Tourism's Forward and Backward Linkages

Junning Cai, PingSun Leung, and James Mak

University of Hawaii at Manoa

Abstract

This paper proposes "linkage analysis" as a complement to the traditional "tourism impact analysis" to examine tourism's economic imprints on a destination's economy. Although related, the two methods are not the same. The starting point of tourism "impact analysis" is "final demand"; impact analysis measures the direct and indirect impacts of tourist spending on the local economy. By contrast, the starting point of "linkage analysis" is the tourism sector; the analysis examines the strengths of the inter-sectoral forward (FL) and backward (BL) relationships between the tourism sector and the non-tourism industries in the rest of the economy. The FL measures the relative importance of the tourism sector as supplier to the other (non-tourism) industries in the economy whereas the BL measures its relative importance as demander. Directly applying conventional linkage analysis to tourism is not straightforward because tourism is not a defined industry. Thus we develop a methodology to calculate tourism's forward and backward linkages using information from national, regional, or local input-output tables and demonstrate its utility by applying it to Hawaii.

I. Introduction

This paper proposes "linkage analysis" as a complement to the traditional "tourism impact analysis" to ascertain tourism's imprints on a destination's economy. Although related, the two methods are not the same. Traditional tourism "impact analysis" begins with "final demand" and measures the direct and indirect impacts of tourist spending on the local economy (See, for example, Archer, 1973; Archer, 1977, and Fletcher, 1994.) All spending by tourists thus flows *backward* through the economy as it works its way upstream from one supplier to the next. By contrast, "linkage analysis" begins with the tourism industry (sector) and examines the strengths of the inter-sectoral forward (FL) and backward (BL) relationships between tourism and the other industries in the rest of the economy. The FL measures the relative importance of tourism as supplier to the other industries in the economy whereas the BL measures its relative importance as demander. It should be transparent that while visitor expenditures (i.e. final demand) *per se* do not have forward linkages, the tourism industries that sell goods and services to tourists may have forward linkages in that they may sell their products to businesses in other industries.

Information on an industry's linkages with the rest of the economy helps us to better understand the structure of an economy and how it changes over time, which in turn is important in formulating industrial policies (Chenery and Watanabe, 1958; Hirschman, 1958; Rasmussen, 1956). Linkage indices have been used to identify key sectors of the economy (Beyers, 1976; Hewings, 1982; Hewings et al., 1989; Sonis et al., 1995, 2000; Cai and Leung, 2004). Key sectors are typically defined as industries which have both strong forward and backward linkages with other industries in the economy.

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Linkage analysis also allows policymakers to ascertain whether or not policies designed to strengthen linkages between, say, tourism and agriculture, have succeeded. Recently, Cai, Leung, Pan and Pooley (2005) employed linkage analysis to show how fisheries regulations affected fisheries and non-fisheries industries in Hawaii's economy. In this paper, we suggest a method of calculating these forward and backward linkages for tourism using information from national, regional, or local input-output tables and demonstrate its application by developing tourism linkage indices for Hawaii for the years 1987 and 1997. [1]

As tourism linkage analysis begins with the industry, in Section II, we discuss the thorny problem of how to define the tourism industry and propose a way to circumvent it. Section III introduces the methodology of linkage analysis and the steps required to calculate the forward and backward linkages for tourism. (Readers who are not interested in the mathematical derivations of these linkages can skip this section.) Section IV demonstrates the application of linkage analysis to Hawaii for the years 1987 and 1997. We conclude in Section V by identifying the methodology's principal strength and weakness and caution researchers how not to misinterpret and misuse the results.

II. Defining Tourism: Problems and Proposed Solution

Computing inter-industry linkage measures for tourism presents special problems not usually encountered for other industries. As linkage analysis begins with the industry, typically one begins by defining the industry of interest. What is the tourism industry? Richard Caves (1987, p. 6) defines an industry as one consisting of "sellers of a particular

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[1] The Hawaii 1987 and 1997 input-output tables are two most recent I-O models for the Hawaii economy. Examining the linkage patterns of Hawaii's tourism at different times can help provide information about the changes in tourism linkages over time.

product." Defining an industry is usually unambiguous when it comes to automobiles, steel, agriculture, and so on. But tourism comprises of sellers of not one particular product but many heterogeneous products. Tourism is not one of the 1,170 "industries" in the North American Industry Classification System (NAICS) (Mak, 2004, Chapter 7.) It does not appear as a separate industry in the typical input-output (I-O) model of an economy. The U.S. Department of Commerce, Office of Tourism Industries (TI) defines travel and tourism as a *sector* made up of "…a diverse group of industries that supply goods and services purchased by business, and other travelers." (Mak, 2004, p. 68.) However, most industries supply tourism goods and services. For example, among the 131 "industries" in the Hawaii 1997 I-O table, only 14 have no relationship to tourism either as direct vendors to tourists or as intermediate suppliers; if we count only those industries that have direct dealings with tourists, 70 industries, or 53 percent, supply goods and services to tourists. Most people would not consider the "hospitals" industry, with 2 percent of its total output sold directly to tourists, as a tourism industry.

In computing the U.S. Travel and Tourism Satellite Accounts (TTSA), the Bureau of Economic Analysis (BEA) identifies tourism industries "by analyzing the relationships shown in the I-O accounts between tourism commodities and the producing industries. Industries that include tourism commodities as a primary product are classified as tourism industries. These industries generally sell a significant portion of their output to visitors where 'significant' indicates that the industries' revenues and profits would be substantially affected if tourism ceased to exist." (Okubo and Planting, July 1998, pp. 12-13.) What is " a significant portion" is left unspecified. Should the threshold for "a significant portion" be set at fifty percent of total sales? Twenty percent? Five percent?

For example, under the Farm and Farm Related (FFR) definition employed by the U.S. Department of Agriculture (USDA), if a sector has 50 percent or more of its work force employed to satisfy domestic final demands for food and fiber products, it is designated as part of FFR and the total output of that sector is regarded as farm-related output (Leones, Schluter, and Goldman 1994). Indeed, the choice of threshold percentages for purpose of industry classification can be arbitrary and vary from case to case (Hoen, 2002).

In the most recent update of the U.S. travel and tourism satellite accounts, the Bureau of Economic Analysis essentially includes the output of any industry that is tourism related (Kuhbach and Herauf, 2005). Following this decision rule, we can construct tourism linkage indices for a "composite" tourism industry based on the individual linkages for each tourism related industry weighted by its share of total tourist spending, and then use these weighted indices as a measure of tourism's overall relationship with the rest of the economy.

Figures 1A and 1B show the backward (BL) and forward (FL) linkages between "tourism" (as a whole) and the other I-O industries in Hawaii for 1987 and 1997. The BL and FL indices are first computed for each of the 60 "industries" in 1987 and 131 "industries" in 1997 using methods described in Section III. To create comparable forward and backward linkage indices for the composite tourism industry, the BL and FL indices for each of the I-O industries are first multiplied by each industry's share of Hawaii's total visitor expenditures, then summed to obtain the linkage indices for the composite tourism industry.

Figure 1A Tourism's Forward and Backward Linkages in the Hawaii Economy: 1987
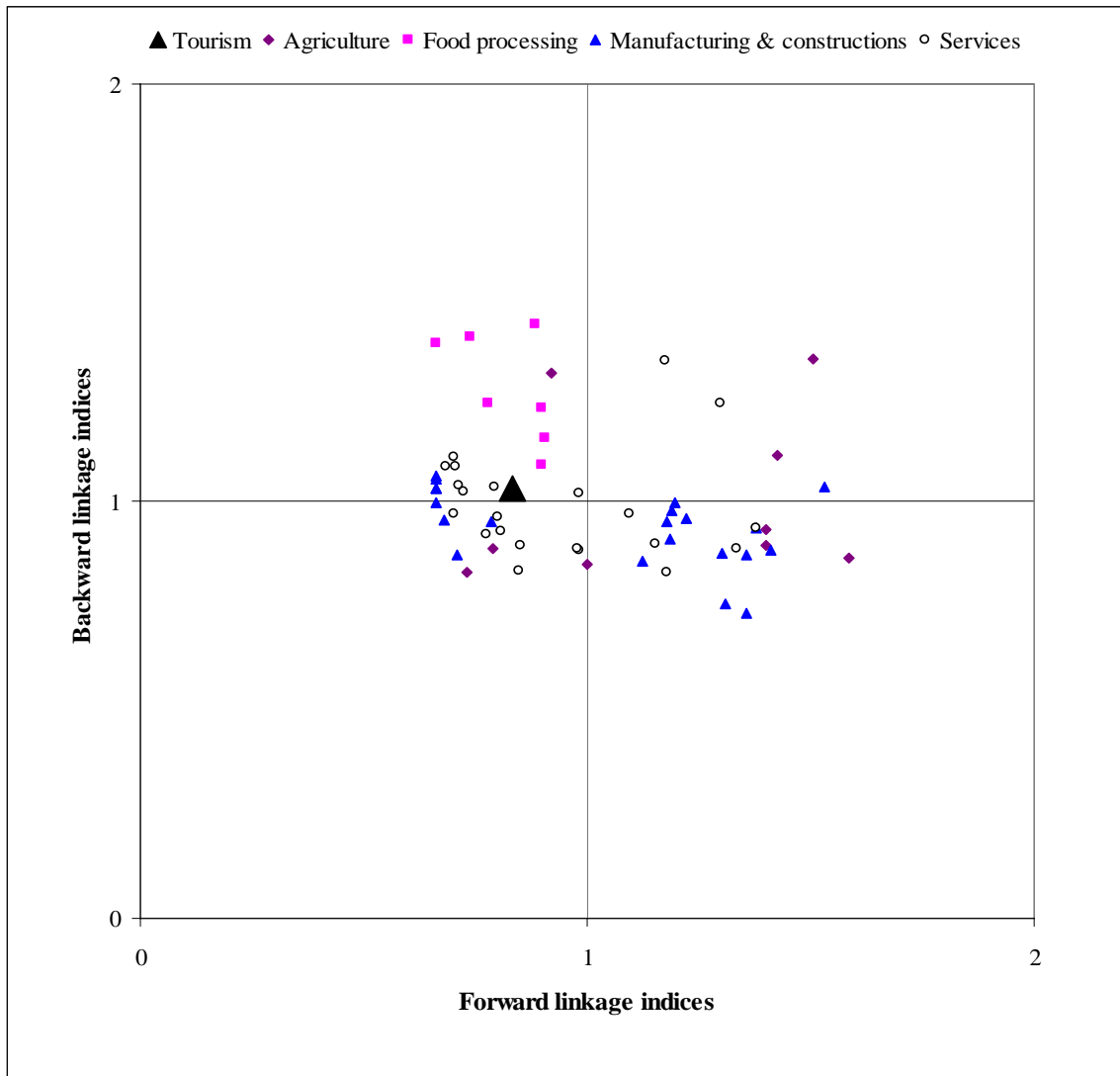
Source: Generated from the Hawaii 1987 input-output table

