THE 2005 STATE INPUT-OUTPUT STUDY FOR HAWAII

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

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PREFACE

This report is the first update of the 2002 benchmark report of input-output (I-O) studies of Hawaii's economy prepared by the Department of Business, Economic Development & Tourism (DBEDT). Eight benchmark reports of I-O studies have been conducted in Hawaii for 1967, 1972, 1977, 1982, 1987, 1992, 1997, and 2002. 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. This update is based on both available and estimated 2005 data.

The report was prepared at the Research and Economic Analysis Division (READ) of DBEDT by Dr. Binsheng Li, under the supervision of Dr. Pearl Imada Iboshi, Division Head.

I. INTRODUCTION

This report presents the 2005 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.

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 2005 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 2005 I-O table updates the 2002 table by including the latest available data on jobs, earnings, final demand, state taxes, components of value added, and outputs of a few industries. The only structure change from the 2002 table is that the 2005 detailed I-O table has a total of 68 sectors compared to 67 sectors in the 2002 table.

The remainder of this report is organized as follows. Section 2 provides the derivation of the direct and total requirements tables and multipliers using the condensed version of the 2005 Hawaii I-O table. Section 3 shows a few examples of economic impact analyses using the I-O model, followed by some cautionary notes in using I-O multipliers. Section 4 provides a description of industries, new data sources, and estimation procedures. Section 5 describes the estimation of the inter-industry matrix and its balancing procedure. Section 6 presents the multipliers derived from the 2005 detailed I-O table for Hawaii. The corresponding transactions table and the direct and total requirements tables are available at the DBEDT Web Site.

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. More detailed information about the I-O methodology can be found in the 2002 benchmark study.

Transactions Table

For illustrative purposes, a condensed version of the 2005 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 2005. 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. 2005 Condensed Input-Output Transactions Table for Hawaii (in $million)

	Industry	Agriculture	Mining and Construction	Food processing	Other manufacturing	Transportation
1	Agriculture	65.2	6.5	168.8	10.5	0.2
2	Mining and construction	7.1	30.7	4.5	4.7	72.9
3	Food processing	5.1	0.0	30.7	14.8	2.3
4	Other manufacturing	32.5	357.6	31.4	209.0	420.8
5	Transportation	17.1	138.3	20.8	86.0	308.2
6	Information	1.7	32.3	3.9	22.8	43.6
7	Utilities	11.4	75.1	12.7	81.7	70.9
8	Wholesale trade	25.4	338.0	42.2	110.8	116.8
9	Retail trade	4.5	322.6	11.1	30.5	8.0
10	Finance and insurance	7.7	74.2	3.8	37.3	94.7
11	Real estate and rentals	29.6	170.7	10.9	49.3	127.2
12	Professional services	2.8	471.3	9.9	55.5	130.0
13	Business services	4.7	124.6	54.1	134.1	379.2
14	Educational services	0.0	1.1	0.2	9.3	21.2
15	Health services	0.0	0.0	0.0	0.0	0.7
16	Arts and entertainment	0.2	2.9	0.9	2.8	1.7
17	Accommodation	0.3	5.5	2.1	6.4	2.6
18	Eating and drinking	0.6	32.8	9.2	19.4	59.2
19	Other services	3.8	39.2	9.1	39.2	39.4
20	Government	4.2	9.9	3.4	17.4	256.1
	Total intermediate input	224.2	2,233.4	429.8	941.6	2,155.6
	Imports	106.6	1,814.0	406.8	2,434.4	1,089.3
	Labor income	271.4	2,698.4	222.2	722.3	1,480.5
	Compensation of employees	259.4	2,316.0	219.7	481.3	1,353.0
	Proprietor's income	12.0	382.4	2.5	241.0	127.5
	TOPI	-63.7	67.0	7.4	12.6	231.0
	Other capital costs	188.3	494.6	4.1	-16.7	280.5
	Total Value added	396.0	3,260.0	233.8	718.2	1,992.0
	Output	726.8	7,307.4	1,070.4	4,094.2	5,236.9
	Wage and salary jobs	8,278.0	34,645.0	6,399.0	8,998.0	28,333.0
	Proprietors' jobs	7,405.0	10,256.0	372.0	2,744.0	3,316.0
	Total jobs	15,683.0	44,901.0	6,771.0	11,742.0	31,649.0
	Earnings	247.1	2,367.7	180.2	608.3	1,210.6
	State taxes	19.6	337.2	12.8	39.3	146.8

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

Table 2.1. 2005 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	0.3	0.4	0.0	25.1
2	Mining and construction	3.9	134.8	5.2	19.4	12.7	358.5
3	Food processing	0.3	0.0	0.7	0.5	0.0	0.0
4	Other manufacturing	5.4	528.8	39.2	73.4	18.6	138.7
5	Transportation	9.2	11.3	13.8	29.6	21.3	56.6
6	Information	136.6	3.1	57.0	75.1	117.1	117.3
7	Utilities	7.0	50.9	15.2	78.2	12.7	115.7
8	Wholesale trade	16.3	12.0	61.4	22.9	5.0	64.3
9	Retail trade	21.8	5.5	24.2	66.3	5.2	119.8
10	Finance and insurance	26.6	15.0	32.4	84.8	674.1	543.3
11	Real estate and rentals	44.1	9.7	81.6	610.2	196.1	1,107.9
12	Professional services	47.4	35.0	53.0	103.8	167.8	264.2
13	Business services	41.0	25.4	134.1	219.0	153.8	408.4
14	Educational services	6.7	14.5	2.7	5.2	12.3	2.8
15	Health services	0.0	0.0	0.0	0.0	0.0	0.0
16	Arts and entertainment	3.7	0.2	0.0	0.0	0.0	0.1
17	Accommodation	2.1	1.5	4.9	8.2	11.0	22.7
18	Eating and drinking	12.8	7.0	16.3	27.1	38.4	36.9
19	Other services	16.0	1.4	24.2	28.9	37.0	475.6
20	Government	5.9	7.2	12.2	44.7	32.5	66.6
	Total intermediate input	407.0	863.4	578.4	1,497.6	1,515.5	3,924.4
	Imports	450.2	246.0	367.5	722.1	489.0	523.6
	Labor income	686.9	299.5	1,010.8	2,325.0	1,253.8	1,062.0
	Compensation of employees	643.0	297.0	922.8	2,132.0	1,157.0	605.6
	Proprietor's income	43.9	2.5	88.0	193.0	96.8	456.4
	TOPI	96.0	154.0	551.6	1,127.0	136.0	654.7
	Other capital costs	555.1	449.5	300.6	550.0	1,005.2	7,845.3
	Total Value added	1,338.0	903.0	1,863.0	4,002.0	2,395.0	9,562.0
	Output	2,195.2	2,012.4	2,808.9	6,221.8	4,399.6	14,009.9
	Wage and salary jobs	10,857.0	2,881.0	17,881.0	71,478.0	17,044.0	13,197.0
	Proprietors' jobs	1,783.0	118.0	3,975.0	17,269.0	8,213.0	29,174.0
	Total jobs	12,640.0	2,999.0	21,856.0	88,747.0	25,257.0	42,371.0
	Earnings	589.3	220.9	899.5	2,070.8	1,087.0	999.4
	State taxes	107.1	84.5	415.2	1,046.8	229.5	395.8

