Decomposing Trade Effects between Two Islands: A Bi-regional Input-Output Model

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Abstract**—**A bi-regional input-output model utilized national and regional data was constructed in this study. It is used to quantify and decompose the industry multipliers of an island named Xiao-liu-qiu, with other industries, both within the island and in the rest of Taiwan. In addition, this study especially focuses on tourism development of Xiao-liu-qiu since tourism is the emerging economic activity. Multiplier analysis was used based on input-output model. Two main findings show based on the results: first, only few tourism characteristic industries can generate relatively higher pulling effects; second, most of the effects leak out to the rest of Taiwan due to the heavy trade dependence on the mainland supplies, and the supply dependence is not mutual between the two regions. The business and policy recommendations are given based on the findings.

Keywords—input-output analysis, regional study, remote community

I. Introduction

Taiwan is a country with one main island and 121 offshore islands. Among these offshore islands, only six of them are inhabited, and each of them has their unique culture, geography and ecosystem. Compared with the mainland of Taiwan, the economic development and the life quality in the islands are weaker due to limited resources and geographical isolation. Xiao-liu-qiu is one out of six insular areas, which is located in the west-southern area of Taiwan with an economy heavily specialized in fishery and tourism as economic activities. It is the only one coral island in Taiwan; with 6.8 km^2 of the total territorial area. The only access from the mainland of Taiwan to the island is by ferry, consuming about thirty minutes. Because of attributes such as its coral formations, abundant natural tourism resources, and easy-going culture, the island attracts a greater number of tourists year by year. In 2013, Xiao-liu-qiu, with 12,415 registered inhabitants, attracted 378,791 visitors [1], [9].

Since the past decade, tourism has been getting popular on this island. However, the island highly relies on the various supplies (e.g., food, water, and construction material), from the mainland of Taiwan. The economic multiplier effects have not been discussed yet in the context of high resource dependence. Therefore, the objective of this study is to explore this issue, especially focuses on tourism characteristic industries. To that end, the study intends to decompose the trade effects within and between the islands based on a bi-regional input-output model.

II. Method

A. A. Data

The 166 by 166 industries of national benchmark input-output table for 2011 was aggregated into 14 by 14 sectors. The name of each industry is given based on the standard industrial classification system of the Republic of China published by Directorate-General of Budget, Accounting, and Statistics, Executive Yun, Taiwan [2]. This study particularly intends to focus on the effects of tourism. Therefore, it is needed to define the industries related to tourism. Tourism is not an independent industry in the national account system [4], it is a combination of group of industries that are related to tourism characteristic activities [7].

TABLE 1
INDUSTRY CATEGORY

Category (code)	Description
Agriculture, Forestry, and Animal Husbandry (S1)	Growing of Cereals (Except Rice), Growing of Vegetables, and Growing, of Fruits
Fishing (S2)	Marine Fishing, Marine Aquaculture
Mining & Quarrying and Manufacturing (S3)	Manufacture of Fish, Crustaceans and Molluscs Products
Electricity & Gas Supply (S4)	N/A
Water Supply (S5)	N/A
Remediation Services (S6)	N/A
Construction (S7)	Construction
Wholesale & Retail Trade* (S8)	Retail Trade (including souvenir sales to the tourists)
Transportation and Storage* (S9)	Water Transportation (mainly passenger ferry from mainland of Taiwan to Xiao-liu-qiu) and Postal Activities
Accommodation*(S10)	Short Term Accommodation Activities
Food Service* (S11)	Food and Beverage Service Activities
Other Services (S12)	Information and Communication; Financial and Insurance Activities; Professional, Scientific and Technical Activities; Human Health and Social Work Activities; and Other Personal Service Activities
Support Services* (S13)	Rental and Leasing Activities, mainly motorcycle renting to tourists (primary transportation tool on the island)
Entertainment & Recreation* (S14)	Amusement and Recreation Activities (providing water recreation activities and operating equipment renting services to tourists, e.g. snorkeling, scuba diving, banana boating)

Note. * denotes tourism characteristic industry

According to the definition provided by United Nation [14], a tourism industry denotes “the grouping of those establishments whose main activity is the same tourism characteristic activity” (p.25). Second, the products of these industries were mainly sold to tourists. The revenues of the industries would be affected dramatically if tourism activities were not present [8]. Following the rules above, tourism characteristic industries in this study are defined. The description of industry category and the main tourism activity of tourism characteristic industries are described in Table 1.