Figures 1A and 1B show that, compared to the other industries, tourism in Hawaii has about-average backward linkages and below-average forward linkages; "average" is represented by an index value of 1. (The numerical calculations are available from the authors by request.) Simply put, the production of $1 of output in the tourism industry on average generates about the same amount of demand for intermediate inputs from upstream suppliers than the production of $1 of output in the other industries. By contrast, the below-average forward linkage of Hawaii tourism implies that ($1 of) production in

the tourism industry generates less sales to downstream buyers than in the other industries.

Figure 1B Tourism's Forward and Backward Linkages in the Hawaii Economy: 1997
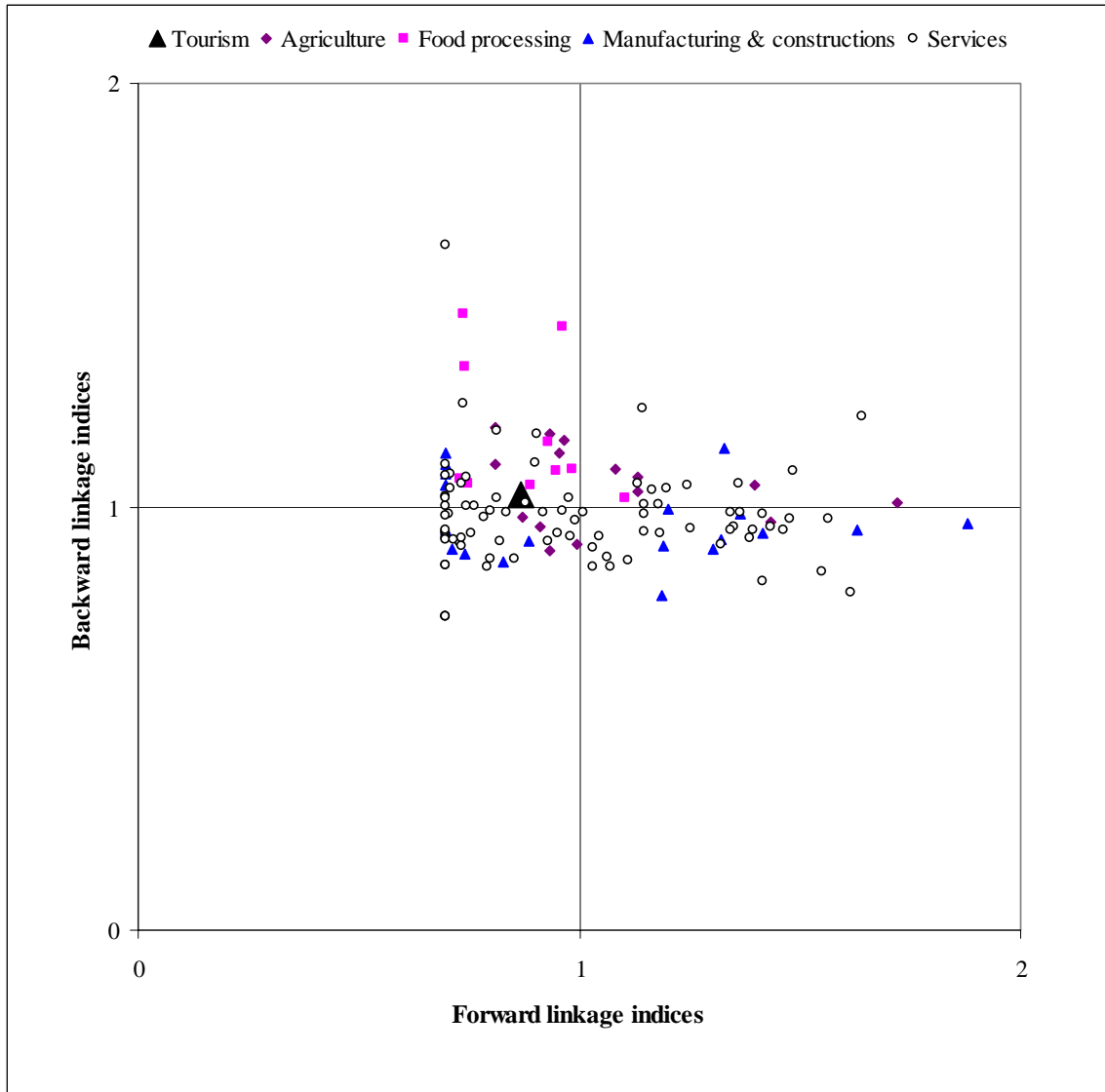
Source: Generated from the Hawaii 1997 input-output table.

There are two shortcomings in using the simple, weighted BL and FL indices (described above) to measure the inter-industry relationships between tourism and the rest of the economy. First, aggregation results in the loss of too much valuable information since not all tourism- related industries have the same supplier-buyer

relationship with other industries. It would be nice to also have information on the differences in the inter-industry relationships among individual tourism-related industries. Second, since most industries sell their outputs both to tourists/tourism businesses and non-tourists/ non-tourism businesses, each I-O industry's BL and FL indices de facto "assume" the inter-industry linkage relationships are the same whether goods and services are produced for tourism consumption or for non-tourism use. That may not be correct.   For example, consider the automobile rental industry: If the industry rents an automobile directly to a tourist, there is no further forward linkage between it and other industries because the tourist is the final consumer. However, if the industry rents the same automobile to a local business for business use, there is a forward linkage in that the automobile rental industry sells its output to another industry downstream which uses it to produce other goods and services for sale. It would be desirable to identify the differences in inter-industry linkages between production for tourism use and for non-tourism related uses. We propose to address both shortcomings.

We begin by decomposing every industry in an input-output (I-O) table into two parts—one part that is tourism related and the other is non-tourism related. The part that is tourism related consists of an industry's output that is *directly* (i.e. sales to tourists) or *indirectly* (sales to other businesses) used to satisfy tourism final demand (i.e. tourist spending); then the other part of the output of an industry is used to satisfy non-tourism related demands—i.e. resident personal consumption, government spending, business investment, and non-tourism exports. [2] By construction, there is no overlap between the

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[2] According to the standard Leontief input-output model, $\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{f}$, i.e., the output vector $\mathbf{x}$ is equal to the Leontief inverse $(\mathbf{I} - \mathbf{A})^{-1}$ multiplied by the final demand vector $\mathbf{f}$. Decomposing the total final demand $\mathbf{f}$ into its tourism component $\mathbf{f}_1$ and the non-tourism component $\mathbf{f}_2$, then the tourism

tourism and non-tourism parts. The tourism part (we shall call it the "tourism component" [of each industry]) can be further decomposed into "direct" and "supporting" components. The direct tourism component of each industry includes output sold directly to tourists, and the supporting tourism component includes those outputs used as intermediate inputs in producing tourism goods and services. Thus, each I-O industry's output is finally divided into 3 parts: direct tourism, supporting tourism, and non-tourism.

To illustrate, Table 1 presents the twenty most tourism-related industries in Hawaii derived from the State's 1997 I-O model. The most tourism related industry in 1997 was the hotel industry. In that year, the tourism component of the hotel industry accounted for 95 percent of the industry's total output; the remaining 5 percent of the output comprised of sales to buyers who were not tourists. By comparison, only 5 percent of the output of "gas stations"--which did not make the top-20 list—were sold directly to tourists. However the industry's tourism component accounted for 17 percent of its total output; the other 12 percent of its output was employed in supporting tourism (i.e. purchased by businesses to produce goods and services ultimately sold to tourists). The gas station example demonstrates that even if an industry's direct linkage to tourism is small, it does not mean that its supporting linkages are necessarily small.

