0.0059	0.0208	0.0087	0.0076	0.0131
3	Food processing	0.0012	0.0022	0.0017	0.0006	0.0016
4	Other manufacturing	0.0151	0.4518	0.0511	0.0295	0.0253
5	Transportation	0.0145	0.0094	0.0114	0.0055	0.0132
6	Information	1.0614	0.0040	0.0302	0.0104	0.0393
7	Utilities	0.0099	1.0334	0.0196	0.0200	0.0150
8	Wholesale trade	0.0178	0.0184	1.0470	0.0068	0.0085
9	Retail trade	0.0154	0.0081	0.0213	1.0137	0.0067
10	Finance and insurance	0.0171	0.0084	0.0250	0.0161	1.2103
11	Real estate and rentals	0.0473	0.0161	0.0813	0.1141	0.1041
12	Professional services	0.0328	0.0164	0.0385	0.0188	0.0682
13	Business services	0.0323	0.0211	0.0806	0.0322	0.0648
14	Educational services	0.0051	0.0058	0.0031	0.0015	0.0054
15	Health services	0.0000	0.0000	0.0000	0.0000	0.0000
16	Arts and entertainment	0.0012	0.0002	0.0001	0.0000	0.0001
17	Accommodation	0.0100	0.0053	0.0174	0.0075	0.0262
18	Eating and drinking	0.0114	0.0059	0.0155	0.0063	0.0243
19	Other services	0.0127	0.0049	0.0194	0.0099	0.0254
20	Government	0.0142	0.0116	0.0230	0.0267	0.0360
	Type I output multipliers	1.33	1.65	1.50	1.33	1.69

Table 2.3. 2012 Condensed Total Requirements Table (Type I) for Hawaii - Continued

	Industry	Real estate and rentals	Professional services	Business services	Educational services	Health services
1	Agriculture	0.0007	0.0005	0.0005	0.0006	0.0020
2	Mining and construction	0.0196	0.0073	0.0062	0.0397	0.0095
3	Food processing	0.0002	0.0011	0.0006	0.0012	0.0066
4	Other manufacturing	0.0138	0.0261	0.0300	0.0292	0.0372
5	Transportation	0.0035	0.0249	0.0117	0.0114	0.0149
6	Information	0.0048	0.0209	0.0155	0.0189	0.0139
7	Utilities	0.0082	0.0121	0.0147	0.0150	0.0289
8	Wholesale trade	0.0043	0.0142	0.0116	0.0123	0.0236
9	Retail trade	0.0071	0.0192	0.0167	0.0055	0.0114
10	Finance and insurance	0.0208	0.0143	0.0114	0.0087	0.0136
11	Real estate and rentals	1.0463	0.1004	0.0496	0.1051	0.0988
12	Professional services	0.0132	1.0652	0.0477	0.0234	0.0403
13	Business services	0.0161	0.0273	1.0389	0.0361	0.0681
14	Educational services	0.0004	0.0037	0.0017	1.0086	0.0042
15	Health services	0.0000	0.0001	0.0000	0.0010	1.0127
16	Arts and entertainment	0.0000	0.0001	0.0000	0.0003	0.0001
17	Accommodation	0.0041	0.0208	0.0072	0.0060	0.0149
18	Eating and drinking	0.0021	0.0099	0.0069	0.0169	0.0169
19	Other services	0.0375	0.0146	0.0111	0.0090	0.0111
20	Government	0.0067	0.0147	0.0209	0.0089	0.0265
	Type I output multipliers	1.21	1.40	1.30	1.36	1.46

	Industry	Arts and entertainment	Accommodation	Eating and drinking	Other services	Government
1	Agriculture	0.0015	0.0007	0.0217	0.0011	0.0002
2	Mining and construction	0.0122	0.0384	0.0271	0.0157	0.0087
3	Food processing	0.0018	0.0017	0.0608	0.0020	0.0004
4	Other manufacturing	0.0319	0.0442	0.0636	0.0677	0.0141
5	Transportation	0.0135	0.0168	0.0179	0.0190	0.0040
6	Information	0.0140	0.0162	0.0124	0.0207	0.0030
7	Utilities	0.0382	0.0605	0.0420	0.0613	0.0107
8	Wholesale trade	0.0128	0.0229	0.0598	0.0215	0.0061
9	Retail trade	0.0049	0.0097	0.0117	0.0186	0.0012
10	Finance and insurance	0.0113	0.0324	0.0174	0.0157	0.0020
11	Real estate and rentals	0.0698	0.0639	0.0853	0.1289	0.0085
12	Professional services	0.0371	0.0411	0.0376	0.0527	0.0100
13	Business services	0.0341	0.0980	0.0439	0.0717	0.0096
14	Educational services	0.0070	0.0014	0.0011	0.0043	0.0014
15	Health services	0.0004	0.0000	0.0000	0.0005	0.0004
16	Arts and entertainment	1.0181	0.0006	0.0017	0.0004	0.0000
17	Accommodation	0.0056	1.0110	0.0118	0.0127	0.0035
18	Eating and drinking	0.0173	0.0132	1.0168	0.0070	0.0030
19	Other services	0.0176	0.0177	0.0140	1.0142	0.0037
20	Government	0.0439	0.0356	0.0218	0.0200	1.0063
	Type I output multipliers	1.39	1.53	1.57	1.56	1.10

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, state taxes, wage and salary jobs, or total jobs) 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 and also in Table 2.4. For example, the output multiplier for agriculture is $1.55, which means that every $1 change in agriculture's final demand results in a change in the economy's total output by $1.55. 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) ($0.55). 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. 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's 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 rows (compensation of employees and proprietors' income) of the transactions table (Table 2.1).

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 earnings 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 0.40 (Table 2.4). Accordingly, a $1 increase in agriculture's final demand would increase the earnings in the economy by 40 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 0.28631. Thus, the Type I direct-effect earnings multiplier for agriculture is 1.41 (0.40 ÷ 0.28631). That means a $1 change in household earnings in agriculture will change total earnings in the economy by $1.41.

State Tax Multipliers

In the 2012 I-O study, the multipliers for total state tax and major components of state tax (individual income tax, GET, TAT, and other state taxes) are also generated because one of the most common impact analyses conducted is the impact of new policies on state tax revenues. Final-demand state tax multipliers measure the economic impact of changes in an industry's final demand in terms of changes in state tax revenues. 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 state taxes in the 2012 I-O (Table 25) include the following 13 categories: (1) general excise and use tax (accounted for about 48.1% of total state taxes), (2) individual income tax (26.2%), (3) corporate income tax (1.8%), (4) transient accommodations tax (5.5%), (5) fuel tax (3.0%), (6) alcohol and tobacco tax (2.9%), (7) PUC tax (2.5%), (8) insurance tax (2.1%), (9) unemployment compensation tax (3.8%), (10) motor vehicle tax/fees (3.3%), (11) conveyance tax (0.7%), (12) bank and other financial institutions tax (0.1%), and (13) licenses, permits, and others (0.01%).[2] Excluded from state taxes were property taxes, other city and county taxes, and federal taxes.

[2] For information on state tax revenues by industry for 2012, refer to the 2012 detailed I-O table at the DBEDT Web Site.

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 are 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 20.49. In other words, one million dollars of additional demand for Hawaii's agricultural products would create about 20.5 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 16.78 (15,809 ÷ 942.2). Thus, the Type I direct-effect employment multiplier for agriculture is 1.22 (20.49 ÷ 16.78).

The final-demand employment multipliers tend to decrease over time due to increases in worker productivity and inflation. The employment multipliers presented in Table 2.4 are for 2012. Although this report is released in 2016, using the 2012 final-demand employment-multipliers for subsequent years would overestimate the employment impacts. Therefore, the final-demand employment multipliers were also computed for each year from 2013 to 2022 by adjusting the 2012 final-demand employment multipliers 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 2012 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]

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

According to BEA's RIMS II methodology, entries in the household row of the direct requirements table 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.

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 2012 condensed table are presented in Table 2.4; and Type I and Type II state tax multipliers from the 2012 condensed table are presented in Table 2.5.

[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. 2012 Condensed Output, Earnings, and Employment Multipliers for Hawaii

	Final-demand multipliers					
	Output		Earnings		Total job	
Industry	Type I	Type II	Type I	Type II	Type I	Type II
1 Agriculture	1.55	2.05	0.40	0.54	20.49	24.00
2 Mining and construction	1.45	2.04	0.48	0.64	8.32	12.48
3 Food processing	1.76	2.19	0.34	0.46	11.50	14.48
4 Other manufacturing	1.27	1.41	0.12	0.15	2.89	3.89
5 Transportation	1.45	1.90	0.36	0.48	8.21	11.36
6 Information	1.33	1.71	0.31	0.42	6.41	9.11
7 Utilities	1.65	1.88	0.19	0.25	2.99	4.61
8 Wholesale trade	1.50	1.93	0.35	0.47	7.90	10.94
9 Retail trade	1.33	1.81	0.38	0.51	13.18	16.52
10 Finance and insurance	1.69	2.22	0.42	0.57	10.43	14.11
11 Real estate and rentals	1.21	1.41	0.16	0.21	4.23	5.61
12 Professional services	1.40	2.14	0.60	0.80	11.91	17.10
13 Business services	1.30	2.06	0.60	0.81	16.98	22.23
14 Educational services	1.36	2.15	0.63	0.85	19.65	25.14
15 Health services	1.46	2.17	0.57	0.76	12.26	17.23
16 Arts and entertainment	1.39	2.01	0.50	0.66	24.10	28.40
17 Accommodation	1.53	2.09	0.45	0.60	9.54	13.46
18 Eating and drinking	1.57	2.16	0.47	0.63	17.90	22.00
19 Other services	1.56	2.30	0.59	0.79	16.78	21.94
20 Government	1.10	1.83	0.59	0.79	10.42	15.54
State weighted average	1.36	1.87	0.41	0.55	12.28	16.52

	Final-demand multipliers		Direct-effect multipliers			
	W&S job		Earnings		Total job	
Industry	Type I	Type II	Type I	Type II	Type I	Type II
1 Agriculture	10.37	12.97	1.41	1.89	1.22	1.43
2 Mining and construction	6.03	9.11	1.32	1.77	1.54	2.30
3 Food processing	8.87	11.07	2.40	3.21	2.33	2.93
4 Other manufacturing	2.10	2.84	2.31	3.08	2.36	3.18
5 Transportation	6.92	9.25	1.59	2.13	1.59	2.20
6 Information	5.08	7.08	1.43	1.92	1.56	2.22
7 Utilities	2.42	3.62	1.78	2.38	2.82	4.34
8 Wholesale trade	6.23	8.48	1.68	2.24	1.82	2.52
9 Retail trade	10.41	12.88	1.27	1.69	1.18	1.47
10 Finance and insurance	6.40	9.13	1.88	2.51	1.86	2.52
11 Real estate and rentals	1.71	2.73	1.62	2.17	1.56	2.06
12 Professional services	6.94	10.79	1.22	1.64	1.28	1.84
13 Business services	13.41	17.30	1.18	1.58	1.15	1.50
14 Educational services	15.94	20.01	1.17	1.57	1.13	1.45
15 Health services	10.07	13.75	1.29	1.73	1.35	1.90
16 Arts and entertainment	13.32	16.51	1.31	1.75	1.14	1.34
17 Accommodation	8.46	11.36	1.54	2.06	1.65	2.33
18 Eating and drinking	16.21	19.25	1.41	1.88	1.25	1.53
19 Other services	11.19	15.01	1.31	1.75	1.25	1.64
20 Government	10.27	14.07	1.05	1.40	1.06	1.59
State weighted average	10.17	13.42	1.48	1.97	1.33	1.82