The economy in Xiao-liu-qiu is much simpler than Taiwan as whole and highly relies on the importation from the mainland. Therefore, it is necessary to take both of them as a system. Besides, only 11 out of 14 industries appear in Xiao-liu-qiu. “Electricity & Gas Supply (S4)”, “Water Supply (S5)”, and “Remediation Services (S6)” are not existing on the island. The services of energy supply (e.g. electricity, gas) and waste treatment (e.g. solid garbage) are provided by the Taiwanese mainland. However, the importance of energy supply and waste treatment cannot be ignored since tourism activities depend heavily on them.

B. B. Estimation Procedure of Bi-Region Input Output Table

The regional industry statistics, including (1) Agriculture, Forestry, Fishery and Animal Husbandry Census, 2010; (2) Pingtung County statistical yearbook, 2011; (3) Industry, Commerce and Service Census, 2011; and (4) Agricultural Statistics Yearbook, 2011 were used to obtain the data for regionalization. Xiao-liu-qiu is under the jurisdiction of Liu-qiu Township of Pingtung County. Therefore, the statistical data were collected from the Pingtung County statistical yearbook. The benchmark input-output table, 2011 was served as the basis tables. Combing the data of national input-output table and regional statistics, the methods of location quotients (LQ) and RAS procedure (a “bi-proportional” matrix balancing method) were utilized to estimate the inter-regional transaction flow and to balance the bi-regional input output table in this study. In algebra, the standard input-output mode.

$$x_i = \sum z_{ij} + f \qquad (1)$$

Where x denotes the output of a given industry; Z denotes the intermediate transaction flow, and f denotes the final demand of a given industry. Each column of the industry represents the inputs required for that industry to generate its total output, and it can be calculated by dividing all column elements in a specific industry by the total production value of that industry. Following this rule, a new matrix A named as input coefficients (technical coefficients) would be obtained. The matrix represents that the relationship of input values from other industries are required by a specific industry to produce one unit of its output.

$$A = Z\hat{x}^{-1} \qquad (2)$$
$$Z = Ax$$

Then, substituting equation (2) into (1):

$$x = Ax + f \tag{3}$$
$$x - Ax = f$$
$$(I - A)x = f$$
$$x = (I - A)^{-1} f \tag{4}$$
$$x = Lf$$

Where $(I - A)^{-1}$ is Leontief inverse matrix L (also called the multiplier matrix or total requirement matrix) [6]. It is the core element in the input-output model, and it describes the relationship between final demand and total production value (output). The matrix shows when one unit of final demand changes, how much unit of total production would be affected.

A bi-regional input output table follows the same structure of a standard input output table but decomposes every industry into two in terms of the geographic areas. Therefore, each industry appears twice in the table: the industries located within the focus region; and the industries located outside of the region. Considering equation (1) and (3) into a bi-regional setting, including region s and region r. So that, the bi-regional input output table can be divided into several sub-matrices and sub-vectors. A location quotients (LQ) method is intended to scale down national input-output coefficients to representative regional ones that are then employed to estimate regional multiplier effect [5], and to estimating trade coefficients [13]. The simple location quotients (LQ) is defined as equation (5) and used to obtain both intraregional technical coefficients and interregional import coefficients.