It is noteworthy that the five industries at the top of the list—i.e. hotels, sightseeing transportation, automobile rental, amusement services, and air transportation-- which most people would acknowledge as tourism industries, all have relatively large direct tourism components but tiny supporting tourism components. In other words, they sell the lion's share (about three-quarters and more) of their output directly to tourists. For

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component of each industry's output is measured by $\mathbf{x}_1 = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{f}_1$; and the non-tourism component is measured by $\mathbf{x}_2 = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{f}_2$.

some other industries—e.g. advertising and bakeries—their relatively large involvement in tourism is primarily as intermediate producers.

Table 1 Hawaii's Top-20 Tourism Related Industries: 1997

Industries	Total tourism	Direct tourism	Supporting tourism
Hotels	95%	95%	0%
Sightseeing transportation	95%	94%	1%
Automobile rental	83%	80%	3%
Amusement services	82%	82%	0%
Air transportation	*74%*	*72%*	*2%*
Ground passenger transportation	64%	59%	4%
Golf courses	61%	61%	0%
Other general merchandise stores	59%	58%	1%
Apparel & accessory stores	59%	58%	1%
Recreation services	57%	56%	1%
Misc. store retailers	56%	54%	3%
Travel arrangement & reservation services	55%	42%	13%
Foodservice	52%	50%	2%
Museums and historical sites	50%	50%	0%
Other state and local gov't enterprises	46%	0%	46%
Investigation & security services	42%	5%	37%
Advertising	40%	10%	30%
Department stores	39%	37%	2%
Bakeries and grain product mfg	37%	5%	32%
Support activities for transportation	36%	0%	36%

Note: Calculated from the Hawaii 1997 input-output table. The sum of "direct tourism" and "supporting tourism" may not be exactly equal to "total tourism" because of rounding.

In sum, by dividing each industry in an I-O model into its three parts, we avoid the problem of having to identify which industry is a tourism industry and which is not; any industry that produces output for tourism, no matter how little, is counted. Moreover, we can compute separate BL and FL indices for the tourism and non-tourism components to enable us to compare potential differences in their inter-industry linkage relationships.

This is a novel—and we suggest, an important--contribution of the paper to inter-industry linkage analysis.

III. Methodology

In the literature on inter-industry linkages, backward (BL) and forward linkages (FL) are widely accepted concepts, but there remains discussion over how best to measure them (Jones, 1976; Hewings, 1982; Cella, 1984; Sonis *et al.*, 1995; Miller and Lahr, 2001; Cai and Leung, 2004). In this paper, we accept the suggestion by Cai and Leung (2004) and use the Leontief supply-driven multiplier (LSD) as a backward-linkage measure and the Ghosh (1958) supply-driven multiplier (GSD) as the corresponding forward-linkage measure (See Leung and Pooley (2002) and Cai, Leung, Pan and Pooley (2005) for similar applications of these supply-driven multipliers).

Briefly, the Leontief supply driven multiplier provides information about an industry's existing relationships with its upstream suppliers; specifically, it measures the dollar amount of production needed directly and indirectly by the industry from its (upstream) suppliers to generate one dollar of sales. For example, to generate $1 of sales in the hotel industry, the lodging industry must purchase inputs from its immediate suppliers. In turn, the supplying firms/industries may require inputs from their own suppliers. If one is patient enough to track the web of inter-firm and inter-industry relationships round by round and calculate the total amount of production in the rest of the economy needed to support one dollar of sales in the hotel industry, one would obtain a figure that is equal to the Leontief supply driven multiplier for the hotel industry.

Likewise, the Ghosh supply driven multiplier describes numerically an industry's

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relationship, directly and indirectly, with its downstream buyers. Again, if one tracks all

the transactions round by round and compute the total amount of production in the rest of

the economy that one dollar of initial sales by the industry has helped to generate, one

would come up with a figure that is equal to the Ghosh supply driven multiplier.

Leontief Supply-Driven Multiplier as a Backward Linkage Measure[3]

In deriving the Leontief supply driven multiplier, we first partition the Leontief

input-output model $\mathbf{x} = \mathbf{A}\mathbf{x} + \mathbf{f}$ ($\mathbf{x}$ and $\mathbf{f}$ represent output and final demand vectors

respectively; and $\mathbf{A}$ is the direct input coefficient matrix) into

$$\begin{pmatrix} x_i \\ \mathbf{x}_j \end{pmatrix} = \begin{pmatrix} \mathbf{A}_{ii} & \mathbf{A}_{ij} \\ \mathbf{A}_{ji} & \mathbf{A}_{jj} \end{pmatrix} \begin{pmatrix} x_i \\ \mathbf{x}_j \end{pmatrix} + \begin{pmatrix} f_i \\ \mathbf{f}_j \end{pmatrix},$$

where i and j denote, respectively, industry i and the rest of the economy. Then, based on

this partitioned I-O model, the backward linkage (BL) from one unit of output change in

industry i can be calculated by $\Delta \mathbf{x}_j = (\mathbf{I} - \mathbf{A}_{jj})^{-1} \mathbf{A}_{ji}$, where the elements in vector $\Delta \mathbf{x}_j$

measure the backward-linkage impacts of the unit output change in industry i on the

output of other industries. Summing these elements and the initial unit output change in

industry i would give a measure of industry i's backward linkage impacts. Thus, industry

i's Leontief supply driven *multiplier* (denoted as LSD_i) is given by

$$LSD_i = 1 + \mathbf{e}'(\mathbf{I} - \mathbf{A}_{jj})^{-1} \mathbf{A}_{ji},$$

where the "1" on the right hand side represents the initial unit output change in industry i

and $\mathbf{e}$ is the summation vector used to aggregate the elements in $\Delta \mathbf{x}_j$, i.e., the impacts of

this initial output change on the rest of the economy through industry i's backward

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[3] See Cai and Leung (2004) for more detailed mathematical derivations.

linkages. To facilitate linkage comparison among the industries, we calculate a backward linkage *index* by using the following formula:

$$\frac{LSD_i}{\sum_k LSD_k / k},$$

Industry i's BL index measures the *relative* strength of its backward linkage vis-à-vis other industries. Note that the BL index for i is simply the industry's Leontief supply driven multiplier divided by the average LSD for all the industries.

Ghosh Supply-Driven Multiplier as a Forward Linkage Measure

Similarly, in deriving the Ghosh supply driven multiplier as a forward linkage measure, we first partition the Ghosh input-output model $\mathbf{x}' = \mathbf{x}'\mathbf{B} + \mathbf{w}'$ into

$$\begin{pmatrix} x_i' & \mathbf{x}_j' \end{pmatrix} = \begin{pmatrix} x_i' & \mathbf{x}_j' \end{pmatrix}\begin{pmatrix} \mathbf{B}_{ii} & \mathbf{B}_{ij} \\ \mathbf{B}_{ji} & \mathbf{B}_{jj} \end{pmatrix} + \begin{pmatrix} \mathbf{w}_i' & \mathbf{w}_j' \end{pmatrix},$$

where $\mathbf{x}$ and $\mathbf{w}$ represent the output and primary input vectors respectively; and $\mathbf{B}$ is the direct output coefficient matrix. Based on this model, the forward linkage (FL) from one unit of output change in industry i can be calculated by $\Delta\mathbf{x}_j = \mathbf{B}_{ij}(\mathbf{I} - \mathbf{B}_{jj})^{-1}$, where the elements in vector $\Delta\mathbf{x}_j$ measure the forward-linkage impacts of the unit output change in industry i on the output of other industries. Summing these elements and the initial unit output change in industry i would give a measure of industry i's forward linkage impacts. Thus, industry i's Ghosh supply driven multiplier is given by

$$GSD_i = 1 + \mathbf{B}_{ij}(\mathbf{I} - \mathbf{B}_{jj})^{-1}\mathbf{e};$$

and the corresponding FL index is

$$\frac{GSD_i}{\sum\limits_{k} GSD_k / k}.$$

As in calculating the BL index, an industry's forward-linkage index is calculated by dividing its Ghosh supply-driven multiplier by the average Ghosh supply-driven multipliers for all the industries.

In sum, calculating the BL and FL indices requires a two-step procedure. The first step is to calculate the Leontief and Ghosh supply-driven (Type I) multipliers, and in the second step, use the multipliers to compute the indices. For both BL and FL indices, a value larger than one means above average (forward or backward) linkage between an industry and the rest of the industries in the economy, and a value below one means below average linkage.

In this paper, since each I-O industry has been decomposed into a tourism component and a non-tourism component, we can calculate separate BL and FL indices for the tourism and non-tourism components of each industry. This will enable us to ascertain whether inter-industry linkages are the same or different when industries produce for use in tourism or for non-tourism related uses.