Table 2.5. 2012 Condensed State Tax Multipliers for Hawaii

	Final-demand multipliers for state tax					
	Total state tax		Individual income		GET	
Industry	Type I	Type II	Type I	Type II	Type I	Type II
1 Agriculture	0.0463	0.0720	0.0132	0.0191	0.0200	0.0338
2 Mining and construction	0.0939	0.1243	0.0198	0.0268	0.0612	0.0775
3 Food processing	0.0506	0.0723	0.0147	0.0197	0.0215	0.0331
4 Other manufacturing	0.0216	0.0290	0.0054	0.0071	0.0073	0.0113
5 Transportation	0.0582	0.0811	0.0168	0.0220	0.0248	0.0371
6 Information	0.0740	0.0937	0.0147	0.0192	0.0348	0.0454
7 Utilities	0.0548	0.0666	0.0083	0.0110	0.0061	0.0124
8 Wholesale trade	0.0449	0.0671	0.0154	0.0205	0.0175	0.0294
9 Retail trade	0.0856	0.1100	0.0157	0.0213	0.0580	0.0710
10 Finance and insurance	0.0827	0.1096	0.0190	0.0252	0.0163	0.0307
11 Real estate and rentals	0.0497	0.0598	0.0062	0.0085	0.0327	0.0381
12 Professional services	0.1022	0.1401	0.0259	0.0346	0.0619	0.0821
13 Business services	0.0996	0.1379	0.0267	0.0355	0.0590	0.0795
14 Educational services	0.1032	0.1433	0.0293	0.0385	0.0594	0.0808
15 Health services	0.0991	0.1354	0.0249	0.0333	0.0591	0.0785
16 Arts and entertainment	0.0892	0.1206	0.0185	0.0257	0.0577	0.0745
17 Accommodation	0.1447	0.1734	0.0162	0.0228	0.0623	0.0776
18 Eating and drinking	0.0951	0.1251	0.0188	0.0257	0.0616	0.0776
19 Other services	0.0771	0.1148	0.0240	0.0326	0.0371	0.0572
20 Government	0.0461	0.0836	0.0311	0.0397	0.0024	0.0224
State weighted average	0.0707	0.0966	0.0182	0.0241	0.0341	0.0480

	Final-demand multipliers for state tax			
	TAT		Other state taxes	
Industry	Type I	Type II	Type I	Type II
1 Agriculture	0.0002	0.0006	0.0128	0.0184
2 Mining and construction	0.0004	0.0008	0.0125	0.0192
3 Food processing	0.0009	0.0012	0.0135	0.0183
4 Other manufacturing	0.0003	0.0004	0.0086	0.0102
5 Transportation	0.0002	0.0006	0.0164	0.0214
6 Information	0.0005	0.0008	0.0240	0.0283
7 Utilities	0.0003	0.0005	0.0402	0.0428
8 Wholesale trade	0.0009	0.0012	0.0111	0.0160
9 Retail trade	0.0004	0.0008	0.0115	0.0169
10 Finance and insurance	0.0013	0.0018	0.0460	0.0519
11 Real estate and rentals	0.0002	0.0004	0.0105	0.0128
12 Professional services	0.0011	0.0017	0.0134	0.0218
13 Business services	0.0004	0.0010	0.0135	0.0220
14 Educational services	0.0003	0.0009	0.0142	0.0231
15 Health services	0.0008	0.0013	0.0143	0.0223
16 Arts and entertainment	0.0003	0.0008	0.0126	0.0196
17 Accommodation	0.0519	0.0523	0.0143	0.0206
18 Eating and drinking	0.0006	0.0011	0.0141	0.0207
19 Other services	0.0007	0.0012	0.0153	0.0236
20 Government	0.0002	0.0008	0.0125	0.0207
State weighted average	0.0034	0.0038	0.0150	0.0207

III. 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 practical applications of the I-O model and the correct use of I-O multipliers.[6]

Economic Impacts of Visitor Spending

Visitor spending contributes significantly to Hawaii's economy. In 2012, visitor spending on goods and services produced in Hawaii totaled more than $15 billion, contributing to about 12.9 percent of total output 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.

Let us hypothesize a special event (a large convention or a special sport event) occurred in Honolulu that attracted 5,000 additional visitors for a week in 2015. What is the impact on the state economy? To estimate the impact of this special event on the economy, we need to estimate the additional visitor spending generated by this event first. Multiplying the 5,000 additional visitors by 7 days gives us 35,000 additional visitor days.[7] Assuming that the average per person per day expenditures is $200 for these additional visitors, total additional visitor spending due to this special event would be $7 million.

To estimate its impact on the economy, this $7 million needs to be allocated to the various industries producing the goods and services purchased by visitors. Unless the analyst has other more accurate information on which to base the allocation of purchases, a reasonable approach is to allocate visitor purchases based on the industries' shares in total visitor expenditure in the 2012 I-O table. Then, the value of the increase in visitor spending for each industry is multiplied by the Type II final-demand output, earnings and job multipliers for each industry and the results are added up to obtain the total output, earnings and job impacts of the increase in visitor expenditures.[8]

The results, as shown in Table 3.1, indicate that a hypothetical special event that attracted 5,000 additional visitors to Honolulu for one week in 2015 could potentially increase Hawaii's total output (sales) by $12.8 million and increase Hawaii's total labor earnings by $3.6 million. The

[6] Additional examples are available in the 1992, 1997, 2002, 2005, and 2007 State of Hawaii Input-Output Study.

[7] To simplify our analysis, we assume that the additional visitors due to this special event do not affect other regular visitors. In reality, the additional visitors due to this special event may have a negative impact on other regular visitors. Increased hotel occupancy rate due to this special event may cause other visitors to cancel their trip to Hawaii.

[8] When impacts of new spending are estimated it is customary to use Type II multipliers to account for induced impacts, which capture the additional impacts of increased consumption by households due to increased earnings from the new economic activity.

impact on jobs; however, should be interpreted with caution. Based on the 2012 I-O table, as shown in Table 3.1, the $7 million additional visitor expenditure should increase Hawaii's total employment by 86 jobs. However, the $7 million additional visitor expenditure is due to a special event that lasts only 7 days. In the real economy, the additional labor demand may be addressed by extending working hours of existing employees rather than adding new jobs. The estimated impact on jobs based on the I-O model depends upon the constraint underlying the I-O model; specifically, the I-O model requires that additional demand for labor be met by adding new jobs rather than extending working hours.

Table 3.1. Economic Impacts of Increasing Visitor Spending by $7 Million

	Visitor expenditure shares	Increase in visitor expenditure	Type II final-demand multipliers (from Table 2.4)			Economic impacts		
Industry	(%)	($ million)	Output	Earnings	Job*	Output ($ million)	Earnings ($ million)	No. of jobs
Agriculture	0.14	0.01	2.05	0.54	21.9	0.02	0.01	0
Mining and construction	0.00	0.00	2.04	0.64	11.2	0.00	0.00	0
Food processing	0.34	0.02	2.19	0.46	13.3	0.05	0.01	0
Other manufacturing	0.33	0.02	1.41	0.15	3.5	0.03	0.00	0
Transportation	18.00	1.26	1.90	0.48	10.4	2.40	0.61	13
Information	0.11	0.01	1.71	0.42	8.3	0.01	0.00	0
Utilities	0.00	0.00	1.88	0.25	4.1	0.00	0.00	0
Wholesale trade	0.66	0.05	1.93	0.47	9.5	0.09	0.02	0
Retail trade	12.56	0.88	1.81	0.51	14.8	1.59	0.45	13
Finance and insurance	0.00	0.00	2.22	0.57	12.9	0.00	0.00	0
Real estate and rentals	8.74	0.61	1.41	0.21	5.2	0.86	0.13	3
Professional services	0.75	0.05	2.14	0.80	15.4	0.11	0.04	1
Business services	1.95	0.14	2.06	0.81	20.1	0.28	0.11	3
Educational services	0.85	0.06	2.15	0.85	22.6	0.13	0.05	1
Health services	0.90	0.06	2.17	0.76	15.8	0.14	0.05	1
Arts and entertainment	3.17	0.22	2.01	0.66	26.6	0.45	0.15	6
Accommodation	33.86	2.37	2.09	0.60	12.1	4.95	1.43	29
Eating and drinking	9.72	0.68	2.16	0.63	20.1	1.47	0.43	14
Other services	0.80	0.06	2.30	0.79	19.8	0.13	0.04	1
Government	0.51	0.04	1.83	0.79	13.9	0.07	0.03	0
Total Hawaii produced	93.39	6.54				12.8	3.6	86
Imports	6.61	0.46						
Total	100.00	7.00				12.8	3.6	86

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

Gross Impact vs. Net Impact: Creating a New Business

Creating a new business will normally have two types of impacts on the economy: (1) the one-time impacts on the economy due to the construction and other investment related to the new business facility, and (2) the long-lasting impacts due to the continuous operation of the new business in the future.

In estimating the long-lasting impacts due to the operation of a new business, the impacts on the economy are often overstated by failing to distinguish between gross and net impacts of the new business.

For instance, a new retail store, hotel, restaurant, or movie theater will not necessarily increase demand for total retail trade, hotel rooms, dinners, or movies unless there are insufficient capacities in existing sectors. In reality, a new retail store might simply be taking business away from existing retail shops. Consumers who shop in this new retail store might have shopped in other retail stores if the new store had not been built. So the impact of the operation of the new store will be overstated unless its impact on other stores is netted out.

On the other hand, the one-time construction impacts of a new business on the economy are much more certain. The construction impacts of a new business can be analyzed similar to the impacts of increased visitor expenditures discussed above.

As an example, let us consider the impact of a new retail store selling mainly groceries and assume that the construction cost of the store is $10 million and the estimated annual sales value is $20 million.

The one-time impacts of the construction on the economy can be estimated using the 2012 I-O model. As shown in Table 3.2, the construction of a $10 million new retail store in 2015 could potentially increase Hawaii's total output by $11.0 million, increase Hawaii's total earnings by $3.4 million, and increase Hawaii's total employment by 63 jobs.