The data of total output in each industry in the given year are used to account for the value differences between the mainland of Taiwan and Xiao-liu-qiu.

$$LQ_i^r = \left(\frac{x_i^r / x^r}{x_i^n / x^n}\right) \tag{5}$$

Where x_i^r denotes the total production value of industry i in region r; and x^r is the total production value of all industries in region r. x_i^n and x^n are data at national level. Similarly, data at region s were also used to measure industry concentration level. If the industry with $LQ_i^r > 1$, it indicates that industry i has more concentrated development in region r than in the entire nation, and that it can satisfy the demands of other regions. In other words, the regional economy has a comparative advantage in those industries. By contrast, when the industry with $LQ_i^r < 1$, it means that industry i is not more focused on region r than in the nation, it is not sufficient to drive the economy. These LQ coefficients are calculated to estimate input-output coefficient from the national level to the regional level. Combining the concepts of LQ and a bi-regional input output table setting together, if industry i has more concentrated development in region r than in the nation ($LQ_i^r > 1$), it is assumed that the national input coefficient (a_{ij}^n) is used as the regional input coefficient (a_{ij}^{rr}), no adjustment is made for that industry. On the contrary, the industry with $LQ_i^r < 1$, its regional direct input coefficients (a_{ij}^{rr}) has to be reduced and is estimated from the national coefficient (a_{ij}^n) and multiplied by LQ_i^r. The intraregional input coefficients and interregional import coefficients are estimated based on the equations (6) and (7), respectively.

$$a_{ij}^{rr} = \begin{cases} (LQ_i^r) a_{ij}^n, & if\ LQ_i^r < 1 \\ a_{ij}^n, & if\ LQ_i^r \geq 1 \end{cases} \tag{6}$$

$$a_{ij}^{sr} = \left(1 - \widetilde{LQ}_i^r\right) a_{ij}^r = a_{ij}^n - a_{ij}^{rr} \tag{7}$$

Once the inter-intermediate trade matrices representing the transactions of each goods between region s and region r are estimated. The structure of inra-regional input coefficients and inter-regional import coefficients are obtained in this step. Similarly, the final demands of each industry of inter-regions and intra-regions are estimated. Further, a new bi-regional intermediate transaction table can be estimated based on the equation (2). The vector of valued added of each industry in different regions are estimated based on the national census and regional industry statistics. Once the new matrices of the bi-regional intermediate transaction, final demand and the vector of valued added are obtained. The combined matrix has to be adjusted to balance the supply and demand. This procedure is done by an RAS technique. RAS procedure is widely used to update and to regionalize the input output table. Following the criterion given in reference [6], when the tolerance error ε, between the estimates and the target values is smaller than 0.001, the new balanced matrix is obtained. Further, Leontief inverse matrix of the bi-regional input output model can be estimated after RAS adjustment.

C.C. Estimation and Decomposition of Multiplier

The interest in the study is to decompose the effect which part is caused by inter-regional effects and which part is caused by intra-regional effects, when the shock happened in the regional final demand for the particular products of a given industry. For this purpose, additive decomposition proposed by Stone [12] is utilized to isolate net effects.

The Leontief inverse matrix of the bi-regional input output model capture the changes in output production as a variation in final demand. Taking an example, when final demand of industry i change one monetary unit, the rows of corresponding industries in the region and outside of the region would be affected. The effect comprises not only the direct effect between two industries, but the second, the third, and more round effects of all the inter-industry connections in the economy, including inter-regional trade. Therefore, when the effect on an industry in a given region due to a demand change for the products of another industries within the region, the spillover effect to the outside of the region would also be generated.