IV. Tourism's Forward and Backward Linkages in Hawaii

Backward and Forward Linkages Within Tourism

We compute tourism BL and FL supply-driven multipliers and linkage indices for Hawaii using the 1987 and 1997 input-output models for Hawaii. These linkage indices show how the tourism component of each industry is linked to other industries in the economy. Table A1 in the Appendix presents the LSD and GSD multipliers and their

respective BL and FL indices for each of the tourism components within the 131 I-O "industries" in 1997. Table A2 in the Appendix presents the same information for the 60 "industries" in 1987. The interpretations of the Leontief and Ghosh supply-driven multipliers are straight-forward. For example, the LSD for hotels (tourism component, 1997) in Table A1 has a value of 1.4123 and a GSD value of 1.0040 meaning that to produce $1 of output in the hotel industry, hotels use $0.41 of output produced directly and indirectly by other industries, but hotels sell little to other industries as intermediate inputs. Indeed, for the tourism related industries that sell the lion's share of their outputs directly to tourists, there are virtually no, or extremely small, forward linkages, meaning that their Ghosh supply driven multipliers (GSD) are close to unity. Table A1 shows that the GSD for hotels in 1997 was 1.004; 1.000 for the amusement services industry, 1.0240 for air transportation, 1.0570 for automobile rentals, and 1.01 for sightseeing transportation.

We then grouped the industries into 4 categories depending on the values (i.e. size) of their BL and FL indices:

Strong backward and forward linkages: BL>1 and FL>1.

Strong backward but weak forward linkages: BL>1 and FL<1.

Weak backward but strong forward linkages: BL<1 and FL>1.

Weak backward and forward linkages: BL<1 and FL<1.

To illustrate using the numerical calculations from Table A1, if we take the top-20 tourism related industries for Hawaii in 1997, Table 2 shows that 10 of them have tourism components that have strong backward linkages but weak forward linkages, 6 have both weak backward and forward linkages, 3 have weak backward but strong

forward linkages, and only 1 has both strong forward and backward linkages. If we reduce the list to the top-10 tourism related industries, 7 of the tourism components have strong backward but weak forward linkages and 3 have both weak backward and forward linkages. Thus, among the leading tourism-related industries, most of their tourism components have strong backward linkages to other industries but weak forward linkages. More importantly, the backward and forward linkages differ among the tourism related industries.

Table 2 Inter-industry Linkages for Hawaii's Top-20 Tourism Related Industries: 1997

Industries	BL>1 FL>1	BL>1 FL<1	BL<1 FL>1	BL<1 FL<1
Hotels		X		
Sightseeing transportation				X
Automobile rental		X		
Amusement services		X		
Air transportation				X[*]
Ground passenger transportation				X
Golf courses		X		
Other general merchandise stores		X		
Apparel & accessory stores		X		
Recreation services		X		
Misc. store retailers				X
Travel arrangement & reservation services				X
Foodservice		X		
Museums and historical sites		X		
Other state and local gov't enterprises	X			
Investigation & security services			X	
Advertising			X	
Department stores				X
Bakeries and grain product mfg		X		
Support activities for transportation			X	

Note: *the BL value for air transportation was .9975, or close to unity.
Source: Table 1 and Table A1.

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Figure 2 also uses "bubbles" to display the absolute size, measured by their dollar value, of the tourism producers; the larger the bubble, the bigger the dollar value of tourism production. For 1997, the three largest tourism producers were hotels, food service, and air transportation. The largest producers of tourism commodities generally had relatively strong backward linkages but relatively weak forward linkages.

Figure 2 Inter-industry Linkages for Hawaii's Top 20 Tourism Related Industries: 1997
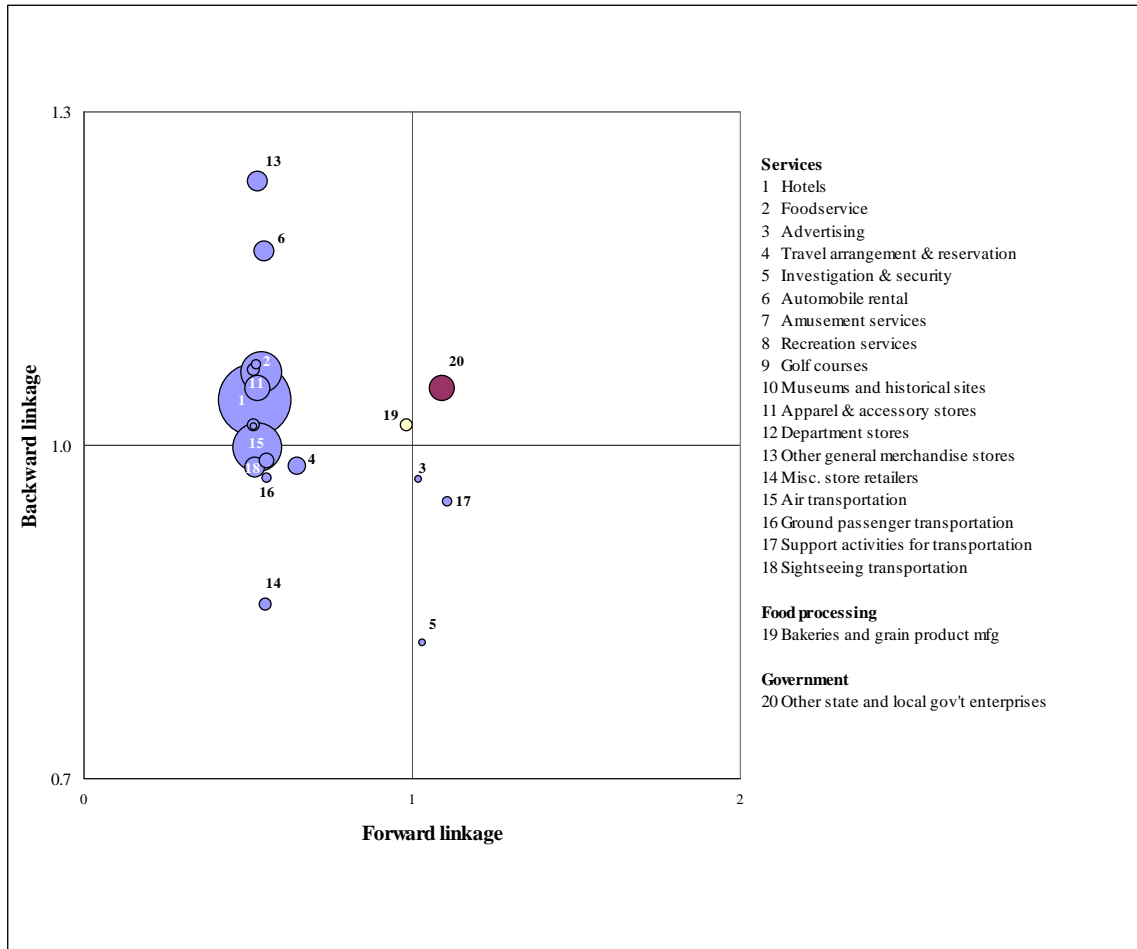
Source: Generated from the Hawaii 1997 input-output table. The size of each bubble represents the dollar value of each industry's tourism output.

Inter-industry Linkages for Non-Tourism

We also computed BL and FL indices for the non-tourism components of each I-O industry. The corresponding linkage calculations are displayed in Tables A3 (1997) and

A4 (1987) in the Appendix. Table 3 compares the backward (Leontief) and forward (Ghosh) supply driven multipliers for the tourism and non-tourism components of the top 20 tourism-related industries in 1997. Note that the backward linkage (BL) multipliers are exactly the same for the tourism and non-tourism components in Table 3. By construction, they should be identical as the production functions for tourism and non-tourism production are assumed to be the same. Intuitively, it means that it does not matter whether commodities are produced for tourism or non-tourism use, as long as they are produced using the same method, the demand for the outputs of the supplier industries is the same. However, the forward linkages need not be the same. Recall from our earlier example that a car rental to a tourist (final consumer) and one to a local business may have different forward linkages. Thus, the forward linkage multipliers in tourism and non-tourism are not the same in Table 3.

In Table 3 some of the forward linkage multipliers are higher for non-tourism use than for tourism use. In particular, hotels, automobile rental, and air transportation have stronger forward linkage when they produce and sell their outputs for non-tourism than for tourism use. In all three, sales to tourists—who are final consumers—generate no further downstream sales, but outputs sold to non-tourists (e.g. local businesses) may generate further downstream sales as they may be used as intermediate inputs in further production. But Table 3 also shows that some of the top 20 tourism-related industries (e.g., "travel arrangement and reservation services", "bakeries and grain product manufacturing", and "support activities for transportation") actually have stronger forward linkages when commodities are produced for tourism use than for non-tourism use. Indeed, most of the 131 industries have stronger forward linkages in tourism than

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non-tourism. While the average Ghosh (FL) supply driven multiplier in tourism is 1.93, the corresponding average in non-tourism is just 1.44. This means that $1 of output sold for tourism use generated $0.90 of downstream sales, but the same dollar of output sold for non-tourism uses generates only $0.44 of downstream transactions.