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

Table 2.1. 2005 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	1.1	0.0	6.6	0.6
2	Mining and construction	10.1	13.7	30.2	21.4	3.7
3	Food processing	1.2	0.0	0.0	26.3	0.3
4	Other manufacturing	51.9	60.9	17.8	60.6	3.7
5	Transportation	66.7	36.7	8.2	80.6	3.9
6	Information	91.8	94.7	27.5	79.0	8.2
7	Utilities	21.2	47.3	9.1	95.3	14.7
8	Wholesale trade	43.3	35.6	7.9	101.1	4.5
9	Retail trade	64.7	58.7	1.1	39.3	0.9
10	Finance and insurance	44.3	40.9	6.1	49.7	4.7
11	Real estate and rentals	326.9	159.0	111.4	435.8	29.8
12	Professional services	276.4	246.1	22.4	217.1	20.8
13	Business services	87.3	186.7	41.9	405.8	18.3
14	Educational services	11.2	6.7	7.7	21.8	2.9
15	Health services	0.4	0.0	0.8	36.9	0.2
16	Arts and entertainment	0.0	0.0	0.4	0.3	16.0
17	Accommodation	19.8	6.0	1.3	16.2	0.4
18	Eating and drinking	29.3	22.2	15.8	63.2	7.5
19	Other services	35.8	35.4	5.4	36.6	7.7
20	Government	19.8	23.5	2.9	54.1	9.0
	Total intermediate input	1,202.6	1,075.4	317.9	1,848.0	157.8
	Imports	358.8	290.0	53.7	789.0	57.5
	Labor income	2,091.1	2,109.6	495.0	3,026.2	415.1
	Compensation of employees	1,587.6	1,974.0	480.0	2,709.0	344.0
	Proprietor's income	503.5	135.6	15.0	317.2	71.1
	TOPI	86.7	72.0	38.0	169.0	69.0
	Other capital costs	272.2	346.4	30.0	394.8	120.9
	Total Value added	2,450.0	2,528.0	563.0	3,590.0	605.0
	Output	4,011.4	3,893.3	934.6	6,226.9	820.3
	Wage and salary jobs	24,631.0	51,167.0	14,403.0	59,526.0	12,269.0
	Proprietors' jobs	17,872.0	11,760.0	2,744.0	9,481.0	9,634.0
	Total jobs	42,503.0	62,927.0	17,147.0	69,007.0	21,903.0
	Earnings	1,933.5	1,895.8	445.7	2,713.5	380.4
	State taxes	262.0	265.0	62.9	278.3	34.9

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

Table 2.1. 2005 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	33.7	1.4	1.4	322.5
2	Mining and construction	108.3	57.3	19.3	58.6	977.1
3	Food processing	2.6	185.0	1.9	2.3	274.1
4	Other manufacturing	17.8	88.4	48.0	32.8	2,237.5
5	Transportation	33.8	39.5	26.9	32.0	1,040.5
6	Information	71.6	35.1	48.7	30.8	1,098.0
7	Utilities	168.3	86.7	73.8	59.1	1,106.9
8	Wholesale trade	63.1	156.5	43.6	43.4	1,313.9
9	Retail trade	15.0	16.7	40.3	0.2	856.4
10	Finance and insurance	121.8	41.9	27.6	12.1	1,943.2
11	Real estate and rentals	165.7	203.3	231.8	39.0	4,140.1
12	Professional services	138.6	107.9	92.5	70.4	2,533.2
13	Business services	406.5	101.2	148.5	66.1	3,140.6
14	Educational services	1.2	0.7	3.6	7.2	139.0
15	Health services	0.0	0.0	0.5	2.2	41.8
16	Arts and entertainment	3.1	7.9	1.1	0.1	41.4
17	Accommodation	7.1	5.9	7.1	5.2	136.2
18	Eating and drinking	35.2	36.7	9.6	17.0	496.0
19	Other services	56.2	27.7	23.1	21.9	963.8
20	Government	44.4	19.7	17.0	16.1	666.8
	Total intermediate input	1,460.3	1,251.8	866.5	518.0	23,469.2
	Imports	400.0	590.0	426.0	348.9	11,963.4
	Labor income	1,819.3	1,174.9	1,096.0	11,224.0	35,483.9
	Compensation of employees	1,729.0	1,142.0	936.0	11,224.0	32,512.4
	Proprietor's income	90.3	32.9	160.0	0.0	2,971.5
	TOPI	378.0	162.0	100.0	-68.0	3,980.3
	Other capital costs	833.7	294.1	171.0	1,279.0	15,398.8
	Total Value added	3,031.0	1,631.0	1,367.0	12,435.0	54,863.0
	Output	4,891.3	3,472.8	2,659.5	13,301.8	90,295.6
	Wage and salary jobs	39,187.0	56,698.0	30,558.0	172,528.0	680,958.0
	Proprietors' jobs	925.0	2,449.0	18,140.0	0.0	157,630.0
	Total jobs	40,112.0	59,147.0	48,698.0	172,528.0	838,588.0
	Earnings	1,629.3	1,056.5	1,009.6	8,031.9	29,577.0
	State taxes	425.6	142.9	118.7	447.7	4,872.4

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

Table 2.1. 2005 Condensed Input-Output Transactions Table for Hawaii (in $million) - Continued

	Industry	PCE	Visitor expenditures	Gross private investment*	State and local government
1	Agriculture	159.2	26.3	0.0	2.9
2	Mining and construction	0.0	0.0	5,161.7	735.4
3	Food processing	370.4	40.5	0.3	11.1
4	Other manufacturing	647.4	66.1	104.0	73.0
5	Transportation	1,099.3	2,505.4	219.3	71.1
6	Information	851.6	40.3	0.0	33.8
7	Utilities	671.9	0.0	0.0	208.6
8	Wholesale trade	863.6	262.0	225.2	51.7
9	Retail trade	3,369.6	1,601.4	335.6	35.4
10	Finance and insurance	1,854.0	0.0	0.0	29.1
11	Real estate and rentals	7,427.1	2,084.0	38.7	91.1
12	Professional services	492.8	102.9	439.1	8.7
13	Business services	193.1	370.9	0.0	0.0
14	Educational services	665.3	127.2	0.0	0.0
15	Health services	6,037.7	132.3	0.0	0.0
16	Arts and entertainment	318.8	442.1	0.0	0.0
17	Accommodation	173.8	4,569.8	0.0	10.2
18	Eating and drinking	1,386.3	1,580.4	0.0	0.0
19	Other services	1,448.8	115.2	0.0	124.0
20	Government	647.9	74.4	0.0	5,029.0
	Total Hawaii produced	28,678.5	14,141.2	6,523.9	6,515.3
	Imports	7,707.6	2,233.4	1,384.0	329.4
	Total	36,386.2	16,374.6	7,907.9	6,844.7

* Changes in inventories are combined with gross private investment.

Table 2.1. 2005 Condensed Input-Output Transactions Table for Hawaii (in $million) - Continued

	Industry	Federal government: military	Federal government: civilian	Exports	Total Output
1	Agriculture	0.8	0.1	214.9	726.8
2	Mining and construction	381.7	49.4	2.1	7,307.4
3	Food processing	6.0	2.1	365.9	1,070.4
4	Other manufacturing	93.1	0.1	872.8	4,094.2
5	Transportation	4.1	1.9	295.3	5,236.9
6	Information	7.0	2.1	162.5	2,195.2
7	Utilities	21.3	3.6	0.0	2,012.4
8	Wholesale trade	7.8	0.9	83.8	2,808.9
9	Retail trade	3.0	0.5	19.8	6,221.8
10	Finance and insurance	0.0	0.0	573.2	4,399.6
11	Real estate and rentals	1.1	3.7	224.1	14,009.9
12	Professional services	171.3	11.5	251.9	4,011.4
13	Business services	38.0	0.6	150.1	3,893.3
14	Educational services	3.2	0.0	0.0	934.6
15	Health services	5.1	10.1	0.0	6,226.9
16	Arts and entertainment	0.2	0.0	17.8	820.3
17	Accommodation	1.3	0.0	0.0	4,891.3
18	Eating and drinking	2.3	0.2	7.6	3,472.8
19	Other services	7.6	0.0	0.0	2,659.5
20	Government	6,336.0	547.7	0.0	13,301.8
	Total Hawaii produced	7,090.9	634.6	3,241.8	90,295.6
	Imports	1,141.1	125.9	580.4	25,465.1
	Total	8,232.0	760.5	3,822.2	

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 2005, total output for agriculture amounted to $726.8 million. Of total agricultural sales, total inter-industry sales to agriculture itself and other industries amounted to $322.5 million. Food processing accounted for the largest share ($168.8 million or 52%) of total inter-industry sales of agriculture. Agricultural sales to final demand sectors totaled $404.3 million, including $159.2 million to Hawaii residents and $245.1 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 2005, total agriculture's purchases included $224.2 million from Hawaii's industries (including $65.2 million from agriculture itself and $159.0 million from other industries), $271.4 million as payments to households (i.e. compensation of employees plus proprietors' income), $124.6 million as other value added (taxes on production and imports less subsidies plus other capital costs), and $106.6 million worth of imported inputs. In 2005, there were 8,278 wage and salary jobs and 7,405 self-employed jobs in Hawaii's agricultural sector. Total earnings and state taxes generated from Hawaii's agricultural sector were $247.1 million and $19.6 million, respectively, in 2005.