To determine the impacts of the long-lasting impacts of the new store operation, we need to estimate the net impacts of the new store on total retail sales first. Let us assume that half of the $20 million annual gross sales generated by the new store are due to increased final demand and the remaining half are simply displacement revenues of other existing retail stores. Therefore, the net impact of the new store on final demand would be $10 million instead of the original $20 million. To determine the economic impacts on output, earnings, and employment we need to allocate the $10 million into transportation costs, wholesale and retail trade margins, and cost of goods sold at producers' prices. The transportation, wholesale and retail trade margins for groceries are obtained from Appendix C. In addition, it is assumed that all the groceries sold in the new store are imported from the U.S. mainland or from foreign countries. Since the goods sold are all imported, impacts are due solely to the increased demand for distribution and trade services, but not from the production of goods by local industries.

Table 3.2. Economic Impacts of Increasing Private Investment by $10 Million

Industry	Private investment shares (%)	Increase in private investment ($ million)	Type II final-demand multipliers (from Table 2.4) Output	Earnings	Job*	Economic impacts Output ($ million)	Earnings ($ million)	No. of jobs
Agriculture	0.00	0.00	2.05	0.54	21.9	0.0	0.0	0
Mining and construction	39.55	3.96	2.04	0.64	11.2	8.1	2.5	44
Food processing	0.01	0.00	2.19	0.46	13.3	0.0	0.0	0
Other manufacturing	1.64	0.16	1.41	0.15	3.5	0.2	0.0	1
Transportation	1.09	0.11	1.90	0.48	10.4	0.2	0.1	1
Information	0.00	0.00	1.71	0.42	8.3	0.0	0.0	0
Utilities	0.00	0.00	1.88	0.25	4.1	0.0	0.0	0
Wholesale trade	3.47	0.35	1.93	0.47	9.5	0.7	0.2	3
Retail trade	3.74	0.37	1.81	0.51	14.8	0.7	0.2	6
Finance and insurance	0.00	0.00	2.22	0.57	12.9	0.0	0.0	0
Real estate and rentals	0.38	0.04	1.41	0.21	5.2	0.1	0.0	0
Professional services	4.89	0.49	2.14	0.80	15.4	1.0	0.4	8
Business services	0.00	0.00	2.06	0.81	20.1	0.0	0.0	0
Educational services	0.00	0.00	2.15	0.85	22.6	0.0	0.0	0
Health services	0.00	0.00	2.17	0.76	15.8	0.0	0.0	0
Arts and entertainment	0.00	0.00	2.01	0.66	26.6	0.0	0.0	0
Accommodation	0.00	0.00	2.09	0.60	12.1	0.0	0.0	0
Eating and drinking	0.00	0.00	2.16	0.63	20.1	0.0	0.0	0
Other services	0.00	0.00	2.30	0.79	19.8	0.0	0.0	0
Government	0.00	0.00	1.83	0.79	13.9	0.0	0.0	0
Total intermediate input	54.77	5.48				11.0	3.4	63
Imports	45.23	4.52						
Total	100.00	10.00				11.0	3.4	63

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

As shown in Table 3.3, the $10 million net additional retail sales generated by this new store could potentially increase Hawaii's total output by about $7.1 million, increase Hawaii's total earnings by about $2.0 million, and increase Hawaii's total employment by 52 jobs. Unlike the one-time impacts of the construction work, the long lasting impacts will be permanent throughout the life of the new store.

It should be noted that the economic impacts of the new store estimated above are really caused by an increase in final demand for groceries not just because a new store went into operation. Without increases in final demand, the opening of a new retail store cannot generate the estimated impacts on the economy. Final demand of consumers is affected by many variables, such as personal income, population, the prices of the goods, and unemployment rate.

Table 3.3. Economic Impacts of an Increase in Grocery Sales by $10 Million

			Type II final-demand multipliers (from Table 6.1)			Economic impacts		
	Margin (%)	Allocation ($ million)	Output	Earnings	Job	Output ($ million)	Earnings ($ million)	No. of jobs
Margins								
Truck transportation	0.80	0.08	2.00	0.64	14.0	0.2	0.1	1
Air transportation	0.30	0.03	1.73	0.36	6.7	0.1	0.0	0
Water transportation	1.75	0.18	2.07	0.49	9.5	0.4	0.1	2
Wholesale trade	9.00	0.90	1.94	0.48	9.9	1.7	0.4	9
Retail trade	26.40	2.64	1.82	0.52	15.1	4.8	1.4	40
Producers' prices (imports)	61.75	6.18						
Total	100.00	10.00				7.1	2.0	52

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 state government program to provide early childhood health screening for low-income families. We assume that funds for the new program will be generated through General Fund tax revenues. The Type II output multiplier for government spending from Table 2.4 is 1.83. That suggests that the $10 million expenditure will ultimately generate about $18.3 million in output -- $8.3 million more than the actual expenditures on the program.

However, this conclusion ignores an important factor. Since the $10 million in program funds come from available tax revenue, there may be up to $10 million less spending elsewhere. In other words, if this program were not funded, another program would be. 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 that the entire program will be funded by a small increase in the personal income tax rate. Let us also assume that households will adsorb this 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 3.4. 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 a small net economic impact with respect to total output in the economy.

Table 3.4. Net Impact of Government Spending

	Direct effect ($ million)	Type II output multiplier*	Total output impact ($ million)
Government	10.00	1.83	18.3
Households (PCE)	-10.00	1.54	-15.4
Net impact			2.9

* Note that the government multiplier is from Table 2.4 and the household or PCE multiplier is from Table 6.1. 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. However, in the case of Federal government funded programs, because the required funds will be generated from federal taxes or reduction in other federal programs, in most cases, there is no need to subtract the impact of increases in taxes or non-funding of other programs in an analysis of the impact of the federal spending in Hawaii.

Impact of New Construction Jobs

The multipliers presented in Tables 2.4 and 6.1 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 to determine how the economy will be affected. In that case, initial earnings and employment change should be translated into output change by using the industry's direct-earnings coefficient (earnings-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 1,000 new jobs in Hawaii's construction sector. The calculation of the total job impact is quite straightforward. This is obtained by multiplying the direct or initial increase in jobs by the Type II direct-effect job multiplier for the construction sector. This gives a total job impact of 2,302 jobs (2.302 x 1,000 = 2,302), including the initial increase of 1,000 jobs plus 1,302 additional 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-total job (0.067) and output-to-total job (0.184) ratios. This gives the initial (direct) earnings change of $67 million and initial output change of $184 million. The total earnings effect of $118 million is obtained by multiplying the direct earnings effect by the direct-

effect earnings multiplier for the construction sector (67 x 1.769 = 118). The total output effect of $377 million is obtained based on the direct output effect and final-demand output multiplier. Alternatively, the total job and earnings effects can also be derived using the direct output effect and final-demand employment and earnings multipliers, respectively. These results are presented in Table 3.5.

Table 3.5. Impacts of 1,000 New Jobs in Hawaii's Construction Sector

	Direct impact	Final-demand multipliers (from Table 2.4)	Direct-effect multipliers (from Table 2.4)	Total impact
Employment (no. of jobs)*	1,000	12.481	2.302	2,302
Earnings ($ million)	67	0.640	1.769	118
Output ($ million)	184	2.045	2.045	377
Earings/total job ratio	0.067			
Output/total job ratio	0.184			

* Note that final-demand employment multipliers will change from year to year due to worker productivity growth and inflation-driven wage changes. The base, 2012 multipliers are used in this illustration for simplicity and clarity. For actual impact estimations the current year employment multipliers should be used.

Increase in Garment Sales to Visitors

As another example, let us consider the impact of a $100 million increase in sales of clothing to tourists (Table 3.6). It would be incorrect to apply the multipliers of the retail trade sector directly to the $100 million, because output for retail trade is not the total revenue (sales) for the industry, but its margin or retail markup. 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 impacts should be broken down into the prices for the good (or service), the transportation costs, wholesale and retail trade margins (mark up) 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 retail trade sectors.

In order to do the impact analysis correctly, the $100 million in increased garment sales needs to be broken down into the value of the clothing, the transportation costs, and the trade margins. As shown in Appendix C, the retail margin for clothing is 42 percent, the wholesale margin is 6 percent, the truck transportation margin is 0.8 percent, the air transportation margin is 0.3 percent, and the water transportation margin is 1.75 percent. Thus, as shown in Table 3.6, the $100 million in clothing expenditures should be distributed into various sectors representing the contributions of the transportation industry, the wholesale and retail trade services provided, as well as cloth manufacturing. This yields $49.15 million as the value of clothing at producers' prices or cost of garments.

Note also in Table 3.6 that the cost of clothing ($49.15 million) is further divided into what is contributed through the manufacturing process in Hawaii and what is imported. According to the 2012 I-O table and data from the 2012 Economic Census, the percentage of total clothing

sales that is made and sold in Hawaii was estimated to be about 6 percent of total producers' value of clothing. Accordingly, of the $49.15 million of clothing sales in producers' prices, 6 percent or $2.95 million was allocated to Hawaii's apparel manufacturing and 94 percent or $46.2 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 3.6, an increase in clothing sales to visitors of $100 million would generate about $99.8 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.

Table 3.6. Output Impact of an Increase in Clothing Sales by $100 Million

	Margin (%)	Allocation ($ million)	Type II output multipliers (from Table 6.1)	Total output impact ($ million)
Margins				
Truck transportation	0.80	0.80	2.00	1.6
Air transportation	0.30	0.30	1.73	0.5
Water transportation	1.75	1.75	2.07	3.6
Wholesale trade	6.00	6.00	1.94	11.7
Retail trade	42.00	42.00	1.82	76.3
Cost of garments	49.15	49.15		
Hawaii's apparel manufacturing		2.95	2.05	6.0
Imports (94%)		46.20		
Total	100.00	100.00		99.8

Considerations in Using I-O Models in Impact Analysis

There are a number of important cautions about using the I-O to estimate economic impacts. When conducting an impact analysis using I-O models, the following 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 6.1 contains 1,440 multipliers and many more multipliers can be derived from an I-O table.

2. 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 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.

3. The values for 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, analyses that require alternative assumptions, other economic tools may be required.

4. 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.

5. Output in several industries is measured not in terms of their total sales (revenues), but by their "mark up" or 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.

6. 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 State and Local Government sector should be used to calculate the economic impacts.

7. 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.

8. Impact assessments are only the estimates of economic impacts of an anticipated external change. 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.

IV. INDUSTRY CLASSIFICATION, DATA SOURCES, AND ESTIMATION PROCEDURES

Industry Classification

Industry classification in the 2012 I-O table was primarily based on the 2012 NAICS (North American Industry Classification System). However, several data sources used in the 2012 I-O table were reported in a more aggregate format and therefore were disaggregated using the detailed Economic Modeling Specialists, Inc. (EMSI) jobs data. In addition, in the 2012 I-O table, government enterprises were combined into the corresponding government sectors.