Table 3 Indices of Backward and Forward Multipliers for Tourism and Non-Tourism Components of Hawaii's Top-20 Tourism Related Industries: 1997

Industries	Leontief supply driven multiplier (as a BL multiplier)		Ghosh supply driven multiplier (as a FL multiplier)	
	Tourism	Non-tourism	Tourism	Non-tourism
Hotels	1.412	1.412	1.004	1.181
Sightseeing transportation	1.330	1.330	1.010	1.012
Automobile rental	1.594	1.594	1.057	1.707
Amusement services	1.383	1.383	1.000	1.000
Air transportation	1.355	1.355	1.024	1.183
Ground passenger transportation	1.317	1.317	1.076	1.214
Golf courses	1.450	1.450	1.000	1.000
Other general merchandise stores	1.681	1.681	1.024	1.109
Apparel & accessory stores	1.428	1.428	1.024	1.086
Recreation services	1.456	1.456	1.015	1.015
Misc. store retailers	1.163	1.163	1.066	1.225
Travel arrangement & reservation services	1.333	1.333	1.251	1.128
Foodservice	1.447	1.447	1.045	1.088
Museums and historical sites	1.381	1.381	1.000	1.000
Other state and local gov't enterprises	1.427	1.427	2.109	1.821
Investigation & security services	1.117	1.117	1.991	2.058
Advertising	1.316	1.316	1.964	2.218
Department stores	1.338	1.338	1.077	1.187
Bakeries and grain product mfg	1.381	1.381	1.899	1.399
Support activities for transportation	1.289	1.289	2.137	1.823

Source: Calculated from the Hawaii 1997 input-output table

These results suggest that production for tourism consumption is more complicated and round-about than production for non-tourism use. This should not be surprising. Except for a few commodities which are sold directly to tourists (e.g. hotel room and automobile rentals), businesses that produce commodities for tourism use usually sell them to other (intermediate) businesses which in turn use them to produce other commodities for resell to tourists. For example, a local consumer buys electricity

directly from the local utility company, but the tourist buys his electricity through the hotel. Hence, when the utility company produces electricity for sale to local consumers, the sale is to a final consumer which generates no additional downstream sales (forward linkage); but when the utility company sells electricity to a hotel to be used to light or air condition a hotel room, that sale is an intermediate transaction and the hotel, in effect, re-sells the electricity to the tourist.

<u>Linkages Between Tourism and Non-Tourism Components</u>

The way tourism and non-tourism is defined in this paper imposes the requirement that there are no relationships between the two. By construction each industry has a part that produces for tourism consumption and a part that produces for non-tourism consumption; the two do not overlap. That does not mean that production ultimately for two different uses may not be related. In reality, an industry's production of tourism and non-tourism commodities may be closely tied to each other through joint production. For example, an airline may carry tourists (tourism) and commercial cargo (non-tourism); and a restaurant may serve tourists (tourism) and locals (non-tourism). If either tourism or non-tourism production were to cease, the entire industry could disappear. Linkage analysis is not designed to address those issues.

V. Conclusion

In this paper, we introduced linkage analysis to tourism as a complement to the traditional "impact analysis" to provide a better understanding of tourism's relationship to the other industries in an economy. Since tourism is not a well-defined industry, directly applying linkage analysis is not possible. One of the main contributions of our

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paper is to develop an approach to tailor the conventional linkage assessment methodology to the case of tourism. To illustrate the empirical application of the tourism linkage assessment methodology developed here, we applied it to Hawaii. An interesting finding from this study is that the web of inter-industry relationships differ whether industries produce goods and services for tourism consumption or for non-tourism use. Indeed, we find that except for a few (large) tourism related industries such as hotels and air transportation which sell most of their output directly to tourists, in most other industries the web of forward linkages tend to be greater when producing for tourism than for non-tourism consumption. Thus, production for tourism consumption is generally more indirect in that it involves more forward (i.e. downstream) transactions. This finding is not readily obvious using traditional tourism impact analysis.

Linkage analysis may be quite useful to assess the effectiveness of development strategies aimed at strengthen linkages over time among industries, say between tourism and agriculture. Unfortunately, because the number and definitions of industries in Hawaii's I-O model changed between 1987 and 1997, we could not compare industry linkages over time. It might be useful to apply the same analysis to the (more stable) U.S. I-O model over time.

We conclude by cautioning that one must take great care in interpreting the meaning of backward and forward linkages. Linkage analysis is intended to provide information about tourism-related inter-industry relationships at a given moment in time. Such information is useful when comparing different countries' or regions' inter-industry relationships between tourism and other industries at a given moment in time or when examining changes in a country's or region's industrial structure between two points in

time. It should not be used to infer causality. For example, what would happen to tourism if a hurricane were to destroy a large percentage of the agricultural (food) crops in Hawaii? Would a reduction in agricultural food production cause food sales at restaurants to decline by the magnitudes indicated by the forward linkage multipliers? Perhaps not, as restaurants might be able to replace locally produced agricultural products by imports to maintain their previous levels of sales. Thus, knowing the strengths and shortcomings of linkage analysis can provide important guidance on when it is most appropriate to use it.

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Appendix Tables

Table A1 Linkages of the Tourism Components of Hawaii's 131 Industries in 1997

		Industries	Leontief supply driven multipliers	Ghosh supply driven multipliers	Backward linkage indices	Forward linkage indices
	27	Sugar mfg	1.9699	3.2208	1.4506	1.6708
	44	Non-metallic mineral product mfg	1.5367	3.0701	1.1316	1.5926
	89	Architectural and engineering services	1.4035	3.0531	1.0335	1.5838
	8	Dairy cattle and milk production	1.3623	3.0110	1.0032	1.5620
	11	Hog and pig farming	1.4232	2.5560	1.0480	1.3260
	6	Coffee	1.4491	2.5452	1.0671	1.3204
	123	Organizations	1.6653	2.5179	1.2263	1.3062
	92	Research and development services	1.3591	2.4351	1.0008	1.2632
Strong BL Strong FL	95	Other professional services	1.4207	2.3322	1.0462	1.2098
	102	Waste management & remediation services	1.4696	2.2636	1.0822	1.1743
	14	Other agricultural products	1.4851	2.2434	1.0936	1.1638
	64	Electricity	1.4286	2.2123	1.0520	1.1476
	65	Gas production & distribution	1.4110	2.2112	1.0390	1.1471
	50	Warehousing	1.6398	2.1840	1.2075	1.1330
	124	Other state and local gov't enterprises	1.4267	2.1087	1.0506	1.0939
	26	Fruit and vegetable product mfg	1.7974	2.0717	1.3235	1.0747
	15	Commercial fishing	1.5650	1.9484	1.1524	1.0107
	30	Dairy product mfg	1.4711	1.9034	1.0832	0.9874
	31	Bakeries and grain product mfg	1.3814	1.8986	1.0172	0.9849
	32	Beverage mfg	1.4656	1.8869	1.0792	0.9789
	9	Poultry and eggs	1.4713	1.8677	1.0834	0.9689
	35	Other food product mfg	1.4209	1.7968	1.0463	0.9321
	2	Vegetables	1.5824	1.7961	1.1653	0.9317
	29	Meat product mfg	1.9249	1.7938	1.4175	0.9306
	3	Macadamia nuts	1.3997	1.6418	1.0307	0.8517
	49	Truck transportation	1.3808	1.6295	1.0167	0.8453
	85	Equipment rental	1.3588	1.6240	1.0005	0.8425
	121	Parking lots and garages	1.5837	1.6093	1.1662	0.8348
	5	Other fruits	1.6040	1.5828	1.1811	0.8211
	116	Dry-cleaning and laundry services	1.3668	1.5651	1.0064	0.8119
	34	Coffee and tea mfg	1.5584	1.5496	1.1476	0.8038
Strong BL Weak FL	4	Pineapples	1.5246	1.5219	1.1227	0.7895
	28	Confectionery product mfg	1.4285	1.2948	1.0519	0.6717
	51	Water transportation	1.4920	1.2373	1.0987	0.6419
	107	Other medical services	1.3820	1.1455	1.0177	0.5942
	33	Snack food mfg	1.4437	1.1265	1.0631	0.5844
	86	Automobile rental	1.5939	1.0570	1.1737	0.5483
	115	Foodservice	1.4469	1.0451	1.0655	0.5422
	77	Other general merchandise stores	1.6805	1.0244	1.2375	0.5314
	74	Apparel & accessory stores	1.4275	1.0236	1.0512	0.5310
	111	Recreation services	1.4556	1.0154	1.0719	0.5268
	114	Hotels	1.4123	1.0040	1.0400	0.5208
	126	State and local gov't enterprises: Transit	2.1903	1.0000	1.6128	0.5188
	106	Hospitals	1.4872	1.0000	1.0951	0.5188
	112	Golf courses	1.4496	1.0000	1.0674	0.5188
	110	Amusement services	1.3828	1.0000	1.0183	0.5188
	113	Museums and historical sites	1.3807	1.0000	1.0167	0.5188

Table A1 Linkages of the Tourism Components of Hawaii's 131 Industries in 1997 (continued)