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 31 cents worth of inputs from Hawaii's industries, including 9 cents worth of inputs from agriculture itself, about 4 cents worth of inputs from other manufacturing, about 4 cents from real estate and rentals, and about 3 cents worth of wholesale services. Value added, and imported commodities accounted for remaining 69 cents.

Table 2.2. 2005 Condensed Direct Requirements Table for Hawaii

	Industry	Agriculture	Mining and Construction	Food processing	Other manufacturing	Transportation
1	Agriculture	0.0897	0.0009	0.1577	0.0026	0.0000
2	Mining and construction	0.0098	0.0042	0.0042	0.0011	0.0139
3	Food processing	0.0071	0.0000	0.0286	0.0036	0.0004
4	Other manufacturing	0.0447	0.0489	0.0294	0.0511	0.0804
5	Transportation	0.0236	0.0189	0.0194	0.0210	0.0589
6	Information	0.0024	0.0044	0.0037	0.0056	0.0083
7	Utilities	0.0157	0.0103	0.0119	0.0200	0.0135
8	Wholesale trade	0.0349	0.0463	0.0394	0.0271	0.0223
9	Retail trade	0.0062	0.0441	0.0104	0.0074	0.0015
10	Finance and insurance	0.0107	0.0102	0.0035	0.0091	0.0181
11	Real estate and rentals	0.0408	0.0234	0.0102	0.0121	0.0243
12	Professional services	0.0039	0.0645	0.0093	0.0136	0.0248
13	Business services	0.0065	0.0170	0.0505	0.0327	0.0724
14	Educational services	0.0000	0.0001	0.0002	0.0023	0.0041
15	Health services	0.0000	0.0000	0.0000	0.0000	0.0001
16	Arts and entertainment	0.0003	0.0004	0.0009	0.0007	0.0003
17	Accommodation	0.0004	0.0008	0.0019	0.0016	0.0005
18	Eating and drinking	0.0008	0.0045	0.0086	0.0047	0.0113
19	Other services	0.0052	0.0054	0.0085	0.0096	0.0075
20	Government	0.0058	0.0014	0.0032	0.0042	0.0489
	Total intermediate input	0.3084	0.3056	0.4016	0.2300	0.4116
	Imports	0.1467	0.2482	0.3801	0.5946	0.2080
	Value added	0.5449	0.4461	0.2184	0.1754	0.3804
	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	0.0001	0.0000
2	Mining and construction	0.0018	0.0670	0.0019	0.0031	0.0029
3	Food processing	0.0001	0.0000	0.0002	0.0001	0.0000
4	Other manufacturing	0.0025	0.2628	0.0140	0.0118	0.0042
5	Transportation	0.0042	0.0056	0.0049	0.0048	0.0048
6	Information	0.0622	0.0016	0.0203	0.0121	0.0266
7	Utilities	0.0032	0.0253	0.0054	0.0126	0.0029
8	Wholesale trade	0.0074	0.0060	0.0218	0.0037	0.0011
9	Retail trade	0.0099	0.0028	0.0086	0.0107	0.0012
10	Finance and insurance	0.0121	0.0075	0.0115	0.0136	0.1532
11	Real estate and rentals	0.0201	0.0048	0.0291	0.0981	0.0446
12	Professional services	0.0216	0.0174	0.0189	0.0167	0.0381
13	Business services	0.0187	0.0126	0.0477	0.0352	0.0350
14	Educational services	0.0031	0.0072	0.0010	0.0008	0.0028
15	Health services	0.0000	0.0000	0.0000	0.0000	0.0000
16	Arts and entertainment	0.0017	0.0001	0.0000	0.0000	0.0000
17	Accommodation	0.0009	0.0007	0.0017	0.0013	0.0025
18	Eating and drinking	0.0058	0.0035	0.0058	0.0044	0.0087
19	Other services	0.0073	0.0007	0.0086	0.0046	0.0084
20	Government	0.0027	0.0036	0.0043	0.0072	0.0074
	Total intermediate input	0.1854	0.4290	0.2059	0.2407	0.3445
	Imports	0.2051	0.1222	0.1308	0.1161	0.1112
	Value added	0.6095	0.4487	0.6632	0.6432	0.5444
	Total	1.0000	1.0000	1.0000	1.0000	1.0000

Table 2.2. 2005 Condensed Direct Requirements Table for Hawaii - Continued

	Industry	Real estate and rentals	Professional services	Business services	Educational services	Health services
1	Agriculture	0.0018	0.0001	0.0003	0.0000	0.0011
2	Mining and construction	0.0256	0.0025	0.0035	0.0324	0.0034
3	Food processing	0.0000	0.0003	0.0000	0.0000	0.0042
4	Other manufacturing	0.0099	0.0129	0.0156	0.0190	0.0097
5	Transportation	0.0040	0.0166	0.0094	0.0088	0.0130
6	Information	0.0084	0.0229	0.0243	0.0294	0.0127
7	Utilities	0.0083	0.0053	0.0122	0.0097	0.0153
8	Wholesale trade	0.0046	0.0108	0.0091	0.0084	0.0162
9	Retail trade	0.0086	0.0161	0.0151	0.0012	0.0063
10	Finance and insurance	0.0388	0.0110	0.0105	0.0066	0.0080
11	Real estate and rentals	0.0791	0.0815	0.0408	0.1192	0.0700
12	Professional services	0.0189	0.0689	0.0632	0.0239	0.0349
13	Business services	0.0291	0.0218	0.0480	0.0449	0.0652
14	Educational services	0.0002	0.0028	0.0017	0.0082	0.0035
15	Health services	0.0000	0.0001	0.0000	0.0009	0.0059
16	Arts and entertainment	0.0000	0.0000	0.0000	0.0005	0.0000
17	Accommodation	0.0016	0.0049	0.0015	0.0013	0.0026
18	Eating and drinking	0.0026	0.0073	0.0057	0.0169	0.0101
19	Other services	0.0339	0.0089	0.0091	0.0057	0.0059
20	Government	0.0048	0.0049	0.0060	0.0031	0.0087
	Total intermediate input	0.2801	0.2998	0.2762	0.3401	0.2968
	Imports	0.0374	0.0894	0.0745	0.0575	0.1267
	Value added	0.6825	0.6108	0.6493	0.6024	0.5765
	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	0.0097	0.0005	0.0001
2	Mining and construction	0.0046	0.0221	0.0165	0.0072	0.0044
3	Food processing	0.0004	0.0005	0.0533	0.0007	0.0002
4	Other manufacturing	0.0045	0.0036	0.0254	0.0180	0.0025
5	Transportation	0.0048	0.0069	0.0114	0.0101	0.0024
6	Information	0.0100	0.0146	0.0101	0.0183	0.0023
7	Utilities	0.0179	0.0344	0.0250	0.0278	0.0044
8	Wholesale trade	0.0055	0.0129	0.0451	0.0164	0.0033
9	Retail trade	0.0011	0.0031	0.0048	0.0152	0.0000
10	Finance and insurance	0.0057	0.0249	0.0121	0.0104	0.0009
11	Real estate and rentals	0.0363	0.0339	0.0585	0.0872	0.0029
12	Professional services	0.0254	0.0283	0.0311	0.0348	0.0053
13	Business services	0.0223	0.0831	0.0291	0.0558	0.0050
14	Educational services	0.0035	0.0002	0.0002	0.0014	0.0005
15	Health services	0.0002	0.0000	0.0000	0.0002	0.0002
16	Arts and entertainment	0.0195	0.0006	0.0023	0.0004	0.0000
17	Accommodation	0.0005	0.0015	0.0017	0.0027	0.0004
18	Eating and drinking	0.0091	0.0072	0.0106	0.0036	0.0013
19	Other services	0.0094	0.0115	0.0080	0.0087	0.0016
20	Government	0.0110	0.0091	0.0057	0.0064	0.0012
	Total intermediate input	0.1924	0.2986	0.3605	0.3258	0.0389
	Imports	0.0701	0.0818	0.1699	0.1602	0.0262
	Value added	0.7375	0.6197	0.4697	0.5140	0.9348
	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 16 cents worth of agricultural commodities to produce every $1 of food processing output. Agriculture has to purchase inputs from various suppliers to produce 16 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 $1.43, of which $1.10 (including initial $1 increase) comes from agriculture itself and the remaining 33 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. 2005 Condensed Total Requirements Table (Type I) for Hawaii