The effect generated due to the variation in final demand is given by the Leontief inverse matrix, $x = Ax + f = (I - A)^{-1} = Lf$. In a bi-regional input output model, the relationship can be written as,

$$\begin{bmatrix} x^r \\ x^s \end{bmatrix} = \begin{bmatrix} A^{rr} & A^{rs} \\ A^{sr} & A^{ss} \end{bmatrix} \begin{bmatrix} x^r \\ x^s \end{bmatrix} + \begin{bmatrix} f^r \\ f^s \end{bmatrix} = \begin{bmatrix} L^{rr} & L^{rs} \\ L^{sr} & L^{ss} \end{bmatrix} \begin{bmatrix} f^r \\ f^s \end{bmatrix} \tag{8}$$

With a view toward decompositions, the matrix A can be divide into intra-regional elements A^{ss} and A^{rr} and inter-regional elements A^{rs} and A^{sr}, in terms of the regional nature, let

$$A = \begin{bmatrix} A^{rr} & A^{rs} \\ A^{sr} & A^{ss} \end{bmatrix} = \begin{bmatrix} A^{rr} & 0 \\ 0 & A^{ss} \end{bmatrix} + \begin{bmatrix} 0 & A^{rs} \\ A^{sr} & 0 \end{bmatrix} \quad (9)$$

Define $A_{intra} = \begin{bmatrix} A^{rr} & 0 \\ 0 & A^{ss} \end{bmatrix}$ and $A_{inter} = \begin{bmatrix} 0 & A^{rs} \\ A^{sr} & 0 \end{bmatrix}$, these two matrices represent only intra-regional effects and only inter-regional effects, respectively. Assuming a standard input output model only reflecting intra-regional effect by using matrix A_{intra} .

$$x = A_{intra}x + f = (I - A_{intra})^{-1}f \quad (10)$$

Let $\tilde{L} = (I - A_{intra})^{-1}$,

$$\tilde{L} = \left[\begin{bmatrix} I & 0 \\ 0 & I \end{bmatrix} - \begin{bmatrix} A^{rr} & 0 \\ 0 & A^{ss} \end{bmatrix}\right]^{-1} = \begin{bmatrix} I - A^{rr} & 0 \\ 0 & I - A^{ss} \end{bmatrix}^{-1} = \begin{bmatrix} (I - A^{rr})^{-1} & 0 \\ 0 & (I - A^{ss})^{-1} \end{bmatrix} \quad (11)$$

The matrix $\tilde{L}$ is said to capture an intra-regional effects, leaving out all inter-regional effects. Following the elements relationship of Leontief inverse matrix in equation (4), equation (12) is obtained, only reflecting intra-regional effect. Further, two independent systems would be obtained separately as equation (13).

$$\begin{bmatrix} x^r \\ x^s \end{bmatrix} = \begin{bmatrix} (I - A^{rr})^{-1} & 0 \\ 0 & (I - A^{ss})^{-1} \end{bmatrix} \begin{bmatrix} f^r \\ f^s \end{bmatrix} \quad (12)$$

$$x^r = (I - A^{rr})^{-1}f^r; \text{ and } x^s = (I - A^{ss})^{-1}f^s \quad (13)$$

The matrix $\tilde{L}$ represent the relationship between final demand change and total output under the only intra-regional effect structure. In other words, it is composed of the initial shock and the net intra-regional effect (M_R), therefore,

$$\tilde{L} = I + M_R \quad (14)$$

Since matrix A consists of submatrices of A_{intra} and A_{inter}, applying them into an basic input output function as equation (3):

$$A = A_{intra} + A_{inter}$$
$$x = (A_{intra} + A_{inter})x + f = A_{intra}x + A_{inter}x + f$$
$$(I - A_{intra})x = A_{inter}x + f$$
$$x = (I - A_{intra})^{-1}(A_{inter}x + f)$$