		Industries	Leontief supply driven multipliers	Ghosh supply driven multipliers	Backward linkage indices	Forward linkage indices
	1	Sugarcane	1.3051	4.2209	0.9611	2.1896
	18	Mining	1.2981	3.8323	0.9559	1.9880
	38	Furniture mfg	1.2431	3.5013	0.9154	1.8163
	68	Furniture and home furnishing stores	1.1866	3.2516	0.8738	1.6868
	37	Wood product mfg	1.2266	3.1594	0.9032	1.6390
	81	Securities and investment activities	1.2723	2.9157	0.9369	1.5126
	39	Paper mfg	1.2451	2.8786	0.9169	1.4933
	16	Support activities for agriculture	1.3336	2.8632	0.9820	1.4853
	41	Chemical mfg	1.2668	2.8608	0.9328	1.4841
	45	Metal product mfg	1.2179	2.8483	0.8968	1.4776
	70	Building materials & gardening equipment dealers	1.2664	2.8031	0.9325	1.4542
	59	Motion picture and sound production	1.1620	2.5393	0.8557	1.3173
	40	Printing	1.2783	2.5298	0.9413	1.3124
	25	Maintenance & repair construction	1.3441	2.5073	0.9898	1.3007
	58	Software & information services	1.2786	2.4771	0.9415	1.2850
	10	Cattle Ranching	1.2296	2.4591	0.9054	1.2757
	87	Legal services	1.1824	2.4519	0.8707	1.2719
	12	Misc. livestock	1.3164	2.4480	0.9694	1.2699
	118	Other repair services	1.2333	2.3700	0.9081	1.2294
	88	Accounting services	1.3158	2.3430	0.9689	1.2154
Weak BL	17	Landscape services	1.2865	2.3273	0.9473	1.2073
Strong FL	101	Services to buildings & dwellings	1.1473	2.3209	0.8448	1.2040
	97	Employment services	1.0796	2.3204	0.7950	1.2037
	55	Couriers	1.3304	2.2987	0.9797	1.1925
	43	Rubber & plastic product mfg	1.3296	2.2872	0.9791	1.1865
	42	Petroleum mfg	1.0682	2.2863	0.7866	1.1860
	117	Automotive repair services	1.3376	2.2856	0.9849	1.1857
	47	Transportation equipment mfg	1.1776	2.2851	0.8672	1.1854
	127	Federal gov't enterprises: Postal service	1.3320	2.2313	0.9808	1.1575
	67	Motor vehicle and parts dealers	1.3093	2.2251	0.9641	1.1543
	63	Telecommunications	1.1607	2.1709	0.8547	1.1262
	125	State and local gov't enterprises: Water and sewer	1.2435	2.1595	0.9157	1.1203
	13	Aquaculture	1.2891	2.1402	0.9493	1.1103
	54	Support activities for transportation	1.2887	2.1370	0.9490	1.1086
	80	Banking and credit intermediation	1.2664	2.1193	0.9325	1.0994
	62	Cable TV	1.2352	2.1018	0.9095	1.0903
	61	Radio and TV broadcasting	1.2502	2.1016	0.9206	1.0902
	94	Photographic services	1.3311	2.0850	0.9802	1.0816
	82	Insurance	1.2557	2.0726	0.9246	1.0752
	91	Management, scientific, and consulting services	1.2786	2.0426	0.9416	1.0596
	57	Publishing	1.2817	1.9967	0.9438	1.0358
	100	Investigation & security services	1.1167	1.9909	0.8223	1.0328
	93	Advertising	1.3159	1.9635	0.9690	1.0186
	96	Administrative and facilities support services	1.3347	1.9247	0.9828	0.9985
	7	Greenhouse and nursery products	1.2107	1.8629	0.8915	0.9664
	69	Electronics and appliance stores	1.2699	1.8584	0.9351	0.9641
	73	Gas stations	1.3339	1.8232	0.9822	0.9458
	98	Business support services	1.2798	1.7872	0.9424	0.9271
	90	Computer systems design services	1.2568	1.6410	0.9255	0.8513
	66	Wholesale trade	1.2210	1.6162	0.8991	0.8384
	84	Real estate	1.1922	1.5708	0.8779	0.8149
	75	Sporting goods, hobby, book, and music stores	1.1877	1.3054	0.8746	0.6772
	109	Performing arts and related services	1.2417	1.3023	0.9143	0.6756
	99	Travel arrangement & reservation services	1.3329	1.2510	0.9815	0.6490
	36	Apparel and textile mfg	1.2028	1.2059	0.8857	0.6256
Weak BL	71	Food stores	1.2245	1.1310	0.9017	0.5867
Weak FL	76	Department stores	1.3380	1.0775	0.9853	0.5590
	53	Ground passenger transportation	1.3173	1.0765	0.9700	0.5584
	103	Educational services	1.3530	1.0679	0.9963	0.5540
	78	Misc. store retailers	1.1626	1.0657	0.8561	0.5529
	79	Nonstore retailers	1.2529	1.0492	0.9226	0.5443
	72	Health and personal care stores	1.2476	1.0399	0.9187	0.5395
	52	Air transportation	1.3546	1.0240	0.9975	0.5312
	48	Misc. product mfg	1.2143	1.0113	0.8941	0.5246
	56	Sightseeing transportation	1.3299	1.0100	0.9793	0.5240
	119	Personal care services	1.2798	1.0000	0.9424	0.5188
	104	Doctors and dentists	1.2733	1.0000	0.9376	0.5188
	60	Motion picture exhibition	1.2702	1.0000	0.9353	0.5188
	122	Other personal services and households	1.1673	1.0000	0.8596	0.5188
	128	Other federal gov't enterprises	1.1634	1.0000	0.8567	0.5188

Source: calculated from the Hawaii 1997 input-output table.

Table A2 Linkages of the Tourism Components of Hawaii's 60 Industries in 1987

	Industries	Leontief supply driven multiplier	Ghosh supply driven multiplier	Backward linkage indices	Forward linkage indices
Strong BL Strong FL	12 MINING	1.4114	3.1513	1.0325	1.7063
	6 DAIRY FARM PRODUCTS	1.8289	2.5140	1.3380	1.3613
	5 BEEF AND HOGS	1.5164	2.3028	1.1093	1.2469
	4 SUGAR PROCESSING	1.9021	2.1940	1.3915	1.1880
	45 GAS	1.6839	2.1809	1.2319	1.1809
	46 WATER AND SANITARY SERVICES	1.8244	2.0904	1.3346	1.1319
Strong BL Weak FL	17 OTHER FOOD PRODUCTS	1.4851	1.6937	1.0864	0.9171
	7 POULTRY	1.7831	1.6752	1.3044	0.9071
	15 BAKERY PRODUCTS	1.6715	1.6392	1.2228	0.8876
	16 BEVERAGES	1.5734	1.6284	1.1510	0.8817
	13 MEAT PRODUCTS	1.9421	1.6181	1.4207	0.8761
	14 MILK PRODUCTS	1.6866	1.3881	1.2339	0.7516
	55 AUTO AND OTHER REPAIR	1.3913	1.3201	1.0178	0.7148
	3 PINEAPPLE CANNING	1.8830	1.1481	1.3775	0.6216
	42 LOCAL GROUND TRANSPORTATION	1.4111	1.1272	1.0323	0.6103
	58 EDUCATION AND OTHER SERVICES	1.5107	1.1046	1.1052	0.5981
	48 RETAIL TRADE	1.4172	1.0526	1.0368	0.5700
	49 EATING AND DRINKING PLACES	1.3947	1.0512	1.0203	0.5692
	56 AMUSEMENT SERVICES	1.4758	1.0488	1.0796	0.5679
	52 HOTELS	1.4786	1.0073	1.0817	0.5454
Weak BL Strong FL	27 PRIMARY METALS	1.0000	3.8058	0.7316	2.0607
	1 SUGARCANE	1.2193	3.1936	0.8920	1.7292
	30 TRANSPORTATION EQUIPMENT	1.1705	2.8508	0.8563	1.5436
	9 TREE NUTS	1.1798	2.7476	0.8631	1.4877
	28 FABRICATED METAL PRODUCTS	1.1879	2.7364	0.8690	1.4817
	19 LUMBER AND WOOD PRODUCTS	1.1934	2.4469	0.8731	1.3249
	37 MAINTENANCE AND REPAIR	1.2745	2.3019	0.9324	1.2464
	21 PAPER AND PAPER PRODUCTS	1.2029	2.2720	0.8800	1.2302
	44 ELECTRICITY	1.3242	2.1619	0.9687	1.1706
	29 MACHINERY	1.2410	2.1580	0.9079	1.1685
	8 FISHING AND FORESTRY PRODUCTS	1.2709	2.1543	0.9298	1.1665
	51 REAL ESTATE	1.1384	2.1283	0.8328	1.1524
	24 PETROLEUM REFINING	1.0292	2.0810	0.7529	1.1268
	54 BUSINESS SERVICES	1.2115	2.0784	0.8863	1.1254
	23 CHEMICALS AND ALLIED PRODUCTS	1.2972	2.0735	0.9490	1.1227
	43 COMMUNICATION	1.1321	2.0594	0.8282	1.1151
	59 GOVERNMENT ENTERPRISES	1.1747	2.0320	0.8594	1.1002
	22 PRINTING AND PUBLISHING	1.3572	1.9747	0.9929	1.0692
	57 HEALTH AND PROFESSIONAL SERVICES	1.2212	1.9652	0.8934	1.0641
	50 FINANCE AND INSURANCE	1.2656	1.9585	0.9259	1.0605
	26 CEMENT, STONE, AND CLAY	1.3349	1.8827	0.9766	1.0194
Weak BL Weak FL	38 TRUCKING AND WAREHOUSING	1.2243	1.8437	0.8956	0.9983
	11 OTHER AGRICULTURAL PRODUCTS	1.2102	1.7672	0.8853	0.9569
	25 RUBBER, PLASTIC, AND LEATHER	1.3066	1.7252	0.9558	0.9341
	53 PERSONAL SERVICES	1.2054	1.7036	0.8818	0.9225
	47 WHOLESALE TRADE	1.2073	1.6612	0.8832	0.8995
	40 OCEAN TRANSPORTATION	1.3112	1.2715	0.9592	0.6885
	10 NURSERY AND GREENHOUSE PRODUCTS	1.1304	1.2199	0.8270	0.6606
	31 MISCELLANEOUS MANUFACTURING	1.2964	1.1786	0.9484	0.6382
	2 PINEAPPLE	1.1558	1.1316	0.8456	0.6127
	39 TRANSPORTATION SERVICES	1.2552	1.0994	0.9182	0.5953
	18 TEXTILES AND APPAREL	1.1904	1.0827	0.8708	0.5862
	20 FURNITURE AND FIXTURES	1.3005	1.0261	0.9514	0.5556
	41 AIR TRANSPORTATION	1.3237	1.0198	0.9684	0.5522