	Industry	Agriculture	Mining and construction	Food processing	Other manufacturing	Transportation
1	Agriculture	1.1004	0.0015	0.1791	0.0039	0.0009
2	Mining and construction	0.0148	1.0077	0.0097	0.0047	0.0190
3	Food processing	0.0084	0.0007	1.0316	0.0044	0.0017
4	Other manufacturing	0.0636	0.0623	0.0522	1.0658	0.1014
5	Transportation	0.0308	0.0246	0.0293	0.0258	1.0682
6	Information	0.0068	0.0111	0.0099	0.0103	0.0164
7	Utilities	0.0214	0.0150	0.0196	0.0243	0.0204
8	Wholesale trade	0.0440	0.0523	0.0527	0.0323	0.0312
9	Retail trade	0.0098	0.0485	0.0154	0.0103	0.0066
10	Finance and insurance	0.0197	0.0189	0.0122	0.0154	0.0294
11	Real estate and rentals	0.0578	0.0451	0.0324	0.0244	0.0446
12	Professional services	0.0130	0.0784	0.0219	0.0232	0.0427
13	Business services	0.0194	0.0318	0.0672	0.0447	0.0929
14	Educational services	0.0007	0.0010	0.0009	0.0030	0.0053
15	Health services	0.0000	0.0000	0.0000	0.0000	0.0002
16	Arts and entertainment	0.0004	0.0005	0.0011	0.0008	0.0005
17	Accommodation	0.0010	0.0016	0.0027	0.0021	0.0014
18	Eating and drinking	0.0027	0.0069	0.0111	0.0066	0.0146
19	Other services	0.0098	0.0098	0.0134	0.0127	0.0129
20	Government	0.0093	0.0046	0.0074	0.0069	0.0545
	Type I output multipliers	1.43	1.42	1.57	1.32	1.56

	Industry	Information	Utilities	Wholesale trade	Retail trade	Finance and insurance
1	Agriculture	0.0003	0.0013	0.0005	0.0005	0.0005
2	Mining and construction	0.0039	0.0715	0.0045	0.0081	0.0068
3	Food processing	0.0006	0.0015	0.0008	0.0005	0.0007
4	Other manufacturing	0.0071	0.2938	0.0209	0.0212	0.0116
5	Transportation	0.0065	0.0157	0.0078	0.0078	0.0090
6	Information	1.0695	0.0073	0.0261	0.0174	0.0380
7	Utilities	0.0055	1.0346	0.0085	0.0162	0.0066
8	Wholesale trade	0.0101	0.0197	1.0253	0.0070	0.0050
9	Retail trade	0.0125	0.0099	0.0116	1.0140	0.0049
10	Finance and insurance	0.0185	0.0161	0.0184	0.0239	1.1872
11	Real estate and rentals	0.0321	0.0207	0.0428	0.1166	0.0697
12	Professional services	0.0299	0.0337	0.0290	0.0273	0.0568
13	Business services	0.0264	0.0310	0.0578	0.0460	0.0513
14	Educational services	0.0036	0.0085	0.0015	0.0014	0.0039
15	Health services	0.0000	0.0000	0.0000	0.0000	0.0000
16	Arts and entertainment	0.0019	0.0004	0.0001	0.0001	0.0001
17	Accommodation	0.0014	0.0017	0.0023	0.0019	0.0036
18	Eating and drinking	0.0073	0.0066	0.0074	0.0060	0.0120
19	Other services	0.0100	0.0059	0.0120	0.0102	0.0142
20	Government	0.0041	0.0067	0.0061	0.0092	0.0106
	Type I output multipliers	1.25	1.59	1.28	1.34	1.49

Table 2.3. 2005 Condensed Total Requirements Table (Type I) for Hawaii - Continued

	Industry	Real estate and rentals	Professional services	Business services	Educational services	Health services
1	Agriculture	0.0024	0.0007	0.0007	0.0009	0.0025
2	Mining and construction	0.0303	0.0073	0.0075	0.0387	0.0086
3	Food processing	0.0004	0.0010	0.0006	0.0013	0.0052
4	Other manufacturing	0.0200	0.0227	0.0264	0.0319	0.0223
5	Transportation	0.0079	0.0215	0.0139	0.0137	0.0176
6	Information	0.0149	0.0305	0.0319	0.0374	0.0198
7	Utilities	0.0127	0.0095	0.0162	0.0149	0.0200
8	Wholesale trade	0.0094	0.0155	0.0136	0.0151	0.0214
9	Retail trade	0.0132	0.0205	0.0193	0.0069	0.0106
10	Finance and insurance	0.0535	0.0218	0.0191	0.0183	0.0175
11	Real estate and rentals	1.1010	0.1058	0.0613	0.1443	0.0913
12	Professional services	0.0328	1.0836	0.0779	0.0401	0.0497
13	Business services	0.0425	0.0356	1.0605	0.0601	0.0797
14	Educational services	0.0008	0.0036	0.0025	1.0090	0.0043
15	Health services	0.0000	0.0001	0.0000	0.0009	1.0060
16	Arts and entertainment	0.0001	0.0001	0.0001	0.0007	0.0002
17	Accommodation	0.0024	0.0058	0.0024	0.0022	0.0034
18	Eating and drinking	0.0046	0.0096	0.0079	0.0194	0.0124
19	Other services	0.0396	0.0150	0.0137	0.0132	0.0115
20	Government	0.0071	0.0080	0.0085	0.0059	0.0115
	Type I output multipliers	1.40	1.42	1.38	1.47	1.42

	Industry	Arts and entertainment	Accommodation	Eating and drinking	Other services	Government
1	Agriculture	0.0013	0.0006	0.0208	0.0012	0.0002
2	Mining and construction	0.0083	0.0275	0.0224	0.0136	0.0051
3	Food processing	0.0011	0.0012	0.0560	0.0013	0.0003
4	Other manufacturing	0.0142	0.0212	0.0448	0.0345	0.0050
5	Transportation	0.0075	0.0114	0.0179	0.0149	0.0031
6	Information	0.0143	0.0222	0.0172	0.0259	0.0032
7	Utilities	0.0211	0.0393	0.0310	0.0330	0.0051
8	Wholesale trade	0.0088	0.0183	0.0544	0.0216	0.0042
9	Retail trade	0.0037	0.0080	0.0101	0.0199	0.0007
10	Finance and insurance	0.0114	0.0359	0.0226	0.0214	0.0019
11	Real estate and rentals	0.0494	0.0527	0.0798	0.1103	0.0052
12	Professional services	0.0343	0.0450	0.0459	0.0501	0.0073
13	Business services	0.0304	0.0971	0.0468	0.0709	0.0068
14	Educational services	0.0041	0.0012	0.0010	0.0023	0.0007
15	Health services	0.0002	0.0000	0.0000	0.0002	0.0002
16	Arts and entertainment	1.0200	0.0008	0.0025	0.0005	0.0000
17	Accommodation	0.0010	1.0022	0.0026	0.0035	0.0005
18	Eating and drinking	0.0107	0.0095	1.0134	0.0059	0.0016
19	Other services	0.0127	0.0160	0.0140	1.0150	0.0022
20	Government	0.0127	0.0116	0.0088	0.0093	1.0016
	Type I output multipliers	1.27	1.42	1.51	1.46	1.05

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 $1.43, which means that every $1 change in agriculture's final demand results in a change in the economy's total output by $1.43. 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) ($0.43). 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 0.45 (Table 2.4). Accordingly, a $1 increase in agriculture's final demand would increase the earnings in the economy by 45 cents.

The direct-effect earnings multiplier is derived by calculating the ratio between the final-demand earnings multiplier and the direct earnings coefficient. The direct earnings coefficient for agriculture is 0.340. Thus, the Type I direct-effect earnings multiplier for agriculture is 1.34 (0.454 ÷ 0.340). That means a $1 change in household earnings in agriculture will change total earnings in the economy by $1.34.