It has known that $\tilde{L} = (I - A_{intra})^{-1}$, then it can be rearranged as,

$$x = \tilde{L}(A_{inter}x + f) = \tilde{L}A_{inter}x + \tilde{L}f \quad (15)$$

The equation above represents the combination of inter-regional effects, $\tilde{L}A_{inter}x$ and intra-regional effect, $\tilde{L}f$. Where $\tilde{L}A_{inter}x$ is the composition of inter-regional spillover effects, M_s , and inter-regional feedback effects, M_F. Where M_s mean the inter-regional spillover effect caused by a shock in a region to the other region; and M_F represent a close loop effect caused by these effects back to the original region, via the other region. In order to isolate these two effects, the same operation is recurred. So, equation (15) is rearranged as equation (16),

$$x = \tilde{L}A_{inter}(\tilde{L}A_{inter}x + \tilde{L}f) + \tilde{L}f$$
$$= (\tilde{L}A_{inter})^2 x + \tilde{L}A_{inter}\tilde{L}f + \tilde{L}f \quad (16)$$

Then, considering the whole economy system and the structure consistency with the equation (4) that $x = Lf$, the substitution is done,

$$x = (\tilde{L}A_{inter})^2 Lf + \tilde{L}A_{inter}\tilde{L}f + \tilde{L}f \quad (17)$$
$$x = (M_F + M_S + M_R + I)f \quad (18)$$

Therefore, three isolated net effects of the combined Leontief inverse matrix L are obtained as,

$$M_R = \tilde{L} - I; M_S = \tilde{L}A_{inter}\tilde{L}; M_F = (\tilde{L}A_{inter})^2 L \quad (19)$$

Under the assumption of input output model, L is constant in the short run and it becomes the key matrix that transforms the changes in final demand into the changes in total output. Calculating each column in the Leontief inverse, multipliers of output to each sector are gained showing the direct and indirect change in output sectors needed to meet one unit increase in final demand for this sector of output. Based on the equation (4) that the equation can be written as equation (20). Where ΔX is the change of total output, $\acute{\iota} = [1 \ \cdots \ 1]$ is a row vector to generate column sums; and Δf is the change of final demand of each industry.

$$\Delta X = \acute{\iota}L\Delta f \quad \text{where } L = (I - A)^{-1} \quad (20)$$

The simple output multiplier is defined as an initial monetary worth of a specific industry's output required to satisfy an extra unit of final demand. So, it is obtained by the ratio of the direct and indirect effect to the initial effect [6]. It means the column sums of Leontief inverse matrix as well, so it is written as,

$$m = \acute{\iota}L \quad (21)$$

Combining the equations (18) and (21), simple output multiplier can be decomposed as three isolated multipliers as below,

$$M = \acute{\iota}(I + M_R + M_s + M_F) = \acute{\iota}I + \acute{\iota}M_R + \acute{\iota}M_s + \acute{\iota}M_F \quad (22)$$

III. Results

The decomposition of multiplier allows us to view separately how these effects affect the output variations within and between the regions when one monetary unit of change in final demand of the specific industry. Table 2 summarized the decomposition of the net simple output multipliers, both in Xiao-liu-qiu and the rest of Taiwan. The total net multipliers (M_T) are obtained by excluding the initial shock. The decomposition of the multipliers includes intra-regional net multiplier (M_R), inter-regional net spillover multiplier (M_S), and inter-regional net feedback multiplier (M_F).

By comparing the multipliers of both geographical regions, the total net simple multiplier in Xiao-liu-qiu are significantly lower than in the rest of Taiwan. Each change of one unit in final demand in Xiao-liu-qiu creates additional 1.25 monetary unit of output. At the same time, additional 1.73 monetary unit of output would be generated in the rest of Taiwan under the same change in demand, averagely. The comparison of the values are not meaningful because the values of their geographical sizes are very different. But, it may provide a hint about the relationship between geographical size and economic effect: the bigger size of the geographical region, the bigger economic impact may generate.

Regarding the intraregional multiplier (M_R), the average values are 0.07 in Xiao-liu-qiu and 1.73 in the rest of Taiwan. A possible explanation for the big difference is that the composition of industry of Xiao-liu-qiu is relatively simpler than in the rest of Taiwan, it results in the smaller intra-regional effect. In addition, although tourism is an emerging economic activity in Xiao-liu-qiu, only “Transportation and Storage (S9)”, with 0.29 of the intra-regional effect, can generate comparatively higher pulling effect to the other industries in Xiao-liu-qiu. The pulling effects of the other tourism characteristic industries are lower than the average value (0.07) except “Accommodation (S10)”.