Source: calculated from the Hawaii's 1987 input-output table.

Table A3 Linkages of the Non-Tourism Components of Hawaii's 131 Industries in 1997

		Industries	Leontief supplier driven multipliers	Ghosh supply driven multipliers	Backward linkage indices	Forward linkage indices
	50	Warehousing	1.6398	2.4317	1.2128	1.7421
	8	Dairy cattle and milk production	1.3623	2.2928	1.0076	1.6426
	102	Waste management & remediation services	1.4696	2.0641	1.0869	1.4788
	44	Non-metallic mineral product mfg	1.5367	1.8895	1.1366	1.3537
	11	Hog and pig farming	1.4232	1.8765	1.0526	1.3444
	124	Other state and local gov't enterprises	1.4267	1.8215	1.0552	1.3050
	86	Automobile rental	1.5939	1.7072	1.1789	1.2231
	95	Other professional services	1.4207	1.6955	1.0508	1.2147
Strong BL	85	Equipment rental	1.3588	1.6480	1.0049	1.1807
Strong FL	89	Architectural and engineering services	1.4035	1.6233	1.0381	1.1630
	3	Macadamia nuts	1.3997	1.6217	1.0352	1.1618
	92	Research and development services	1.3591	1.6166	1.0052	1.1582
	123	Organizations	1.6653	1.5900	1.2316	1.1391
	65	Gas production & distribution	1.4110	1.5161	1.0436	1.0862
	64	Electricity	1.4286	1.4839	1.0566	1.0631
	6	Coffee	1.4491	1.4716	1.0718	1.0543
	9	Poultry and eggs	1.4713	1.4225	1.0882	1.0191
	31	Bakeries and grain product mfg	1.3814	1.3990	1.0217	1.0023
	4	Pineapples	1.5246	1.3540	1.1276	0.9701
	49	Truck transportation	1.3808	1.3525	1.0212	0.9690
	51	Water transportation	1.4920	1.3159	1.1035	0.9427
	29	Meat product mfg	1.9249	1.2595	1.4237	0.9024
	30	Dairy product mfg	1.4711	1.2479	1.0880	0.8940
	34	Coffee and tea mfg	1.5584	1.2382	1.1526	0.8871
	121	Parking lots and garages	1.5837	1.2284	1.1713	0.8801
	2	Vegetables	1.5824	1.2234	1.1704	0.8765
	15	Commercial fishing	1.5650	1.2167	1.1575	0.8717
	32	Beverage mfg	1.4656	1.2064	1.0840	0.8643
	52	Air transportation	1.3546	1.1831	1.0019	0.8476
	114	Hotels	1.4123	1.1806	1.0446	0.8458
	35	Other food product mfg	1.4209	1.1701	1.0509	0.8383
	107	Other medical services	1.3820	1.1666	1.0222	0.8358
	116	Dry-cleaning and laundry services	1.3668	1.1345	1.0109	0.8128
	5	Other fruits	1.6040	1.1238	1.1863	0.8051
	77	Other general merchandise stores	1.6805	1.1092	1.2429	0.7946
	14	Other agricultural products	1.4851	1.1040	1.0984	0.7909
Strong BL	103	Educational services	1.3530	1.1018	1.0007	0.7894
Weak FL	115	Foodservice	1.4469	1.0882	1.0702	0.7797
	74	Apparel & accessory stores	1.4275	1.0861	1.0558	0.7781
	27	Sugar mfg	1.9699	1.0429	1.4570	0.7472
	28	Confectionery product mfg	1.4285	1.0420	1.0566	0.7465
	26	Fruit and vegetable product mfg	1.7974	1.0361	1.3294	0.7423
	33	Snack food mfg	1.4437	1.0283	1.0678	0.7367
	111	Recreation services	1.4556	1.0147	1.0766	0.7270
	126	State and local gov't enterprises: Transit	2.1903	1.0000	1.6199	0.7164
	23	Road construction	1.5214	1.0000	1.1252	0.7164
	106	Hospitals	1.4872	1.0000	1.0999	0.7164
	22	Hotel construction	1.4856	1.0000	1.0988	0.7164
	24	Other construction	1.4648	1.0000	1.0833	0.7164
	21	Commercial building construction	1.4583	1.0000	1.0785	0.7164
	112	Golf courses	1.4496	1.0000	1.0721	0.7164
	20	Multiple family housing construction	1.4230	1.0000	1.0525	0.7164
	19	Single family housing construction	1.4203	1.0000	1.0504	0.7164
	110	Amusement services	1.3828	1.0000	1.0227	0.7164
	113	Museums and historical sites	1.3807	1.0000	1.0212	0.7164
	108	Social assistance	1.3529	1.0000	1.0006	0.7164

Table A3 Linkages of the Non-Tourism Components of Hawaii's 131 Industries in 1997 (continued)