State Tax Multipliers

In the 2005 I-O study, the state tax multipliers 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 2005 I-O include the following 13 categories: (1) general excise and use tax (accounted for about 46.5% of total state taxes), (2) individual income tax (29.7%), (3) corporate income tax (2.7%), (4) transient accommodations tax (4.3%), (5) fuel tax (3.3%), (6) alcohol and tobacco tax (2.6%), (7) PUC tax (2.2%), (8) insurance tax (1.7%), (9) unemployment compensation tax (2.9%), (10) rental vehicle surcharge tax (0.9%), (11) licenses, permits, and others (1.5%), (12) conveyance tax (0.8%), and (13) bank and other financial institutions tax (0.8%).[1] Excluded from state taxes were property taxes, other city and county taxes, and federal taxes

[1] For information on state tax revenues by industry for 2005, refer to the 2005 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 25.93. In words, one million dollars of additional demand for Hawaii's agricultural products would create about 26 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 21.58 (15,683 ÷ 726.8). Thus, the Type I direct-effect employment multiplier for agriculture is 1.17 (25.93 ÷ 21.58).

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 2005. Although this report is released in 2008, using the 2005 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 2006 to 2015 by adjusting the 2005 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 2005 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.[2]

[2] 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.[3] 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.[4] 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, state tax, and employment multipliers from the 2005 condensed table are presented in Table 2.4.

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

[4] 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. 2005 Condensed Output, Earnings, State Tax, 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	1.43	1.97	0.45	0.61	25.93	30.77
2 Mining and construction	1.42	1.96	0.45	0.60	9.73	14.54
3 Food processing	1.57	1.98	0.34	0.46	13.58	17.23
4 Other manufacturing	1.32	1.61	0.24	0.32	5.51	8.06
5 Transportation	1.56	2.05	0.41	0.55	10.93	15.29
6 Information	1.25	1.66	0.34	0.46	7.95	11.63
7 Utilities	1.59	1.88	0.25	0.33	4.79	7.42
8 Wholesale trade	1.28	1.77	0.41	0.54	10.41	14.76
9 Retail trade	1.34	1.83	0.42	0.55	16.79	21.23
10 Finance and insurance	1.49	1.96	0.39	0.52	9.64	13.80
11 Real estate and rentals	1.40	1.61	0.18	0.24	6.32	8.22
12 Professional services	1.42	2.13	0.60	0.80	14.03	20.44
13 Business services	1.38	2.11	0.61	0.81	19.64	26.13
14 Educational services	1.47	2.19	0.60	0.80	22.04	28.44
15 Health services	1.42	2.08	0.56	0.75	14.79	20.76
16 Arts and entertainment	1.27	1.92	0.55	0.73	29.37	35.20
17 Accommodation	1.42	1.98	0.47	0.62	12.04	17.01
18 Eating and drinking	1.51	2.04	0.44	0.59	21.24	25.95
19 Other services	1.46	2.06	0.50	0.67	21.98	27.37
20 Government	1.05	1.79	0.62	0.83	13.43	20.05
State weighted average	1.36	1.88	0.51	0.68	15.13	20.41

	Final-demand multipliers		Direct-effect multipliers			
	State tax		Earnings		Total job	
Industry	Type I	Type II	Type I	Type II	Type I	Type II
1 Agriculture	0.05	0.08	1.34	1.78	1.20	1.43
2 Mining and construction	0.08	0.11	1.39	1.85	1.58	2.37
3 Food processing	0.04	0.06	2.03	2.71	2.15	2.72
4 Other manufacturing	0.03	0.04	1.61	2.14	1.92	2.81
5 Transportation	0.05	0.08	1.77	2.36	1.81	2.53
6 Information	0.06	0.09	1.28	1.71	1.38	2.02
7 Utilities	0.06	0.08	2.24	2.99	3.22	4.98
8 Wholesale trade	0.17	0.19	1.28	1.70	1.34	1.90
9 Retail trade	0.18	0.21	1.25	1.67	1.18	1.49
10 Finance and insurance	0.08	0.10	1.58	2.10	1.68	2.40
11 Real estate and rentals	0.05	0.06	2.50	3.33	2.09	2.72
12 Professional services	0.09	0.13	1.25	1.66	1.32	1.93
13 Business services	0.09	0.13	1.25	1.67	1.22	1.62
14 Educational services	0.09	0.13	1.26	1.68	1.20	1.55
15 Health services	0.07	0.10	1.29	1.71	1.33	1.87
16 Arts and entertainment	0.06	0.09	1.18	1.57	1.10	1.32
17 Accommodation	0.11	0.14	1.40	1.86	1.47	2.07
18 Eating and drinking	0.07	0.10	1.45	1.93	1.25	1.52
19 Other services	0.07	0.10	1.33	1.77	1.20	1.49
20 Government	0.04	0.08	1.03	1.37	1.04	1.55
State weighted average	0.10	0.13	1.32	1.76	1.33	1.83

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.[5]

Economic Impacts of Visitor Spending

Visitor spending contributes significantly to Hawaii's economy. In 2005, visitor spending on goods and services produced in Hawaii totaled more than $14 billion, contributing to more than one-sixth 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 2008. 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.[6] 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 2005 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.[7]

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 2008 could potentially increase Hawaii's total output (sales) by $11.6 million and increase Hawaii's total labor earnings by $3.3 million. The

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[5] Additional examples are available in the 1992 and 1997 State of Hawaii Input-Output Study.

[6] 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.

[7] 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 2005 I-O table, as shown in Table 3.1, the $7 million additional visitor expenditure should increase Hawaii's total employment by 98 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 require 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	0.16	0.01	1.97	0.61	28.0	0.0	0.0	0
Mining and construction	0.00	0.00	1.96	0.60	12.9	0.0	0.0	0
Food processing	0.25	0.02	1.98	0.46	16.8	0.0	0.0	0
Other manufacturing	0.40	0.03	1.61	0.32	6.8	0.0	0.0	0
Transportation	15.30	1.07	2.05	0.55	13.5	2.2	0.6	14
Information	0.25	0.02	1.66	0.46	10.8	0.0	0.0	0
Utilities	0.00	0.00	1.88	0.33	6.6	0.0	0.0	0
Wholesale trade	1.60	0.11	1.77	0.54	13.1	0.2	0.1	1
Retail trade	9.78	0.68	1.83	0.55	18.9	1.3	0.4	13
Finance and insurance	0.00	0.00	1.96	0.52	12.6	0.0	0.0	0
Real estate and rentals	12.73	0.89	1.61	0.24	7.8	1.4	0.2	7
Professional services	0.63	0.04	2.13	0.80	18.0	0.1	0.0	1
Business services	2.27	0.16	2.11	0.81	23.0	0.3	0.1	4
Educational services	0.78	0.05	2.19	0.80	25.1	0.1	0.0	1
Health services	0.81	0.06	2.08	0.75	18.7	0.1	0.0	1
Arts and entertainment	2.70	0.19	1.92	0.73	35.6	0.4	0.1	7
Accommodation	27.91	1.95	1.98	0.62	15.1	3.9	1.2	29
Eating and drinking	9.65	0.68	2.04	0.59	23.6	1.4	0.4	16
Other services	0.70	0.05	2.06	0.67	25.4	0.1	0.0	1
Government	0.45	0.03	1.79	0.83	17.6	0.1	0.0	1
Total intermediate input	86.36	6.05				11.6	3.3	98
Imports	13.64	0.95						
Total	100.00	7.00				11.6	3.3	98

* 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 capacity 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 grocery store built in 2008 selling mainly groceries and assume that the construction cost of the store is $10 million and the estimated annual sales value is $20 million. To simplify our analysis, we assume that all of the construction work is completed in the year of 2008.