Output

The main data source for industries' outputs for the 2012 I-O table was the 2012 Economic Census of Hawaii's industries. The Economic Censuses disclose output estimates for most of the industries included in the 2012 I-O table. Following the 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*
+ Changes 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 were different from the 2012 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's 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's Agriculture and that of commercial fishing was based on information from the National Marine Fisheries Services (NMFS) Web Site.

Forestry & Logging and Support Activities for Agriculture

The forestry & logging and support activities for agriculture are not covered in either the Statistics for Hawaii's Agriculture or the Economic Census. Thus, their outputs were estimated by applying the value added to output ratios for these sectors obtained from Statistics of Hawaii Agriculture to their corresponding valued added obtained from the Bureau of Economic Analysis (BEA).

Construction

Construction output equals the net revenue of construction (total value of construction less subcontracting) plus the value of architectural and engineering services involved in the construction activity. Construction output came from the 2012 Economic Census of Construction.

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.

<u>Air Transportation</u>

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 2013 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 goods 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 company financial reports and available information from the Economic Census.

Utilities

Utilities include electricity, gas, and private water and sewage utilities. Electricity and gas outputs were obtained from the State of Hawaii Data Book 2013. The outputs of private water and sewage utilities were estimated based on the ratio of jobs between gas utilities and water and sewage utilities (from 2012 EMSI data). The output of government water and sewage utilities was included in the government enterprises.

Wholesale and Retail Trade

For wholesale and retail trade industries, outputs are measured as the 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. Information from the National Income and Product Accounts (NIPA) and other BEA data sources were used to estimate the monetary and imputed service charges.

Insurance

In accordance with the 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 2013 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 2013 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 Hawaii Housing Policy Study 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 Hawaii Housing Policy Study.

Hospitals

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

Value Added

Value added is the income side of the Hawaii gross domestic product (GDP) account. For the 2012 I-O table, value added was divided into four components: (1) compensation of employees (COE), (2) proprietors' income, (3) taxes on production and imports less subsidies (TOPILS), and (4) other capital costs. The Bureau of Economic Analysis (BEA) provides the following data by NAICS at various detailed industry level.

The BEA GDP data include three components of value added: (1) COE, (2) TOPILS, and (3) gross operating surplus (GOS) (GOS includes proprietors' income and other capital costs). The BEA GDP data were used to determine the industry level data for COE and TOPILS. The GOS were broken down to proprietors' income and other capital costs.

In its personal income data, BEA also provides the earnings by place of work data (SA05N) and COE data (SA06N) by industry. Earnings by place of work = wage and salary disbursements + supplements to wages and salaries + proprietors' income = Compensation of employees + Proprietors' income.

Compensation of Employees

Compensation of employees consists of wage and salary disbursements plus supplements to wages and salaries. The supplements to wages and salaries include employer contributions for employee pension and insurance funds, and employer contributions for government social insurance. The detailed industry level COE data in the 2012 I-O table were obtained from the BEA's estimate of COE at the NAICS industry level (SA06N).

Proprietors' Income

Proprietors' income was estimated from the BEA's personal income series. The detailed industry level proprietors' income data in the 2012 I-O table were obtained by subtracting the COE from total earnings by place of work (SA05N).

Taxes on Production and Imports less Subsidies

Taxes on production and imports less subsidies (TOPILS) consist of tax liabilities, such as general sales and property taxes that are chargeable to business expense in the calculation of profit-type incomes. Also included are special assessments. TOPILS is the sum of business taxes and fees paid to the federal, state, and local governments. Components of TOPILS include general excise taxes (GET), transient accommodations taxes (TAT), fuel taxes, property taxes, customs duties, and certain types of non-tax fees. Subsidies consist of the monetary grants paid by government agencies to private business or to government enterprises at another level of government. The industry level TOPILS data in the 2012 I-O table were estimated based on BEA's GDP data.

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 by industry were computed by subtracting proprietors' income from gross operating surplus.

Final Demand

Final demand reflects the expenditure side of the GDP account. It consists of personal consumption expenditures (PCEs), visitor's expenditures (VEs), gross private investment, change in inventories, state and local government consumption and investment, federal government consumption and investment, and exports.[9]

[9] 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 and merchandise lines sales of retail industries and source of receipts data by industry from the 2012 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 benchmark I-O composition of U.S. NIPA final demand and assigned to relevant sectors. The NIPA 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 expenditures (VEs) were estimated and allocated into I-O industries based on information obtained from the DBEDT visitor expenditures surveys. As was done for PCEs, visitor expenditures were also adjusted to account for transportation costs and trade margins.

In the 1997 I-O model, all the output of owner-occupied dwellings was assigned to PCE. However, some owner-occupied dwellings in Hawaii are owned by non-residents and some resident owned units are used to serve visitors, such as bed and breakfast (B&B) units. Thus, in the 2012 I-O model, imputed value of these units was allocated to VE rather than PCE.

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. The spending on producers' durable equipment was more difficult to estimate. The main sources used to estimate spending on PDE were wholesale sales and retail merchandise line sales from the 2012 Economic Census.

Change in Inventories

Changes in inventories were estimated based on three sources: BEA agriculture dataset (SA45), which gives change in inventories of livestock; 2012 Economic Census of Manufacturing, which discloses only the total change in inventories for the entire manufacturing sector; and 2012 Economic Census of Wholesale Trade, which gives the change in inventories for the entire sector

and sub-sectors as well. Margins were applied to changes in inventories and allocated the relevant industries.

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). 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. Operating expenses were based on the Census of Governments and a special DAGS report. Investment is the value of new construction and expenditures on durable equipment.

Federal Military Government Consumption and Investment

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

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 U.S. 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 2012 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 2012 Economic Census.

Imports

Imports consist of the commodities and services purchased by industries as intermediate inputs to production and by final users for consumption and investment. Total intermediate imports by industries were computed as a residual between the income and expenditure sides of Hawaii's GDP 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.

Employment

Both wage and salary employment and proprietors' employment numbers are mainly based on BEA employment data by industry. Total jobs data (SA25N) and wage and salary jobs data (SA27N) by industry are available at 3-digit NAICS level. The proprietors' jobs were determined by the difference between total jobs and wage and salary jobs. In addition, the EMSI maintains a detailed data set that provides tabulations of the 2012 number of reporting units, average annual employment, and total earnings for the State of Hawaii based on NAICS. For the industries in the 2012 I-O table that were not consistent with the 3-digit NAICS, the 2012 EMSI data were used to allocate the BEA data to the 2012 I-O industries.

V. 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 services 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 2012 inter-industry matrix were estimated using data from several sources. First, any cells for which reliable estimates could be found were filled in. These estimates came from the 2012 Economic Census, industries' annual reports, the Statistics of Hawaii's Agriculture, and the state and country government annual reports. Values for the rest of the cells were estimated using the production functions from the U.S. I-O table, or the 2007 Hawaii I-O table.

Production functions for construction industries were estimated using the data from the Economic Census of Construction. The Statistics of Hawaii's Agriculture provided values for inter-industry commodity flows of various agricultural sectors. 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 U.S. I-O table was used in estimating the production functions of most of the service sectors. Production functions for the government sectors were based on the U.S. I-O table as well as data received from DAGS and the source of receipts datasets from the EC 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 respective 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. A modified RAS procedure was used in this study 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 were not affected in the balancing process.

The modified RAS procedure used in the 2012 Hawaii I-O table involves the following pieces of information.

i. Total sales or output by sector for 2012
ii. Total sales to final users by sector for 2012
iii. Total purchases or input by sector for 2012
iv. Total value added by sector for 2012
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 the industry's total purchases from Hawaii's industries and the 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 2012 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.

VI. MULTIPLIERS FROM THE 2012 DETAILED I-O TABLE FOR HAWAII

2012 Detailed I-O Table for Hawaii

The 2012 detailed I-O transactions table for the State of Hawaii includes the following.[10]

- Sixty eight (68) producing sectors (see Table 6.1 or Appendix A)
- Eleven (11) final demand sectors
  - Personal consumption expenditures (PCEs)
  - Visitor expenditures (VEs)
  - Change in inventories
  - Gross private investment
  - Six (6) government sectors
    - State and local government consumption
    - State and local government investment
    - Federal government military investment
    - Federal government military consumption
    - Federal government civilian investment
    - Federal government civilian consumption
  - Exports
- Four (4) final payments sectors
  - Compensation of employees
  - Proprietors' income
  - Taxes on production and imports less subsidies (TOPILS)
  - 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)
  - Individual income tax
  - GET
  - TAT
  - Other state taxes

2012 Detailed I-O Multipliers

Using the procedures described in Section 2 and Appendix B, the following multipliers were derived for each industry in the 2012 detailed I-O table and the results are presented in Table 6.1.[11]

[10] For details, refer to the 2012 Input-Output Study for Hawaii at the DBEDT Web Site. The study presents the 2012 transactions table and various I-O multipliers for each of the 68 industry sectors in the detailed I-O table.

Final-demand multipliers (Type I and Type II)
- Output multiplier
- Earnings multiplier
- Total employment multiplier
- Wage and salary 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 2012. 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 2013-2022 are available at the DBEDT Web Site.

The interpretation of each of the above multipliers is provided below. 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.

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.

[11] Although not presented in Table 6.1 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 2012 I-O transactions table at the DBEDT Web Site. Also provided at the DBEDT Web Site are final-demand wage and salary employment and total employment multipliers for 2012 to 2022. Employment multipliers for subsequent years account for projected inflation and labor productivity growth.

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

Table 6.1 presents the 2012 I-O multipliers for Hawaii's 68 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.

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, legal services, architectural and engineering services, educational services, and ambulatory health care 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 0.04 for petroleum manufacturing to 0.79 for forestry and logging. Other industries that have smaller Type I final-demand earnings multipliers include owner-occupied dwellings, rental and leasing, and electricity. 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 Federal government military to 3.64 for apparel and textile manufacturing and Type II direct-effect earnings multipliers vary from 1.33 to 4.85 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 generally lower for labor intensive sectors.

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 0.68 for petroleum manufacturing to 41.55 for other finance and insurance for Type I and from 1.04 to 47.70 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 6.1 are final-demand state tax multipliers. As described before, state tax multipliers show the changes in state tax revenues that result from a $1 change in an industry's final demand.