In terms of the inter-regional effect includes the spillover effect (M_S) and feedback effect (M_F). The effect reflects the variation of the total output of the whole country caused by the final demand changes per monetary unit in each area. In Table 2, it summarized how large that Xiao-liu-qiu relied on the rest of Taiwan for its supply in terms of high value in spillover effects (M_S). The average of inter-regional spillover effect in Xiao-liu-qiu is 1.17. It means that one monetary unit increase in the final demand, it can generate 1.25 monetary unit of total output, but 1.17 monetary unit will outflow to the rest of Taiwan. The high economic leakage results from high resource dependency on the rest of Taiwan. Additionally, it is clear to find that the supply dependence is not mutual between two regions in this case. In other words, the supply is unidirectional since the economy of Xiao-liu-qiu is much smaller than in the rest of Taiwan. In both regions, the feedback effect (M_F) are zero because the spillover effect is too weak for more round effects to be significant. This similar result can be found in earlier literature [11].

TABLE 2
THE DECOMPOSITION OF NET SIMPLE OUTPUT MULTIPLIER BY REGION

	Xiao-liu-qiu				*The rest of Taiwan*			
Code	M_R	M_S	M_F	M_T	M_R	M_S	M_F	M_T
S1	0.15	1.53	0.00	1.68	1.84	0.00	0.00	1.84
S2	0.10	2.00	0.00	2.10	2.19	0.00	0.00	2.19
S3	0.08	3.05	0.00	3.13	3.13	0.00	0.00	3.13
S4	-	-	-	-	3.15	0.00	0.00	3.15
S5	-	-	-	-	1.09	0.00	0.00	1.09
S6	-	-	-	-	1.55	0.00	0.00	1.55
S7	0.10	3.16	0.00	3.26	2.42	0.00	0.00	2.42
S8*	0.06	0.51	0.00	0.56	0.62	0.00	0.00	0.62
S9*	0.29	1.59	0.00	1.88	2.06	0.00	0.00	2.06
S10*	0.08	1.49	0.00	1.57	2.02	0.00	0.00	2.02
S11*	0.03	0.96	0.00	1.00	1.51	0.00	0.00	1.51
S12	0.03	0.62	0.00	0.65	0.71	0.00	0.00	0.71
S13*	0.06	0.88	0.00	0.93	1.10	0.00	0.00	1.10
S14*	0.03	0.65	0.00	0.68	0.84	0.00	0.00	0.84
Average	0.07	1.17	0.00	1.25	1.73	0.00	0.00	1.73

Note. * denotes tourism characteristic industry, M_R denotes intra-regional effect, M_S denotes inter-regional spillover effect, M_F denotes inter-regional feedback effect, and M_T denotes net simple output multiplier.

IV. CONCLUSION

Although tourism expansion has enhanced the economy of Xiao-liu-qiu, it is important to note the high economic leakage to the mainland of Taiwan. The local industries on this island should be aware of the high risk may result from the large supply dependence by the rest of country. When the tourism demand in Xiao-liu-qiu increased, the extra imports would be generated to support it. The imports are regarded as an economic leakage, and as reference [10] showed that the higher import dependence, the lower industry linkages in a given area. In other words, when a region relies on more importation of goods and services than using the production locally, the more profit leaks to the supplier regions and ends up the smaller impact stimulate the local economy. A similar idea is described in reference [3]. The strategic alliance between industries with a higher output multiplier could be considered to generate the bigger profit from tourism sale. Therefore, the local government could try to encourage tourism service providers to provide more diverse products through policies and incentives in order to increase more job opportunities and obtain more economic benefits from tourism.

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