The one-time impacts of the construction on the economy can be estimated using the 2005 I-O model. As shown in Table 3.2, the construction of a $10 million new retail store in 2008 could potentially increase Hawaii's total output by $16.1 million, increase Hawaii's total earnings by $5.0 million, and increase Hawaii's total employment by 111 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. In other words, we assumed that there was insufficient capacity in existing retail stores. Please note that the assumed $10 million additional final demand may be caused by increases in population, personal income, visitor activity, or reduced savings even without the new store. Therefore, the net impact of the new store on final demand would be $10 million instead of original $20 million. Using the $20 million total estimated annual sales to calculate the economic impacts is a common error in applying the I-O model. 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	1.97	0.61	28.0	0.0	0.0	0
Mining and construction	65.27	6.53	1.96	0.60	12.9	12.8	3.9	84
Food processing	0.00	0.00	1.98	0.46	16.8	0.0	0.0	0
Other manufacturing	1.32	0.13	1.61	0.32	6.8	0.2	0.0	1
Transportation	2.77	0.28	2.05	0.55	13.5	0.6	0.2	4
Information	0.00	0.00	1.66	0.46	10.8	0.0	0.0	0
Utilities	0.00	0.00	1.88	0.33	6.6	0.0	0.0	0
Wholesale trade	2.85	0.28	1.77	0.54	13.1	0.5	0.2	4
Retail trade	4.24	0.42	1.83	0.55	18.9	0.8	0.2	8
Finance and insurance	0.00	0.00	1.96	0.52	12.6	0.0	0.0	0
Real estate and rentals	0.49	0.05	1.61	0.24	7.8	0.1	0.0	0
Professional services	5.55	0.56	2.13	0.80	18.0	1.2	0.4	10
Business services	0.00	0.00	2.11	0.81	23.0	0.0	0.0	0
Educational services	0.00	0.00	2.19	0.80	25.1	0.0	0.0	0
Health services	0.00	0.00	2.08	0.75	18.7	0.0	0.0	0
Arts and entertainment	0.00	0.00	1.92	0.73	35.6	0.0	0.0	0
Accommodation	0.00	0.00	1.98	0.62	15.1	0.0	0.0	0
Eating and drinking	0.00	0.00	2.04	0.59	23.6	0.0	0.0	0
Other services	0.00	0.00	2.06	0.67	25.4	0.0	0.0	0
Government	0.00	0.00	1.79	0.83	17.6	0.0	0.0	0
Total intermediate input	82.50	8.25				16.1	5.0	111
Imports	17.50	1.75						
Total	100.00	10.00				16.1	5.0	111

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

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 $7.0 million, increase Hawaii's total earnings by about $2.1 million, and increase Hawaii's total employment by 74 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	1.99	0.67	19.1	0.2	0.1	2
Air transportation	0.30	0.03	2.06	0.53	14.2	0.1	0.0	0
Water transportation	1.75	0.18	2.12	0.44	12.2	0.4	0.1	2
Wholesale trade	9.00	0.90	1.77	0.54	14.8	1.6	0.5	13
Retail trade	26.40	2.64	1.84	0.56	21.5	4.9	1.5	57
Producers' prices (imports)	61.75	6.18						
Total	100.00	10.00				7.0	2.1	74

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 increased General Fund tax revenues. The Type II output multiplier for government spending from Table 2.4 is 1.79. That suggests that the $10 million expenditure will ultimately generate about $17.9 million in output -- $7.9 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	1.79	17.9
Households (PCE)	-10.00	1.47	-14.7
Net impact			3.2

* 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 Jobs in the Construction Sector

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. In this example, we assume that the creation of new jobs in the construction section does not cause reduction of jobs elsewhere in the economy. 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 2,366 jobs (2.366 x 1,000 = 2,366), including the initial increase of 1,000 jobs plus 1,366 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 (0.053) and output-to-total job (0.163) ratios. This gives the initial (direct) earnings change of $53 million and initial output change of $163 million. The total earnings effect of $98 million is obtained by multiplying the

direct earnings effect by the direct-effect earnings multiplier for the construction sector (53 x 1.853 = 98). The total output effect of $319 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	14.537	2.366	2,366
Earnings ($ million)	53	0.600	1.853	98
Output ($ million)	163	1.958	1.958	319
Earings/total job ratio	0.053			
Output/total job ratio	0.163			

* Note that final-demand employment multipliers will change from year to year due to worker productivity growth and inflation-driven wage changes. The base, 2005 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 assuming that the increased sales will not cause decreases in other tourist expenditures (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 2005 I-O table, 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 $99.1 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	1.99	1.6
Air transportation	0.30	0.30	2.06	0.6
Water transportation	1.75	1.75	2.12	3.7
Wholesale trade	6.00	6.00	1.77	10.6
Retail trade	42.00	42.00	1.84	77.2
Cost of garments	49.15	49.15		
Hawaii's apparel manufacturing		2.95	1.81	5.4
Imports (94%)		46.20		
Total	100.00	100.00		99.1

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 856 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 2005 I-O table was primarily based on the 2002 NAICS (North American Industry Classification System). However, several data sources used in the 2005 I-O table were reported in a more aggregate format and therefore were disaggregated using the detailed Hawaii's Department of Labor and Industrial Relations (DLIR) ES-202 jobs and income data. In addition, in the 2005 I-O table, government enterprises were combined into the corresponding government sectors.

Output

For most of the industries, expect utilities (include electricity and gas production and distribution), included in the 2005 I-O table, outputs are estimated by DBEDT based on 2005 GDP and the historical relationships between GDP and output. Both electricity and gas outputs were obtained from the State of Hawaii Data Book 2006.

Value Added

Value added is the income side of the Hawaii gross domestic product (GDP) account. For the 2005 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 (TOPI), 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 by state include three components of value added (64 industries by NAICS): (1) COE, (2) TOPI, 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 TOPI. 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 2005 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 2005 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 (TOPI) 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. TOPI is the sum of business taxes and fees paid to the federal, state, and local governments. Components of TOPI 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 TOPI data in the 2005 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.[8]

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

[8] 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).

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.

Other Final Demand Components

In the 2005 I-O table, other final demand components were estimated based primarily on the estimated 2005 outputs and the corresponding ratios between final demand components and output from the 2002 I-O table.

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.

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 2005 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 industries' annual reports and the state and country government annual reports. Values for the rest of the cells were estimated using the 2002 Hawaii I-O table.

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 2005 Hawaii I-O table involves the following pieces of information.

i. Total sales or output by sector for 2005
ii. Total sales to final users by sector for 2005
iii. Total purchases or input by sector for 2005
iv. Total value added by sector for 2005
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 2005 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 2005 DETAILED I-O TABLE FOR HAWAII

2005 Detailed I-O Table for Hawaii

The 2005 detailed I-O transactions table for the State of Hawaii includes the following.[9]

- 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 (TOPI)
  - 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)

2005 Detailed I-O Multipliers

Using the procedures described in Section 2 and Appendix B, the following multipliers were derived for each industry in the 2005 detailed I-O table and the results are presented in Table 6.1.[10]

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[9] For details, refer to the 2005 Input-Output Study for Hawaii at the DBEDT Web Site. The study presents the 2005 transactions table and various I-O multipliers for each of the 68 industry sectors in the detailed I-O table.

[10] 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 2005 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 2006 to 2015. Employment multipliers for subsequent years account for projected inflation and labor productivity growth.

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

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

The final-demand employment multipliers presented in this report are for 2005. 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 2006-2015 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.

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 2005 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.

The Type I output multipliers vary from a minimum of 1.0 for Federal government military to a maximum of 1.73 for water transportation. In general, agriculture (except sugarcane and other crops), food processing, and beverage manufacturing have higher Type I output multipliers, while petroleum and other manufacturing have lower Type I multipliers. This is because agricultural processing sectors are mostly based on inputs produced from Hawaii's industries, while non-agricultural manufacturing inputs are mostly imported.