Table 6.1. 2012 Detailed Output, Earnings, Employment, and Tax Multipliers for Hawaii

	Final-demand multipliers: 2012			
	Output (dollars)		Earnings (dollars)	
Industry	Type I	Type II	Type I	Type II
1 Sugarcane	1.61	2.14	0.43	0.57
2 Vegetables	1.55	2.11	0.44	0.59
3 Macadamia nuts, coffee, and other fruits	1.53	2.04	0.41	0.54
4 Pineapples	1.68	2.23	0.44	0.58
5 Flowers and nursery products	1.59	2.16	0.46	0.61
6 Other crops	1.50	2.01	0.41	0.55
7 Animal production	1.40	1.90	0.40	0.53
8 Aquaculture	1.59	2.14	0.44	0.59
9 Commercial fishing	1.54	1.88	0.27	0.36
10 Forestry & logging	1.73	2.71	0.79	1.05
11 Support activities for agriculture	1.62	2.22	0.49	0.65
12 Mining	1.30	1.78	0.39	0.52
13 Single family construction	1.45	2.03	0.47	0.63
14 Construction of other buildings	1.47	2.10	0.50	0.67
15 Heavy and civil engineering construction	1.48	2.11	0.51	0.68
16 Maintenance & repairs	1.44	2.05	0.48	0.65
17 Food processing	1.77	2.20	0.35	0.47
18 Beverage manufacturing	1.80	2.19	0.32	0.42
19 Apparel and textile manufacturing	1.77	2.05	0.23	0.30
20 Petroleum manufacturing	1.11	1.16	0.04	0.05
21 Other manufacturing	1.52	1.86	0.27	0.35
22 Air transportation	1.40	1.73	0.27	0.36
23 Water transportation	1.62	2.07	0.37	0.49
24 Truck and rail transportation	1.40	2.00	0.48	0.64
25 Transit and ground passenger transportation	1.42	2.09	0.54	0.72
26 Scenic and support activities for transportation	1.42	2.08	0.52	0.70
27 Couriers and messengers	1.60	2.18	0.47	0.62
28 Warehousing and storage	1.30	2.00	0.56	0.75
29 Publishing (include Internet)	1.41	1.79	0.30	0.40
30 Motion picture and sound recording industries	1.36	1.73	0.30	0.40
31 Broadcasting (Radio, TV, Cable)	1.10	1.51	0.33	0.44
32 Telecommunications	1.26	1.65	0.31	0.41
33 Internet providers, web, and data processing	1.64	2.10	0.37	0.49
34 Other information services	1.55	2.08	0.43	0.57
35 Electricity	1.59	1.78	0.16	0.21
36 Other utilities	1.45	1.62	0.14	0.18
37 Wholesale trade	1.50	1.94	0.36	0.48
38 Retail trade	1.33	1.82	0.39	0.52
39 Credit intermediation and related activities	1.78	2.33	0.44	0.59
40 Insurance carriers and related activities	1.60	2.10	0.40	0.53
41 Other finance and insurance	1.22	2.10	0.71	0.95
42 Owner-occupied dwellings	1.25	1.34	0.07	0.10
43 Real estate	1.21	1.50	0.23	0.31
44 Rental & leasing	1.04	1.24	0.16	0.21

Table 6.1. 2012 Detailed Output, Earnings, Employment, and Tax Multipliers for Hawaii - Continued

	Final-demand multipliers: 2012			
	Output (dollars)		Earnings (dollars)	
Industry	Type I	Type II	Type I	Type II
45 Legal services	1.29	2.02	0.59	0.78
46 Architectural and engineering services	1.44	2.22	0.63	0.84
47 Computer systems design services	1.36	2.09	0.59	0.78
48 R&D in the physical, engineering, & life sciences	1.40	2.10	0.57	0.75
49 Other professional services	1.46	2.24	0.63	0.83
50 Management of companies and enterprises	1.35	2.09	0.59	0.79
51 Travel arrangement and reservation services	1.24	2.08	0.67	0.90
52 Administrative and support services	1.26	2.03	0.62	0.82
53 Waste management and remediation services	1.53	2.14	0.49	0.65
54 Colleges, universities, and professional schools	1.21	2.06	0.69	0.91
55 Other educational services	1.39	2.18	0.63	0.84
56 Ambulatory health care services	1.29	2.15	0.70	0.93
57 Hospitals	1.62	2.22	0.49	0.65
58 Nursing and residential care facilities	1.57	2.16	0.47	0.63
59 Social assistance	1.29	2.08	0.63	0.84
60 Arts and entertainment	1.39	2.02	0.50	0.67
61 Accommodation	1.52	2.09	0.46	0.61
62 Eating and drinking	1.58	2.18	0.48	0.64
63 Repair and maintenance	1.23	2.17	0.75	1.00
64 Personal and laundry services	1.49	2.35	0.69	0.92
65 Organizations	1.69	2.34	0.52	0.69
66 Federal government military	1.00	1.75	0.60	0.80
67 Federal government: civilian	1.07	1.84	0.62	0.82
68 State and local government	1.20	1.91	0.57	0.76
PCE	1.16	1.54	0.31	0.41
Visitor's expenditures	1.34	1.81	0.38	0.51
State and local government consumption	1.18	1.85	0.54	0.72
Federal military consumption	1.01	1.69	0.55	0.73
Federal civilian consumption	1.09	1.83	0.60	0.79

Table 6.1. 2012 Detailed Output, Earnings, Employment, and Tax Multipliers for Hawaii - Continued

	Final-demand multipliers: 2012			
	Employment (total jobs)		State Tax (dollars)	
Industry	Type I	Type II	Type I	Type II
1 Sugarcane	20.91	24.63	0.05	0.07
2 Vegetables	20.63	24.46	0.05	0.08
3 Macadamia nuts, coffee, and other fruits	20.08	23.61	0.05	0.07
4 Pineapples	21.06	24.85	0.05	0.08
5 Flowers and nursery products	21.09	25.05	0.05	0.08
6 Other crops	20.56	24.14	0.04	0.07
7 Animal production	20.15	23.62	0.04	0.06
8 Aquaculture	22.26	26.06	0.04	0.07
9 Commercial fishing	16.98	19.34	0.04	0.06
10 Forestry & logging	34.68	41.48	0.04	0.09
11 Support activities for agriculture	25.04	29.23	0.09	0.12
12 Mining	14.07	17.42	0.04	0.06
13 Single family construction	8.20	12.28	0.09	0.12
14 Construction of other buildings	8.50	12.84	0.10	0.13
15 Heavy and civil engineering construction	8.49	12.88	0.10	0.13
16 Maintenance & repairs	8.44	12.62	0.10	0.13
17 Food processing	11.25	14.27	0.05	0.07
18 Beverage manufacturing	7.69	10.45	0.05	0.07
19 Apparel and textile manufacturing	8.33	10.28	0.05	0.06
20 Petroleum manufacturing	0.68	1.04	0.01	0.01
21 Other manufacturing	7.19	9.49	0.04	0.06
22 Air transportation	5.04	7.35	0.04	0.05
23 Water transportation	7.24	10.41	0.06	0.08
24 Truck and rail transportation	11.09	15.25	0.09	0.12
25 Transit and ground passenger transportation	20.15	24.83	0.09	0.13
26 Scenic and support activities for transportation	12.30	16.82	0.10	0.13
27 Couriers and messengers	12.07	16.11	0.10	0.13
28 Warehousing and storage	16.45	21.29	0.10	0.13
29 Publishing (include Internet)	7.63	10.24	0.09	0.11
30 Motion picture and sound recording industries	9.47	12.07	0.09	0.11
31 Broadcasting (Radio, TV, Cable)	6.14	8.99	0.08	0.10
32 Telecommunications	5.06	7.70	0.06	0.08
33 Internet providers, web, and data processing	9.29	12.49	0.11	0.13
34 Other information services	9.04	12.72	0.10	0.13
35 Electricity	1.98	3.34	0.05	0.06
36 Other utilities	3.40	4.57	0.04	0.05
37 Wholesale trade	8.33	11.42	0.05	0.07
38 Retail trade	13.49	16.88	0.09	0.11
39 Credit intermediation and related activities	10.77	14.60	0.06	0.09
40 Insurance carriers and related activities	8.55	11.97	0.12	0.14
41 Other finance and insurance	41.55	47.70	0.06	0.10
42 Owner-occupied dwellings	1.78	2.41	0.01	0.02
43 Real estate	6.31	8.33	0.08	0.09
44 Rental & leasing	4.12	5.45	0.06	0.07

Table 6.1. 2012 Detailed Output, Earnings, Employment, and Tax Multipliers for Hawaii - Continued

	Final-demand multipliers: 2012			
	Employment (total jobs)		State Tax (dollars)	
Industry	Type I	Type II	Type I	Type II
45 Legal services	8.11	13.18	0.10	0.14
46 Architectural and engineering services	9.13	14.56	0.11	0.15
47 Computer systems design services	10.72	15.79	0.11	0.14
48 R&D in the physical, engineering, & life sciences	7.36	12.25	0.09	0.13
49 Other professional services	18.84	24.25	0.11	0.15
50 Management of companies and enterprises	8.55	13.65	0.11	0.14
51 Travel arrangement and reservation services	9.05	14.87	0.10	0.14
52 Administrative and support services	26.22	31.53	0.10	0.14
53 Waste management and remediation services	9.47	13.69	0.10	0.13
54 Colleges, universities, and professional schools	20.11	26.03	0.12	0.16
55 Other educational services	20.05	25.51	0.10	0.14
56 Ambulatory health care services	12.53	18.55	0.11	0.15
57 Hospitals	8.92	13.12	0.11	0.14
58 Nursing and residential care facilities	14.47	18.56	0.05	0.08
59 Social assistance	26.20	31.65	0.11	0.15
60 Arts and entertainment	24.28	28.61	0.09	0.12
61 Accommodation	9.72	13.66	0.15	0.17
62 Eating and drinking	18.08	22.24	0.10	0.13
63 Repair and maintenance	16.59	23.05	0.10	0.14
64 Personal and laundry services	24.82	30.77	0.11	0.15
65 Organizations	13.64	18.14	0.06	0.09
66 Federal government military	8.91	14.09	0.05	0.08
67 Federal government: civilian	9.41	14.75	0.05	0.09
68 State and local government	12.11	17.04	0.05	0.08
PCE	8.04	10.70	0.06	0.08
Visitor's expenditures	10.15	13.43	0.09	0.12
State and local government consumption	11.47	16.12	0.05	0.08
Federal military consumption	8.56	13.33	0.05	0.08
Federal civilian consumption	9.50	14.66	0.05	0.09

Table 6.1. 2012 Detailed Output, Earnings, Employment, and Tax Multipliers for Hawaii - Continued