		Industries	Leontief supply driven multiplier	Ghosh supply driven multiplier	Backward linkage indices	Forward linkage indices
	18	Mining	1.2981	2.6753	0.9601	1.9167
	97	Employment services	1.0796	2.3165	0.7985	1.6596
	40	Printing	1.2783	2.2887	0.9454	1.6397
	93	Advertising	1.3159	2.2182	0.9733	1.5892
	88	Accounting services	1.3158	2.2122	0.9732	1.5849
	101	Services to buildings & dwellings	1.1473	2.1803	0.8486	1.5620
	100	Investigation & security services	1.1167	2.0576	0.8259	1.4742
	1	Sugarcane	1.3051	2.0429	0.9653	1.4636
	58	Software & information services	1.2786	2.0032	0.9457	1.4351
	98	Business support services	1.2798	1.9958	0.9466	1.4298
	17	Landscape services	1.2865	1.9878	0.9515	1.4241
	91	Management, scientific, and consulting services	1.2786	1.9793	0.9457	1.4180
	61	Radio and TV broadcasting	1.2502	1.9462	0.9246	1.3943
	41	Chemical mfg	1.2668	1.9317	0.9369	1.3840
	55	Couriers	1.3304	1.9264	0.9840	1.3801
	43	Rubber & plastic product mfg	1.3296	1.8831	0.9834	1.3491
Weak BL	16	Support activities for agriculture	1.3336	1.8725	0.9863	1.3415
Strong FL	127	Federal gov't enterprises: Postal service	1.3320	1.8562	0.9851	1.3298
	54	Support activities for transportation	1.2887	1.8231	0.9531	1.3062
	45	Metal product mfg	1.2179	1.7937	0.9008	1.2851
	118	Other repair services	1.2333	1.7879	0.9121	1.2809
	39	Paper mfg	1.2451	1.7830	0.9209	1.2774
	57	Publishing	1.2817	1.7480	0.9480	1.2524
	37	Wood product mfg	1.2266	1.6797	0.9072	1.2034
	70	Building materials & gardening equipment dealers	1.2664	1.6583	0.9366	1.1881
	25	Maintenance & repair construction	1.3441	1.6159	0.9941	1.1577
	94	Photographic services	1.3311	1.5530	0.9845	1.1126
	42	Petroleum mfg	1.0682	1.5522	0.7901	1.1120
	81	Securities and investment activities	1.2723	1.5511	0.9410	1.1113
	84	Real estate	1.1922	1.5124	0.8818	1.0835
	87	Legal services	1.1824	1.4808	0.8745	1.0609
	66	Wholesale trade	1.2210	1.4368	0.9031	1.0294
	82	Insurance	1.2557	1.4217	0.9287	1.0186
	63	Telecommunications	1.1607	1.4196	0.8585	1.0171
	59	Motion picture and sound production	1.1620	1.3929	0.8595	0.9979
	96	Administrative and facilities support services	1.3347	1.3718	0.9872	0.9828
	90	Computer systems design services	1.2568	1.3611	0.9295	0.9751
	67	Motor vehicle and parts dealers	1.3093	1.3292	0.9684	0.9523
	10	Cattle Ranching	1.2296	1.3287	0.9094	0.9519
	7	Greenhouse and nursery products	1.2107	1.2887	0.8954	0.9233
	117	Automotive repair services	1.3376	1.2853	0.9893	0.9208
	38	Furniture mfg	1.2431	1.2691	0.9194	0.9092
	80	Banking and credit intermediation	1.2664	1.2507	0.9366	0.8960
	78	Misc. store retailers	1.1626	1.2247	0.8599	0.8774
	73	Gas stations	1.3339	1.2165	0.9865	0.8715
	53	Ground passenger transportation	1.3173	1.2138	0.9743	0.8696
	68	Furniture and home furnishing stores	1.1866	1.2135	0.8776	0.8694
	125	State and local gov't enterprises: Water and sewer	1.2435	1.2021	0.9197	0.8612
	12	Misc. livestock	1.3164	1.1876	0.9736	0.8509
	76	Department stores	1.3380	1.1867	0.9896	0.8502
	13	Aquaculture	1.2891	1.1859	0.9534	0.8496
	99	Travel arrangement & reservation services	1.3329	1.1277	0.9858	0.8079
	47	Transportation equipment mfg	1.1776	1.1261	0.8710	0.8067
Weak BL	109	Performing arts and related services	1.2417	1.1128	0.9183	0.7973
Weak FL	75	Sporting goods, hobby, book, and music stores	1.1877	1.0913	0.8785	0.7819
	69	Electronics and appliance stores	1.2699	1.0651	0.9393	0.7631
	79	Nonstore retailers	1.2529	1.0489	0.9267	0.7514
	36	Apparel and textile mfg	1.2028	1.0412	0.8896	0.7459
	71	Food stores	1.2245	1.0391	0.9056	0.7444
	62	Cable TV	1.2352	1.0233	0.9135	0.7332
	48	Misc. product mfg	1.2143	1.0199	0.8981	0.7307
	72	Health and personal care stores	1.2476	1.0173	0.9228	0.7288
	56	Sightseeing transportation	1.3299	1.0117	0.9836	0.7248
	105	Nursing and residential care facilities	1.3260	1.0000	0.9807	0.7164
	119	Personal care services	1.2798	1.0000	0.9465	0.7164
	46	Electrical product mfg	1.2786	1.0000	0.9456	0.7164
	104	Doctors and dentists	1.2733	1.0000	0.9417	0.7164
	60	Motion picture exhibition	1.2702	1.0000	0.9394	0.7164
	83	Owner-occupied dwellings	1.2535	1.0000	0.9271	0.7164
	120	Death care services	1.2485	1.0000	0.9234	0.7164
	122	Other personal services and households	1.1673	1.0000	0.8633	0.7164
	128	Other federal gov't enterprises	1.1634	1.0000	0.8605	0.7164
	129	Federal gov't: Military	1.0000	1.0000	0.7396	0.7164
	130	Federal gov't: Civilian	1.0000	1.0000	0.7396	0.7164
	131	State and local government	1.0000	1.0000	0.7396	0.7164

Source: calculated from the Hawaii 1997 input output table.

Table A4 Linkages of the Non-Tourism Components of Hawaii's 60 Industries in 1987

	Industries	Leontief supply driven multiplier	Ghosh supply driven multiplier	Backward linkage indices	Forward linkage indices
Strong BL Strong FL	12 MINING	1.4114	2.2432	1.0344	1.4837
	6 DAIRY FARM PRODUCTS	1.8289	2.1929	1.3404	1.4505
	5 BEEF AND HOGS	1.5164	2.0745	1.1113	1.3722
	45 GAS	1.6839	1.8358	1.2341	1.2143
	55 AUTO AND OTHER REPAIR	1.3913	1.6770	1.0196	1.1092
	46 WATER AND SANITARY SERVICES	1.8244	1.6505	1.3370	1.0917
Strong BL Weak FL	52 HOTELS	1.4786	1.5075	1.0836	0.9971
	42 LOCAL GROUND TRANSPORTATION	1.4111	1.2905	1.0341	0.8536
	7 POULTRY	1.7831	1.2745	1.3067	0.8430
	17 OTHER FOOD PRODUCTS	1.4851	1.2631	1.0884	0.8355
	16 BEVERAGES	1.5734	1.2290	1.1531	0.8129
	15 BAKERY PRODUCTS	1.6715	1.2220	1.2250	0.8083
	13 MEAT PRODUCTS	1.9421	1.2098	1.4233	0.8002
	49 EATING AND DRINKING PLACES	1.3947	1.1601	1.0221	0.7673
	14 MILK PRODUCTS	1.6866	1.1084	1.2361	0.7331
	56 AMUSEMENT SERVICES	1.4758	1.0908	1.0816	0.7215
	48 RETAIL TRADE	1.4172	1.0896	1.0386	0.7207
	4 SUGAR PROCESSING	1.9021	1.0736	1.3940	0.7101
	58 EDUCATION AND OTHER SERVICES	1.5107	1.0490	1.1072	0.6938
	3 PINEAPPLE CANNING	1.8830	1.0009	1.3800	0.6620
	33 MULTI-FAMILY CONSTRUCTION	1.4496	1.0000	1.0624	0.6614
	32 SINGLE-FAMILY CONSTRUCTION	1.4346	1.0000	1.0514	0.6614
	36 OTHER CONSTRUCTION	1.4069	1.0000	1.0311	0.6614
	34 HOTEL CONSTRUCTION	1.4052	1.0000	1.0298	0.6614
Weak BL Strong FL	27 PRIMARY METALS	1.0000	3.0064	0.7329	1.9885
	9 TREE NUTS	1.1798	2.2971	0.8647	1.5194
	8 FISHING AND FORESTRY PRODUCTS	1.2709	2.0930	0.9314	1.3844
	21 PAPER AND PAPER PRODUCTS	1.2029	2.0923	0.8816	1.3839
	1 SUGARCANE	1.2193	2.0729	0.8936	1.3711
	37 MAINTENANCE AND REPAIR	1.2745	1.9887	0.9340	1.3154
	54 BUSINESS SERVICES	1.2115	1.9818	0.8879	1.3109
	59 GOVERNMENT ENTERPRISES	1.1747	1.9647	0.8609	1.2995
	28 FABRICATED METAL PRODUCTS	1.1879	1.9568	0.8706	1.2943
	25 RUBBER, PLASTIC, AND LEATHER	1.3066	1.9503	0.9575	1.2900
	19 LUMBER AND WOOD PRODUCTS	1.1934	1.9300	0.8746	1.2766
	24 PETROLEUM REFINING	1.0292	1.9094	0.7543	1.2629
	26 CEMENT, STONE, AND CLAY	1.3349	1.7881	0.9783	1.1827
	39 TRANSPORTATION SERVICES	1.2552	1.7644	0.9199	1.1670
	22 PRINTING AND PUBLISHING	1.3572	1.7386	0.9947	1.1500
	23 CHEMICALS AND ALLIED PRODUCTS	1.2972	1.7164	0.9507	1.1353
	38 TRUCKING AND WAREHOUSING	1.2243	1.7035	0.8972	1.1268
	43 COMMUNICATION	1.1321	1.6770	0.8297	1.1092
	29 MACHINERY	1.2410	1.6595	0.9095	1.0977
	30 TRANSPORTATION EQUIPMENT	1.1705	1.5715	0.8578	1.0394
	2 PINEAPPLE	1.1558	1.5311	0.8471	1.0127
	41 AIR TRANSPORTATION	1.3237	1.5152	0.9701	1.0022
	44 ELECTRICITY	1.3242	1.5121	0.9705	1.0001
Weak BL Weak FL	47 WHOLESALE TRADE	1.2073	1.4208	0.8848	0.9398
	53 PERSONAL SERVICES	1.2054	1.3860	0.8834	0.9168
	57 HEALTH AND PROFESSIONAL SERVICES	1.2212	1.2330	0.8949	0.8156
	31 MISCELLANEOUS MANUFACTURING	1.2964	1.1961	0.9501	0.7911
	40 OCEAN TRANSPORTATION	1.3112	1.1924	0.9609	0.7887
	51 REAL ESTATE	1.1384	1.1911	0.8343	0.7878
	50 FINANCE AND INSURANCE	1.2656	1.1408	0.9275	0.7546
	11 OTHER AGRICULTURAL PRODUCTS	1.2102	1.1293	0.8869	0.7470
	10 NURSERY AND GREENHOUSE PRODUCTS	1.1304	1.0681	0.8284	0.7065
	18 TEXTILES AND APPAREL	1.1904	1.0618	0.8724	0.7023
	20 FURNITURE AND FIXTURES	1.3005	1.0288	0.9531	0.6805
	35 COMMERCIAL CONSTRUCTION	1.3593	1.0000	0.9962	0.6614
	60 OTHER INDUSTRIES (GOVERNMENT)	1.0000	1.0000	0.7329	0.6614

Source: calculated from the Hawaii 1987 input-output table.