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 0.10 for petroleum manufacturing to 0.73 for computer systems design services. Other industries that have smaller Type I final-demand earnings multipliers include owner-occupied dwellings, real estate, utilities, and telecommunications. 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 1.00 for Federal government military to 4.03 for water transportation and Type II direct-effect earnings multipliers vary from 1.33 to 5.35 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 2.37 for petroleum manufacturing to 50.93 for commercial fishing for Type I and from 3.46 to 56.55 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. 2005 Detailed Output, Earnings, Employment, and Tax Multipliers for Hawaii

	Industry	Final-demand multipliers			
		Output (dollars)		Earnings (dollars)	
		Type I	Type II	Type I	Type II
1	Sugarcane	1.31	1.83	0.44	0.59
2	Vegetables	1.58	2.06	0.41	0.54
3	Macadamia nuts, coffee, and other fruits	1.43	1.95	0.44	0.58
4	Pineapples	1.40	2.03	0.53	0.71
5	Flowers and nursery products	1.47	2.02	0.46	0.61
6	Other crops	1.28	1.81	0.44	0.59
7	Animal production	1.45	1.90	0.38	0.51
8	Aquaculture	1.55	1.96	0.35	0.46
9	Commercial fishing	1.61	2.24	0.53	0.71
10	Forestry & logging	1.46	2.15	0.59	0.78
11	Support activities for agriculture	1.34	2.01	0.56	0.75
12	Mining	1.72	2.39	0.57	0.75
13	Single family construction	1.40	1.92	0.44	0.59
14	Construction of other buildings	1.43	1.98	0.47	0.62
15	Heavy and civil engineering construction	1.44	2.01	0.48	0.64
16	Maintenance & repairs	1.40	1.93	0.45	0.60
17	Food processing	1.57	1.97	0.34	0.46
18	Beverage manufacturing	1.51	1.85	0.28	0.38
19	Apparel and textile manufacturing	1.24	1.81	0.48	0.64
20	Petroleum manufacturing	1.30	1.43	0.10	0.14
21	Other manufacturing	1.33	1.88	0.46	0.61
22	Air transportation	1.61	2.06	0.38	0.50
23	Water transportation	1.73	2.12	0.33	0.44
24	Truck and rail transportation	1.40	1.99	0.50	0.66
25	Transit and ground passenger transportation	1.50	2.01	0.43	0.57
26	Scenic and support activities for transportation	1.19	1.94	0.63	0.84
27	Couriers and messengers	1.22	1.72	0.43	0.57
28	Warehousing and storage	1.31	1.97	0.56	0.74
29	Publishing (include Internet)	1.07	1.63	0.47	0.62
30	Motion picture and sound recording industries	1.20	1.55	0.29	0.39
31	Broadcasting (Radio, TV, Cable)	1.29	1.74	0.38	0.51
32	Telecommunications	1.29	1.64	0.30	0.40
33	Internet providers, web, and data processing	1.38	1.85	0.39	0.52
34	Other information services	1.47	1.90	0.36	0.48
35	Electricity	1.60	1.85	0.22	0.29
36	Gas production & distribution	1.61	1.87	0.22	0.29
37	Wholesale trade	1.28	1.77	0.41	0.55
38	Retail trade	1.34	1.84	0.42	0.56
39	Credit intermediation and related activities	1.41	1.82	0.34	0.46
40	Insurance carriers and related activities	1.64	2.18	0.46	0.60
41	Other finance and insurance	1.38	2.12	0.63	0.84
42	Owner-occupied dwellings	1.34	1.47	0.11	0.14
43	Real estate	1.42	1.68	0.22	0.29
44	Rental & leasing	1.51	1.92	0.35	0.46

Table 6.1. 2005 Detailed Output, Earnings, Employment, and Tax Multipliers for Hawaii - Continued

	Industry	Final-demand multipliers			
		Output (dollars)		Earnings (dollars)	
		Type I	Type II	Type I	Type II
45	Legal services	1.35	2.10	0.63	0.84
46	Architectural and engineering services	1.37	2.08	0.60	0.80
47	Computer systems design services	1.42	2.29	0.73	0.97
48	R&D in the physical, engineering, & life sciences	1.37	2.02	0.55	0.73
49	Other professional services	1.52	2.18	0.56	0.74
50	Management of companies and enterprises	1.45	2.22	0.65	0.86
51	Travel arrangement and reservation services	1.50	2.13	0.53	0.71
52	Administrative and support services	1.29	2.06	0.64	0.85
53	Waste management and remediation services	1.45	1.99	0.45	0.60
54	Colleges, universities, and professional schools	1.47	2.19	0.61	0.81
55	Other educational services	1.47	2.20	0.62	0.82
56	Ambulatory health care services	1.17	1.97	0.68	0.90
57	Hospitals	1.65	2.19	0.46	0.61
58	Nursing and residential care facilities	1.38	2.09	0.60	0.79
59	Social assistance	1.35	2.05	0.59	0.78
60	Arts and entertainment	1.27	1.92	0.55	0.73
61	Accommodation	1.42	1.97	0.47	0.62
62	Eating and drinking	1.52	2.05	0.45	0.59
63	Repair and maintenance	1.39	1.99	0.50	0.66
64	Personal and laundry services	1.54	2.14	0.51	0.68
65	Organizations	1.43	2.05	0.52	0.69
66	Federal government military	1.00	1.70	0.59	0.78
67	Federal government: civilian	1.14	1.89	0.64	0.84
68	State and local government	1.10	1.86	0.65	0.86
	PCE	1.11	1.47	0.30	0.40
	Visitor's expenditures	1.24	1.68	0.36	0.48
	State and local government consumption	1.09	1.77	0.58	0.77
	Federal military consumption	0.89	1.50	0.51	0.67
	Federal civilian consumption	0.99	1.61	0.53	0.70

Table 6.1. 2005 Detailed Output, Earnings, Employment, and Tax Multipliers for Hawaii - Continued

	Industry	Final-demand multipliers			
		Employment (total jobs)		State Tax (dollars)	
		Type I	Type II	Type I	Type II
1	Sugarcane	19.79	24.42	0.04	0.07
2	Vegetables	22.10	26.35	0.05	0.08
3	Macadamia nuts, coffee, and other fruits	26.64	31.21	0.05	0.07
4	Pineapples	23.83	29.43	0.05	0.08
5	Flowers and nursery products	31.85	36.70	0.05	0.08
6	Other crops	23.83	28.50	0.04	0.07
7	Animal production	20.17	24.17	0.04	0.06
8	Aquaculture	15.08	18.73	0.04	0.06
9	Commercial fishing	50.93	56.55	0.06	0.10
10	Forestry & logging	40.01	46.17	0.04	0.07
11	Support activities for agriculture	28.22	34.14	0.07	0.10
12	Mining	9.34	15.30	0.07	0.11
13	Single family construction	8.03	12.66	0.08	0.11
14	Construction of other buildings	9.88	14.79	0.08	0.11
15	Heavy and civil engineering construction	12.09	17.13	0.05	0.08
16	Maintenance & repairs	11.11	15.86	0.09	0.12
17	Food processing	12.77	16.37	0.04	0.06
18	Beverage manufacturing	7.55	10.54	0.04	0.06
19	Apparel and textile manufacturing	24.59	29.64	0.04	0.07
20	Petroleum manufacturing	2.37	3.46	0.02	0.02
21	Other manufacturing	9.61	14.48	0.04	0.07
22	Air transportation	9.61	13.57	0.04	0.07
23	Water transportation	8.64	12.14	0.05	0.07
24	Truck and rail transportation	13.59	18.85	0.10	0.13
25	Transit and ground passenger transportation	31.67	36.15	0.09	0.11
26	Scenic and support activities for transportation	12.45	19.09	0.09	0.13
27	Couriers and messengers	13.34	17.82	0.04	0.07
28	Warehousing and storage	18.34	24.17	0.08	0.12
29	Publishing (include Internet)	9.57	14.50	0.09	0.12
30	Motion picture and sound recording industries	14.86	17.94	0.07	0.09
31	Broadcasting (Radio, TV, Cable)	8.55	12.58	0.08	0.10
32	Telecommunications	5.80	8.98	0.05	0.07
33	Internet providers, web, and data processing	10.53	14.65	0.08	0.10
34	Other information services	10.24	14.03	0.08	0.10
35	Electricity	3.94	6.22	0.06	0.07
36	Gas production & distribution	4.05	6.38	0.06	0.07
37	Wholesale trade	10.65	14.99	0.17	0.19
38	Retail trade	17.05	21.49	0.19	0.21
39	Credit intermediation and related activities	8.38	11.99	0.06	0.09
40	Insurance carriers and related activities	10.63	15.41	0.10	0.13
41	Other finance and insurance	23.34	29.96	0.08	0.12
42	Owner-occupied dwellings	3.17	4.29	0.02	0.03
43	Real estate	8.15	10.46	0.06	0.08
44	Rental & leasing	10.56	14.20	0.13	0.15