	Final-demand multipliers: 2012			
	Individual Income (dollars)		GET (dollars)	
Industry	Type I	Type II	Type I	Type II
1 Sugarcane	0.0110	0.0172	0.0210	0.0349
2 Vegetables	0.0156	0.0220	0.0185	0.0328
3 Macadamia nuts, coffee, and other fruits	0.0130	0.0189	0.0190	0.0322
4 Pineapples	0.0144	0.0207	0.0204	0.0345
5 Flowers and nursery products	0.0166	0.0231	0.0169	0.0316
6 Other crops	0.0138	0.0197	0.0175	0.0309
7 Animal production	0.0127	0.0184	0.0132	0.0262
8 Aquaculture	0.0143	0.0206	0.0153	0.0295
9 Commercial fishing	0.0115	0.0154	0.0180	0.0268
10 Forestry & logging	0.0178	0.0290	0.0144	0.0398
11 Support activities for agriculture	0.0143	0.0212	0.0591	0.0748
12 Mining	0.0162	0.0218	0.0120	0.0245
13 Single family construction	0.0196	0.0263	0.0618	0.0770
14 Construction of other buildings	0.0209	0.0281	0.0653	0.0815
15 Heavy and civil engineering construction	0.0212	0.0284	0.0650	0.0814
16 Maintenance & repairs	0.0201	0.0270	0.0635	0.0791
17 Food processing	0.0149	0.0199	0.0228	0.0341
18 Beverage manufacturing	0.0150	0.0195	0.0218	0.0321
19 Apparel and textile manufacturing	0.0103	0.0135	0.0217	0.0290
20 Petroleum manufacturing	0.0020	0.0026	0.0021	0.0034
21 Other manufacturing	0.0121	0.0159	0.0194	0.0280
22 Air transportation	0.0131	0.0169	0.0070	0.0156
23 Water transportation	0.0174	0.0226	0.0144	0.0263
24 Truck and rail transportation	0.0210	0.0278	0.0612	0.0767
25 Transit and ground passenger transportation	0.0216	0.0293	0.0595	0.0770
26 Scenic and support activities for transportation	0.0213	0.0288	0.0633	0.0802
27 Couriers and messengers	0.0215	0.0281	0.0611	0.0762
28 Warehousing and storage	0.0241	0.0321	0.0611	0.0792
29 Publishing (include Internet)	0.0138	0.0181	0.0648	0.0745
30 Motion picture and sound recording industries	0.0151	0.0194	0.0631	0.0728
31 Broadcasting (Radio, TV, Cable)	0.0156	0.0203	0.0538	0.0644
32 Telecommunications	0.0144	0.0188	0.0078	0.0177
33 Internet providers, web, and data processing	0.0176	0.0229	0.0725	0.0844
34 Other information services	0.0190	0.0251	0.0686	0.0823
35 Electricity	0.0069	0.0091	0.0039	0.0089
36 Other utilities	0.0068	0.0088	0.0036	0.0080
37 Wholesale trade	0.0158	0.0209	0.0195	0.0310
38 Retail trade	0.0161	0.0217	0.0606	0.0732
39 Credit intermediation and related activities	0.0195	0.0259	0.0236	0.0379
40 Insurance carriers and related activities	0.0184	0.0240	0.0141	0.0269
41 Other finance and insurance	0.0321	0.0423	0.0090	0.0320
42 Owner-occupied dwellings	0.0031	0.0041	0.0055	0.0079
43 Real estate	0.0091	0.0125	0.0548	0.0623
44 Rental & leasing	0.0055	0.0077	0.0475	0.0525

Table 6.1. 2012 Detailed Output, Earnings, Employment, and Tax Multipliers for Hawaii - Continued

	Final-demand multipliers: 2012			
	Individual Income (dollars)		GET (dollars)	
Industry	Type I	Type II	Type I	Type II
45 Legal services	0.0250	0.0334	0.0614	0.0803
46 Architectural and engineering services	0.0278	0.0368	0.0680	0.0883
47 Computer systems design services	0.0267	0.0351	0.0633	0.0823
48 R&D in the physical, engineering, & life sciences	0.0215	0.0296	0.0584	0.0767
49 Other professional services	0.0271	0.0361	0.0668	0.0870
50 Management of companies and enterprises	0.0279	0.0364	0.0636	0.0826
51 Travel arrangement and reservation services	0.0271	0.0367	0.0583	0.0800
52 Administrative and support services	0.0268	0.0356	0.0587	0.0786
53 Waste management and remediation services	0.0216	0.0285	0.0609	0.0767
54 Colleges, universities, and professional schools	0.0350	0.0447	0.0656	0.0878
55 Other educational services	0.0286	0.0376	0.0616	0.0820
56 Ambulatory health care services	0.0294	0.0393	0.0624	0.0849
57 Hospitals	0.0225	0.0294	0.0711	0.0868
58 Nursing and residential care facilities	0.0201	0.0269	0.0165	0.0317
59 Social assistance	0.0264	0.0354	0.0667	0.0871
60 Arts and entertainment	0.0187	0.0258	0.0597	0.0758
61 Accommodation	0.0163	0.0228	0.0640	0.0787
62 Eating and drinking	0.0192	0.0261	0.0641	0.0797
63 Repair and maintenance	0.0283	0.0390	0.0577	0.0819
64 Personal and laundry services	0.0272	0.0370	0.0674	0.0896
65 Organizations	0.0219	0.0294	0.0212	0.0380
66 Federal government military	0.0343	0.0428	0.0000	0.0193
67 Federal government: civilian	0.0343	0.0432	0.0019	0.0219
68 State and local government	0.0271	0.0352	0.0054	0.0238
PCE	0.0133	0.0177	0.0301	0.0400
Visitor's expenditures	0.0151	0.0205	0.0480	0.0603
State and local government consumption	0.0254	0.0331	0.0069	0.0243
Federal military consumption	0.0311	0.0390	0.0028	0.0206
Federal civilian consumption	0.0326	0.0412	0.0052	0.0244

Table 6.1. 2012 Detailed Output, Earnings, Employment, and Tax Multipliers for Hawaii - Continued

	Final-demand multipliers: 2012			
	TAT (dollars)		Other State Taxes (dollars)	
Industry	Type I	Type II	Type I	Type II
1 Sugarcane	0.0003	0.0007	0.0135	0.0195
2 Vegetables	0.0003	0.0007	0.0139	0.0200
3 Macadamia nuts, coffee, and other fruits	0.0003	0.0007	0.0146	0.0202
4 Pineapples	0.0004	0.0008	0.0146	0.0207
5 Flowers and nursery products	0.0005	0.0009	0.0149	0.0213
6 Other crops	0.0002	0.0006	0.0131	0.0188
7 Animal production	0.0001	0.0005	0.0123	0.0179
8 Aquaculture	0.0003	0.0007	0.0138	0.0199
9 Commercial fishing	0.0002	0.0004	0.0101	0.0139
10 Forestry & logging	0.0001	0.0008	0.0108	0.0217
11 Support activities for agriculture	0.0003	0.0007	0.0127	0.0194
12 Mining	0.0002	0.0005	0.0108	0.0162
13 Single family construction	0.0003	0.0008	0.0129	0.0194
14 Construction of other buildings	0.0004	0.0008	0.0129	0.0198
15 Heavy and civil engineering construction	0.0004	0.0009	0.0129	0.0200
16 Maintenance & repairs	0.0003	0.0008	0.0123	0.0190
17 Food processing	0.0009	0.0012	0.0138	0.0186
18 Beverage manufacturing	0.0008	0.0011	0.0134	0.0178
19 Apparel and textile manufacturing	0.0008	0.0010	0.0130	0.0161
20 Petroleum manufacturing	0.0002	0.0002	0.0067	0.0073
21 Other manufacturing	0.0006	0.0009	0.0119	0.0156
22 Air transportation	0.0002	0.0004	0.0160	0.0197
23 Water transportation	0.0003	0.0006	0.0263	0.0314
24 Truck and rail transportation	0.0002	0.0007	0.0121	0.0188
25 Transit and ground passenger transportation	0.0003	0.0008	0.0118	0.0193
26 Scenic and support activities for transportation	0.0002	0.0007	0.0127	0.0199
27 Couriers and messengers	0.0005	0.0009	0.0139	0.0204
28 Warehousing and storage	0.0001	0.0007	0.0136	0.0214
29 Publishing (include Internet)	0.0007	0.0010	0.0111	0.0153
30 Motion picture and sound recording industries	0.0005	0.0008	0.0110	0.0152
31 Broadcasting (Radio, TV, Cable)	0.0001	0.0004	0.0092	0.0137
32 Telecommunications	0.0002	0.0005	0.0369	0.0412
33 Internet providers, web, and data processing	0.0024	0.0028	0.0144	0.0196
34 Other information services	0.0020	0.0025	0.0139	0.0197
35 Electricity	0.0002	0.0004	0.0402	0.0424
36 Other utilities	0.0002	0.0003	0.0295	0.0314
37 Wholesale trade	0.0009	0.0013	0.0111	0.0161
38 Retail trade	0.0004	0.0008	0.0116	0.0171
39 Credit intermediation and related activities	0.0022	0.0026	0.0179	0.0240
40 Insurance carriers and related activities	0.0004	0.0007	0.0861	0.0916
41 Other finance and insurance	0.0003	0.0010	0.0178	0.0277
42 Owner-occupied dwellings	0.0001	0.0002	0.0036	0.0046
43 Real estate	0.0003	0.0005	0.0140	0.0172
44 Rental & leasing	0.0001	0.0002	0.0061	0.0083

Table 6.1. 2012 Detailed Output, Earnings, Employment, and Tax Multipliers for Hawaii - Continued

	Final-demand multipliers: 2012			
	TAT (dollars)		Other State Taxes (dollars)	
Industry	Type I	Type II	Type I	Type II
45 Legal services	0.0016	0.0021	0.0118	0.0199
46 Architectural and engineering services	0.0003	0.0009	0.0141	0.0227
47 Computer systems design services	0.0014	0.0019	0.0136	0.0217
48 R&D in the physical, engineering, & life sciences	0.0007	0.0012	0.0121	0.0200
49 Other professional services	0.0014	0.0020	0.0143	0.0230
50 Management of companies and enterprises	0.0002	0.0007	0.0149	0.0231
51 Travel arrangement and reservation services	0.0004	0.0011	0.0110	0.0203
52 Administrative and support services	0.0005	0.0010	0.0137	0.0222
53 Waste management and remediation services	0.0006	0.0011	0.0139	0.0207
54 Colleges, universities, and professional schools	0.0003	0.0010	0.0152	0.0246
55 Other educational services	0.0003	0.0009	0.0142	0.0229
56 Ambulatory health care services	0.0004	0.0011	0.0135	0.0232
57 Hospitals	0.0013	0.0017	0.0156	0.0223
58 Nursing and residential care facilities	0.0007	0.0011	0.0141	0.0206
59 Social assistance	0.0003	0.0009	0.0141	0.0229
60 Arts and entertainment	0.0003	0.0008	0.0127	0.0196
61 Accommodation	0.0519	0.0523	0.0140	0.0203
62 Eating and drinking	0.0006	0.0011	0.0142	0.0208
63 Repair and maintenance	0.0006	0.0014	0.0114	0.0217
64 Personal and laundry services	0.0009	0.0015	0.0144	0.0239
65 Organizations	0.0006	0.0011	0.0173	0.0245
66 Federal government military	0.0000	0.0006	0.0121	0.0204
67 Federal government: civilian	0.0001	0.0007	0.0128	0.0213
68 State and local government	0.0004	0.0009	0.0127	0.0206
PCE	0.0009	0.0012	0.0129	0.0171
Visitor's expenditures	0.0178	0.0182	0.0125	0.0178
State and local government consumption	0.0004	0.0009	0.0129	0.0203
Federal military consumption	0.0001	0.0006	0.0117	0.0193
Federal civilian consumption	0.0002	0.0007	0.0130	0.0212

Table 6.1. 2012 Detailed Output, Earnings, Employment, and Tax Multipliers for Hawaii - Continued

	Industry	Direct-effect multipliers: 2012			
		Earnings (dollars)		Employment (total jobs)	
		Type I	Type II	Type I	Type II
1	Sugarcane	1.45	1.93	1.27	1.49
2	Vegetables	1.50	1.99	1.25	1.48
3	Macadamia nuts, coffee, and other fruits	1.38	1.84	1.21	1.43
4	Pineapples	1.48	1.97	1.27	1.50
5	Flowers and nursery products	1.55	2.06	1.28	1.52
6	Other crops	1.39	1.86	1.24	1.46
7	Animal production	1.35	1.80	1.22	1.43
8	Aquaculture	1.48	1.97	1.35	1.58
9	Commercial fishing	1.70	2.26	1.18	1.34
10	Forestry & logging	1.57	2.09	1.54	1.85
11	Support activities for agriculture	1.44	1.92	1.22	1.43
12	Mining	1.25	1.66	1.18	1.46
13	Single family construction	1.30	1.73	1.54	2.30
14	Construction of other buildings	1.39	1.84	1.60	2.41
15	Heavy and civil engineering construction	1.40	1.87	1.59	2.42
16	Maintenance & repairs	1.34	1.78	1.58	2.37
17	Food processing	2.46	3.27	2.28	2.89
18	Beverage manufacturing	2.54	3.37	3.03	4.11
19	Apparel and textile manufacturing	3.64	4.85	2.25	2.77
20	Petroleum manufacturing	2.49	3.32	7.47	11.35
21	Other manufacturing	2.21	2.95	2.09	2.76
22	Air transportation	1.81	2.40	1.94	2.83
23	Water transportation	2.45	3.25	3.02	4.34
24	Truck and rail transportation	1.33	1.77	1.33	1.83
25	Transit and ground passenger transportation	1.29	1.71	1.17	1.44
26	Scenic and support activities for transportation	1.32	1.76	1.32	1.81
27	Couriers and messengers	1.77	2.35	1.64	2.19
28	Warehousing and storage	1.16	1.54	1.14	1.48
29	Publishing (include Internet)	1.77	2.36	1.82	2.45
30	Motion picture and sound recording industries	1.47	1.95	1.39	1.78
31	Broadcasting (Radio, TV, Cable)	1.09	1.46	1.15	1.68
32	Telecommunications	1.35	1.80	1.58	2.41
33	Internet providers, web, and data processing	2.32	3.09	2.59	3.49
34	Other information services	1.71	2.28	2.13	3.00
35	Electricity	1.47	1.96	2.06	3.47
36	Other utilities	1.64	2.18	1.63	2.20
37	Wholesale trade	1.72	2.29	1.92	2.63
38	Retail trade	1.29	1.72	1.20	1.50
39	Credit intermediation and related activities	2.42	3.22	3.21	4.36
40	Insurance carriers and related activities	1.75	2.32	1.94	2.71
41	Other finance and insurance	1.12	1.49	1.06	1.22
42	Owner-occupied dwellings	NA	NA	NA	NA
43	Real estate	1.33	1.77	1.29	1.70
44	Rental & leasing	1.11	1.47	1.09	1.45

Table 6.1. 2012 Detailed Output, Earnings, Employment, and Tax Multipliers for Hawaii - Continued

Industry	Direct-effect multipliers: 2012			
	Earnings (dollars)		Employment (total jobs)	
	Type I	Type II	Type I	Type II
45 Legal services	1.18	1.57	1.35	2.19
46 Architectural and engineering services	1.27	1.68	1.51	2.41
47 Computer systems design services	1.22	1.62	1.33	1.96
48 R&D in the physical, engineering, & life sciences	1.26	1.67	1.55	2.57
49 Other professional services	1.29	1.71	1.24	1.59
50 Management of companies and enterprises	1.24	1.64	1.39	2.22
51 Travel arrangement and reservation services	1.12	1.49	1.24	2.03
52 Administrative and support services	1.15	1.53	1.09	1.32
53 Waste management and remediation services	1.52	2.02	1.65	2.38
54 Colleges, universities, and professional schools	1.09	1.45	1.08	1.39
55 Other educational services	1.22	1.62	1.17	1.49
56 Ambulatory health care services	1.16	1.55	1.23	1.83
57 Hospitals	1.64	2.18	2.09	3.08
58 Nursing and residential care facilities	1.42	1.89	1.37	1.76
59 Social assistance	1.15	1.53	1.09	1.31
60 Arts and entertainment	1.32	1.76	1.15	1.35
61 Accommodation	1.56	2.08	1.68	2.37
62 Eating and drinking	1.44	1.92	1.26	1.55
63 Repair and maintenance	1.09	1.45	1.10	1.53
64 Personal and laundry services	1.25	1.66	1.16	1.43
65 Organizations	1.57	2.09	1.58	2.10
66 Federal government military	1.00	1.33	1.00	1.58
67 Federal government: civilian	1.04	1.38	1.06	1.66
68 State and local government	1.11	1.47	1.11	1.56

REFERENCES

Alexander and Baldwin, Inc., *2008 Annual Report*.

Bureau of Economic Analysis, U.S. Department of Commerce, SA-04 State Income and Employment Summary, September 2015.

Bureau of Economic Analysis, U.S. Department of Commerce, CA-04 County Income and Employment Summary, November 2015.

Bureau of Economic Analysis, U.S. Department of Commerce, SA-05N Personal Income by Major Source and Earnings by Industry, September 2015.

Bureau of Economic Analysis, U.S. Department of Commerce, CA-05N Personal Income by Major Source and Earnings by Industry and by County, November 2015.

Bureau of Economic Analysis, U.S. Department of Commerce, SA-06N Compensation of Employees Received by Industry, September 2015.

Bureau of Economic Analysis, U.S. Department of Commerce, CA-06N Compensation of Employees Received by Industry and by County, November 2015.

Bureau of Economic Analysis, U.S. Department of Commerce, SA-07N Wage and Salary Disbursements by Industry, September 2015.

Bureau of Economic Analysis, U.S. Department of Commerce, SA-25N Total Full-time and Part-time Employment by Industry, September 2015.

Bureau of Economic Analysis, U.S. Department of Commerce, CA-25N Total Full-time and Part-time Employment by Industry and by County, November 2015.

Bureau of Economic Analysis, U.S. Department of Commerce, SA-27N Wage and Salary Employment by Industry, September 2015.

Bureau of Economic Analysis, U.S. Department of Commerce, SA-30 State Economic Profiles, September 2015.

Bureau of Economic Analysis, U.S. Department of Commerce, CA-30 Regional Economic Profiles, November 2015.

Bureau of Economic Analysis, U.S. Department of Commerce, CA-34 Wage and Salary Disbursements and Employment by County, November 2015.

Bureau of Economic Analysis, U.S. Department of Commerce, SA-35 Personal Current Transfer Receipts, September 2015.

Bureau of Economic Analysis, U.S. Department of Commerce, CA-35 Personal Current Transfer Receipts by County, November 2015.

Bureau of Economic Analysis, U.S. Department of Commerce, SA-45 Farm Income and Expenses, September 2015.

Bureau of Economic Analysis, U.S. Department of Commerce, CA-45 Farm Income and Expenses by County, November 2015.

Bureau of Economic Analysis, U.S. Department of Commerce, SA-50 Personal Current Tax, September 2015.

Bureau of Economic Analysis, U.S. Department of Commerce, Gross Domestic Product by State, December 2015.

Bureau of Economic Analysis, U.S. Department of Commerce, Interactive Access to Input-Output Accounts Data, the Use of Commodities by Industries after Redefinitions, July 2015.

Bureau of Economic Analysis, U.S. Department of Commerce, *Preview of the Benchmark Input-Output Accounts for 2002*, September 2005.

Bureau of Economic Analysis, U.S. Department of Commerce, *U.S. Benchmark Input-Output Accounts, 2002*, October 2007.

Bureau of Economic Analysis, U.S. Department of Commerce, *Benchmark Input-Output Accounts of the United States 1997*, December 2002.

Bureau of Economic Analysis, U.S. Department of Commerce, *Concepts and Methods of the U.S. Input-Output Accounts*, September 2006.

Bureau of Economic Analysis, U.S. Department of Commerce, *Personal Consumption Expenditures – Methodology Papers: U.S. National Income and Product Accounts*, June 1990.

Bureau of Economic Analysis, U.S. Department of Commerce, *Regional Multipliers: A User Handbook for the Regional Input-Output Modeling System (RIMS II)*, March 1997.

Bureau of Labor Statistics, U.S. Department of Labor, Consumer Expenditure Survey, March 2010.

Bureau of Labor Statistics, U.S. Department of Labor, Consumer Expenditure Survey for Honolulu MSA, December 2008.

Chase, Robert A., Eastern Washington Transport-Oriented Input-Output Study, Technical report EWITS Research Report No. 10, February 1996.

City and County of Honolulu, *Comprehensive Annual Financial Report for the Fiscal Year Ended June 30, 2013.*

City and County of Honolulu, *Comprehensive Annual Financial Report for the Fiscal Year Ended June 30, 2012.*

County of Hawaii, *Comprehensive Annual Financial Report for the Fiscal Year Ended June 30, 2013.*

County of Hawaii, *Comprehensive Annual Financial Report for the Fiscal Year Ended June 30, 2012.*

County of Kauai, *Comprehensive Annual Financial Report for the Fiscal Year Ended June 30, 2013*.

County of Kauai, *Comprehensive Annual Financial Report for the Fiscal Year Ended June 30, 2012*.

County of Maui, *Comprehensive Annual Financial Report for the Fiscal Year Ended June 30, 2013.*

County of Maui, *Comprehensive Annual Financial Report for the Fiscal Year Ended June 30, 2012.*

Federal Procurement Data System (FPDS), *Federal Procurement Dollars by State*, July 2015.

Friedenberg, Howard L. and Richard M. Beemiller, "Comprehensive Revision of Gross State Product by Industry, 1977-94," *Survey of Current Business*, June 1997, pp. 15-41.

Hawaii Agricultural Statistics Service, *Statistics of Hawaii Agriculture* 2011.

Hawaii Department of Accounting and General Services (DAGS), Annual Financial Report, July 2015.

Hawaii Department of Business, Economic Development & Tourism (DBEDT), Foreign-Trade Zone No. 9, *Report to the Foreign-Trade Zones Board on General-Purpose Zone and Special-Purpose Subzone Activity in the State of Hawaii for the Federal Fiscal Year 2013*.