Table 6.1. 2005 Detailed Output, Earnings, Employment, and Tax Multipliers for Hawaii - Continued

	Industry	Final-demand multipliers			
		Employment (total jobs)		State Tax (dollars)	
		Type I	Type II	Type I	Type II
45	Legal services	12.65	19.26	0.09	0.13
46	Architectural and engineering services	12.35	18.68	0.09	0.13
47	Computer systems design services	15.61	23.29	0.10	0.15
48	R&D in the physical, engineering, & life sciences	11.40	17.15	0.06	0.10
49	Other professional services	17.33	23.16	0.09	0.13
50	Management of companies and enterprises	10.68	17.46	0.10	0.14
51	Travel arrangement and reservation services	16.90	22.50	0.09	0.12
52	Administrative and support services	27.70	34.46	0.09	0.13
53	Waste management and remediation services	10.68	15.42	0.08	0.11
54	Colleges, universities, and professional schools	20.32	26.73	0.09	0.13
55	Other educational services	23.23	29.68	0.09	0.13
56	Ambulatory health care services	14.30	21.43	0.09	0.13
57	Hospitals	11.14	15.96	0.06	0.09
58	Nursing and residential care facilities	21.62	27.86	0.05	0.09
59	Social assistance	27.92	34.11	0.06	0.09
60	Arts and entertainment	29.48	35.24	0.06	0.09
61	Accommodation	12.29	17.20	0.11	0.14
62	Eating and drinking	21.36	26.03	0.07	0.10
63	Repair and maintenance	20.88	26.14	0.09	0.12
64	Personal and laundry services	30.04	35.40	0.09	0.12
65	Organizations	17.12	22.61	0.05	0.08
66	Federal government military	11.09	17.30	0.03	0.07
67	Federal government: civilian	12.30	18.97	0.04	0.08
68	State and local government	16.27	23.08	0.04	0.08
	PCE	9.82	13.01	0.06	0.08
	Visitor's expenditures	11.94	15.76	0.08	0.11
	State and local government consumption	14.79	20.87	0.04	0.08
	Federal military consumption	9.69	15.02	0.03	0.06
	Federal civilian consumption	10.53	16.05	0.04	0.07

Table 6.1. 2005 Detailed Output, Earnings, Employment, and Tax Multipliers for Hawaii - Continued

	Industry	Direct-effect multipliers			
		Earnings (dollars)		Employment (total jobs)	
		Type I	Type II	Type I	Type II
1	Sugarcane	1.22	1.62	1.16	1.43
2	Vegetables	1.74	2.31	1.38	1.65
3	Macadamia nuts, coffee, and other fruits	1.41	1.86	1.21	1.42
4	Pineapples	1.30	1.72	1.21	1.49
5	Flowers and nursery products	1.43	1.90	1.22	1.41
6	Other crops	1.23	1.63	1.14	1.37
7	Animal production	1.49	1.98	1.34	1.61
8	Aquaculture	1.75	2.32	1.71	2.12
9	Commercial fishing	1.43	1.89	1.10	1.22
10	Forestry & logging	1.41	1.87	1.37	1.58
11	Support activities for agriculture	1.23	1.63	1.16	1.41
12	Mining	1.64	2.18	2.12	3.47
13	Single family construction	1.37	1.81	1.75	2.76
14	Construction of other buildings	1.45	1.92	1.62	2.43
15	Heavy and civil engineering construction	1.49	1.97	1.51	2.14
16	Maintenance & repairs	1.40	1.86	1.50	2.15
17	Food processing	2.04	2.70	2.02	2.59
18	Beverage manufacturing	2.17	2.88	2.40	3.35
19	Apparel and textile manufacturing	1.17	1.56	1.10	1.33
20	Petroleum manufacturing	3.89	5.15	13.61	19.86
21	Other manufacturing	1.31	1.73	1.48	2.23
22	Air transportation	1.90	2.52	2.02	2.86
23	Water transportation	4.03	5.35	4.08	5.73
24	Truck and rail transportation	1.36	1.81	1.37	1.90
25	Transit and ground passenger transportation	1.57	2.09	1.17	1.33
26	Scenic and support activities for transportation	1.11	1.47	1.16	1.78
27	Couriers and messengers	1.20	1.59	1.18	1.57
28	Warehousing and storage	1.18	1.56	1.18	1.55
29	Publishing (include Internet)	1.06	1.40	1.09	1.65
30	Motion picture and sound recording industries	1.25	1.65	1.16	1.40
31	Broadcasting (Radio, TV, Cable)	1.29	1.71	1.52	2.24
32	Telecommunications	1.38	1.83	1.63	2.52
33	Internet providers, web, and data processing	1.50	1.98	1.65	2.30
34	Other information services	1.77	2.35	1.95	2.67
35	Electricity	1.98	2.63	2.64	4.18
36	Gas production & distribution	2.03	2.69	2.72	4.28
37	Wholesale trade	1.29	1.71	1.37	1.93
38	Retail trade	1.27	1.69	1.20	1.51
39	Credit intermediation and related activities	1.70	2.25	2.03	2.91
40	Insurance carriers and related activities	1.72	2.28	1.89	2.74
41	Other finance and insurance	1.26	1.67	1.20	1.54
42	Owner-occupied dwellings	NA	NA	NA	NA
43	Real estate	2.05	2.72	1.71	2.19
44	Rental & leasing	1.95	2.59	1.83	2.46

Table 6.1. 2005 Detailed Output, Earnings, Employment, and Tax Multipliers for Hawaii - Continued

	Industry	Direct-effect multipliers			
		Earnings (dollars)		Employment (total jobs)	
		Type I	Type II	Type I	Type II
45	Legal services	1.20	1.59	1.32	2.00
46	Architectural and engineering services	1.22	1.61	1.33	2.01
47	Computer systems design services	1.21	1.61	1.32	1.97
48	R&D in the physical, engineering, & life sciences	1.26	1.67	1.37	2.06
49	Other professional services	1.40	1.86	1.39	1.86
50	Management of companies and enterprises	1.30	1.72	1.57	2.57
51	Travel arrangement and reservation services	1.43	1.89	1.37	1.82
52	Administrative and support services	1.18	1.56	1.13	1.40
53	Waste management and remediation services	1.47	1.95	1.59	2.29
54	Colleges, universities, and professional schools	1.26	1.66	1.23	1.62
55	Other educational services	1.30	1.72	1.23	1.57
56	Ambulatory health care services	1.10	1.45	1.14	1.70
57	Hospitals	1.77	2.35	2.16	3.09
58	Nursing and residential care facilities	1.21	1.60	1.19	1.53
59	Social assistance	1.22	1.62	1.13	1.38
60	Arts and entertainment	1.18	1.57	1.10	1.32
61	Accommodation	1.41	1.86	1.50	2.10
62	Eating and drinking	1.46	1.94	1.25	1.53
63	Repair and maintenance	1.29	1.71	1.19	1.48
64	Personal and laundry services	1.43	1.90	1.18	1.39
65	Organizations	1.33	1.77	1.31	1.72
66	Federal government military	1.00	1.33	1.00	1.56
67	Federal government: civilian	1.07	1.42	1.11	1.71
68	State and local government	1.05	1.39	1.05	1.49

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Apendix A. NAICS Codes for Industries in the 2005 I-O Table for Hawaii

Detailed Table Sector		NAICS Code	Condensed Table Sector	
1	Sugarcane	11193	1	Agriculture
2	Vegetables	1112	1	
3	Macadamia nuts, coffee, and other fruits	1113 except part of 111	1	
4	Pineapples	part of 111339	1	
5	Flowers and nursery products	1114	1	
6	Other crops	other 111	1	
7	Animal production	111 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 (include Internet)	511, 516	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	part of 21	7	Utilities
36	Gas production & distribution	part of 22	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 2005 I-O Table for Hawaii - Continued

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:

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

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:

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

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.

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

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

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

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

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

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

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

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

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

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

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

If the household sector is exogenous, the Type I final-demand output multiplier for the *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 jth sector.

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

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

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

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

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

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

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

Appendix C. Various Retail, Wholesale and Transportation Margins

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

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

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

Type	Margin
Truck transportation	.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_js need to be adjusted until each of the three equations is satisfied simultaneously.

Let

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

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.