Hawaii Department of Business, Economic Development & Tourism (DBEDT), Foreign-Trade Zone No. 9, *Report to the Foreign-Trade Zones Board on General-Purpose Zone and Special-Purpose Subzone Activity in the State of Hawaii for the Federal Fiscal Year 2012*.

Hawaii Department of Business, Economic Development and Tourism (DBEDT), *The Hawaii Input-Output Study: 2007 Benchmark Report, December* 2013.

Hawaii Department of Business, Economic Development and Tourism (DBEDT), *The Hawaii Input-Output Study: 2002 Benchmark Report*, June 2006.

Hawaii Department of Business, Economic Development and Tourism (DBEDT), *The Hawaii Input-Output Study: 1997 Benchmark Report*, March 2002.

Hawaii Department of Business, Economic Development and Tourism (DBEDT), *The State of Hawaii Data Book 2013*.

Hawaii Department of Business, Economic Development and Tourism (DBEDT), *Historical Visitor Data*, DBEDT Web Site, July 2015.

Hawaii Department of Commerce and Consumer Affairs, *Report of the Insurance Commissioner of Hawaii: Summary of Insurance Business for the Year 2012*.

Hawaii Department of Taxation, *Annual Report 2011-2013*.

Hawaiian Electric Industries, Inc., 2012 *Annual Report*.

Kuhback, Peter D. and Mark A. Planting, "Annual Input-Output Accounts of the U.S. Economy, 1997," *Survey of Current Business*, January 2001, pp. 9-43.

Hawaii Housing Policy Study, 2006, a Report Prepared for Hawaii Housing Finance and Development Corporation and Housing Officers/Administrators for Honolulu, Maui, Hawaii, and Kauai Counties.

Locations, Inc. Research and Consulting Division + SMS Research and Marketing Services, *Hawaii Housing Policy Study Update, 2003*, A Report Prepared for the State Housing Finance and Development Corporation, City and County of Honolulu and the Counties of Hawaii, Maui, and Kauai.

Miller, R.E., and P.D. Blair, *Input-Output Analysis: Foundations and Extensions*. Englewood Cliffs, New Jersey: Prentice Hall, 1985.

U.S. Army Corps of Engineers, *Waterborne Commerce of the United States, Calendar Year 2013, Part 4 – Waterways and Harbors: Pacific Coast, Alaska and Hawaii*.

U.S. Census Bureau, U.S. Department of Commerce, 2012 NAICS Codes and Titles.

U.S. Census Bureau, U.S. Department of Commerce, *2012 Economic Census: Accommodation and Food Services - Geographic Area Series, Hawaii*, July 2015.

U.S. Census Bureau, U.S. Department of Commerce, *2012 Economic Census: Administrative and Support and Waste Management and Remediation Services - Geographic Area Series, Hawaii*, July 2015.

U.S. Census Bureau, U.S. Department of Commerce, *2012 Economic Census: Arts, Entertainment, and Recreation - Geographic Area Series, Hawaii*, July 2015.

U.S. Census Bureau, U.S. Department of Commerce, *2012 Economic Census: Construction - Geographic Area Series, Hawaii*, July 2015.

U.S. Census Bureau, U.S. Department of Commerce, 2012 *Economic Census: Educational Services - Geographic Area Series, Hawaii*, July 2015.

U.S. Census Bureau, U.S. Department of Commerce, 2012 *Economic Census: Finance and Insurance - Geographic Area Series, Hawaii*, July 2015.

U.S. Census Bureau, U.S. Department of Commerce, *2012 Economic Census: Health Care and Social Assistance - Geographic Area Series, Hawaii*, July 2015.

U.S. Census Bureau, U.S. Department of Commerce, 2012 *Economic Census: Information - Geographic Area Series, Hawaii*, July 2015.

U.S. Census Bureau, U.S. Department of Commerce, *2012 Economic Census: Manufacturing - Geographic Area Series, Hawaii*, April 2015.

U.S. Census Bureau, U.S. Department of Commerce, *2012 Economic Census: Other Services (except Public Administration) - Geographic Area Series, Hawaii*, July 2015.

U.S. Census Bureau, U.S. Department of Commerce, *2012 Economic Census: Professional, Scientific, and Technical Services - Geographic Area Series, Hawaii*, July 2015.

U.S. Census Bureau, U.S. Department of Commerce, *2012 Economic Census: Real Estate and Rental and Leasing - Geographic Area Series, Hawaii*, July 2015.

U.S. Census Bureau, U.S. Department of Commerce, *2012 Economic Census: Retail Trade - Geographic Area Series, Hawaii*, July 2015.

U.S. Census Bureau, U.S. Department of Commerce, *2012 Economic Census: Transportation and Warehousing - Geographic Area Series, Hawaii*, July 2015.

U.S. Census Bureau, U.S. Department of Commerce, *2007 Economic Census: Wholesale Trade - Geographic Area Series, Hawaii*, July 2015.

U.S. Census Bureau, U.S. Department of Commerce, *Census of Governments: State and Local Government Finances, 2012-2013.*

U.S. Census Bureau, U.S. Department of Commerce, *Census of Governments: State and Local Government Finances, 2011-2012.*

U.S. Census Bureau, U.S. Department of Commerce, *Census of Governments: State Government Finances: 2013.*

U.S. Census Bureau, U.S. Department of Commerce, *Census of Governments: State Government Finances: 2012.*

U.S. Census Bureau, U.S. Department of Commerce, *2012 County Business Patterns*.

U.S. Census Bureau, U.S. Department of Commerce, 2012 *Economic Census: Manufacturing Detailed Statistics for the state,* June 2015.

U.S. Census Bureau, U.S. Department of Commerce, *2007 Economic Census: Non-Employer Statistics,* July 2015.

Apendix A. NAICS Codes for Industries in the 2012 I-O Table for Hawaii

Detailed Table Sector		NAICS Code	Condensed Table Sector	
1	Sugarcane	11193	1	Agriculture
2	Vegetable and melon farming	1112	1	
3	Macadamia nuts, coffee, and other fruits	1113 except pineapples	1	
4	Pineapples	part of 111339	1	
5	Flowers and nursery products	1114	1	
6	Other crops	other 111	1	
7	Animal production	112 except 1125	1	
8	Aquaculture	1125	1	
9	Commercial fishing	114	1	
10	Forestry & logging	113	1	
11	Support activities for agriculture	115	1	
12	Mining	21	2	Mining and construction
13	Single family construction	part of 23	2	
14	Construction of other buildings	part of 23	2	
15	Heavy and civil engineering construction	part of 23	2	
16	Maintenance & repairs	part of 23	2	
17	Food processing	311	3	Food processing
18	Beverage manufacturing	312	4	Other manufacturing
19	Apparel and textile manufacturing	313-315	4	
20	Petroleum manufacturing	324	4	
21	Other manufacturing	other 31-33	4	
22	Air transportation	481	5	Transportation
23	Water transportation	483	5	
24	Truck and rail transportation	484	5	
25	Transit and ground passenger transportation	485	5	
26	Scenic and support activities for transportation	487-488	5	
27	Couriers and messengers	492	5	
28	Warehousing and storage	493	5	
29	Publishing (except Internet)	511	6	Information
30	Motion picture and sound recording industries	512	6	
31	Broadcasting (Radio, TV, Cable)	515	6	
32	Telecommunications	517	6	
33	Internet providers, web, and data processing	518	6	
34	Other information services	519	6	
35	Electricity	2211	7	Utilities
36	Other utilities	2212-2213	7	
37	Wholesale trade	42	8	Wholesale trade
38	Retail trade	44-45	9	Retail trade
39	Credit intermediation and related activities	522	10	Finance and insurance
40	Insurance carriers and related activities	524	10	
41	Other finance and insurance	523, 525	10	
42	Owner-occupied dwellings		11	Real estate and rentals
43	Real estate	531	11	
44	Rental & leasing	532-533	11	

Apendix A. NAICS Codes for Industries in the 2012 I-O Table for Hawaii

Detailed Table Sector		NAICS Code	Condensed Table Sector	
45	Legal services	5411	12	Professional services
46	Architectural and engineering services	5413	12	
47	Computer systems design services	5415	12	
48	R&D in the physical, engineering, & life sciences	54171	12	
49	Other professional services	other 54	12	
50	Management of companies and enterprises	55	13	Business services
51	Travel arrangement and reservation services	5615	13	
52	Administrative and support services	561 except 5615	13	
53	Waste management and remediation services	562	13	
54	Colleges, universities, and professional schools	6113	14	Educational services
55	Other educational services	other 611	14	
56	Ambulatory health care services	621	15	Health services
57	Hospitals	622	15	
58	Nursing and residential care facilities	623	15	
59	Social assistance	624	15	
60	Arts and entertainment	71	16	Arts and entertainment
61	Accommodation	721	17	Accommodation
62	Eating and drinking	722	18	Eating and drinking
63	Repair and maintenance	811	19	Other services
64	Personal and laundry services	812, 814	19	
65	Organizations	813	19	
66	Federal government military	part of Federal gov't	20	Government
67	Federal government: civilian	part of Federal gov't	20	
68	State and local government	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:

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

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 *j*th sector (O_j) can be obtained by summing down the *j*th 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 *i*th 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 *j*th 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 *i*th sector's direct employment coefficient in its *i*th 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	.0080
Air transportation	.0030
Water transportation	.0175

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

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.

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 retail trade sector. The retail markup for groceries is around 26.4 percent of the purchasers' price, so $26.40 of the $100 would be a household purchase from the retail trade sector. A wholesaler sells the good to the retail trade sector, and the wholesale margin is around 9 percent of the purchasers' 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 2.85 percent of the purchasers' cost, so $2.85 would be a household purchase from the three transportation sectors. The remaining $61.75 is the producer value, the value that the

vegetable producer received when he/she sold the good. Thus, there is also a household purchase from the vegetable producing sector of $61.75, assuming all of the vegetables are produced locally and not imported.

Typical margins are listed in the Appendix C. One needs to be aware that not all retail goods are purchased from wholesalers in Hawaii. Some are purchased direct 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:

$$U_i = \sum_{j=1}^{i} Z_{ij} = X_i - Y_i \tag{D.1}$$

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

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

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:

$$\sum_{j=1}^{n} M_j = M \tag{D.3}$$

where M is the control total for intermediate imports computed based on relations between the value added and expenditure sides of the GSP account.

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

Let

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

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

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

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

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

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

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

Now columns are balanced, but rows get out of balance. So we have to repeat the above procedure to balance the rows. Once the rows are balanced for the second round, columns get off-balanced again. So the procedure should be repeated many times until all rows and columns of the inter-industry transactions table are balanced or they add up to their control totals. The balancing procedure was implemented using specifically designed macros in Microsoft Excel.