AN INPUT-OUTPUT MODELING APPROACH AS AN EFFECTIVE DEVELOPMENT STRATEGY FOR SRI LANKA

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Chandika Gunasinghe

Abstract

This paper is aimed at measuring industrial interdependence using a symmetric input-output table complied for the Sri Lankan economy for 2006 to find an effective development strategy for the country. The input-output model is constructed for thirty aggregated industrial sectors of the economy as a whole. The output, value added and income multipliers reveal that there are five key industries of the Sri Lankan economy. These are: (1) recreational, cultural, sporting services and other services; (2) manufactured products of food, beverages and tobacco sector; (3) air transport services; (4) rubber & plastic products; and (5) metallic, non-metallic and mineral products. The employment multipliers are highest in: (1) real estate services; (2) electrical products; (3) petroleum & chemical products; and (4) rubber & plastic products industries. We found that five industries (sectors) have strong upstream and downstream vertical integrations with the rest of other sectors in the economy. The results reveal that higher prices charged on the petroleum & chemical products would probably result in higher costs to most of other sectors in the economy relatively equally. As 'mining and quarrying, electricity, gas and water' sector has strong downstream linkages to other sectors in the economy, higher prices (or taxes) charged on these products also result in higher costs to most of other sectors in the economy. The findings of the study reveal that prioritizing industries should be done based on an input-output analysis rather than just depending on the information provided by percentage of contribution in output and value addition to GDP by the sectors. However, the results should be interpreted very carefully as the impact of some sectors such as education difficult to be practically measured in monetary terms based on an input-output model.

Keywords: development planning, input-output model, industry multipliers, forward and backward linkages, Sri Lanka.

Chandika Gunasinghe
Senior Lecturer, Department of Economics, University of Ruhuna, Matara, Sri Lanka. Email: chandika.gunasinghe@griffithuni.edu.au

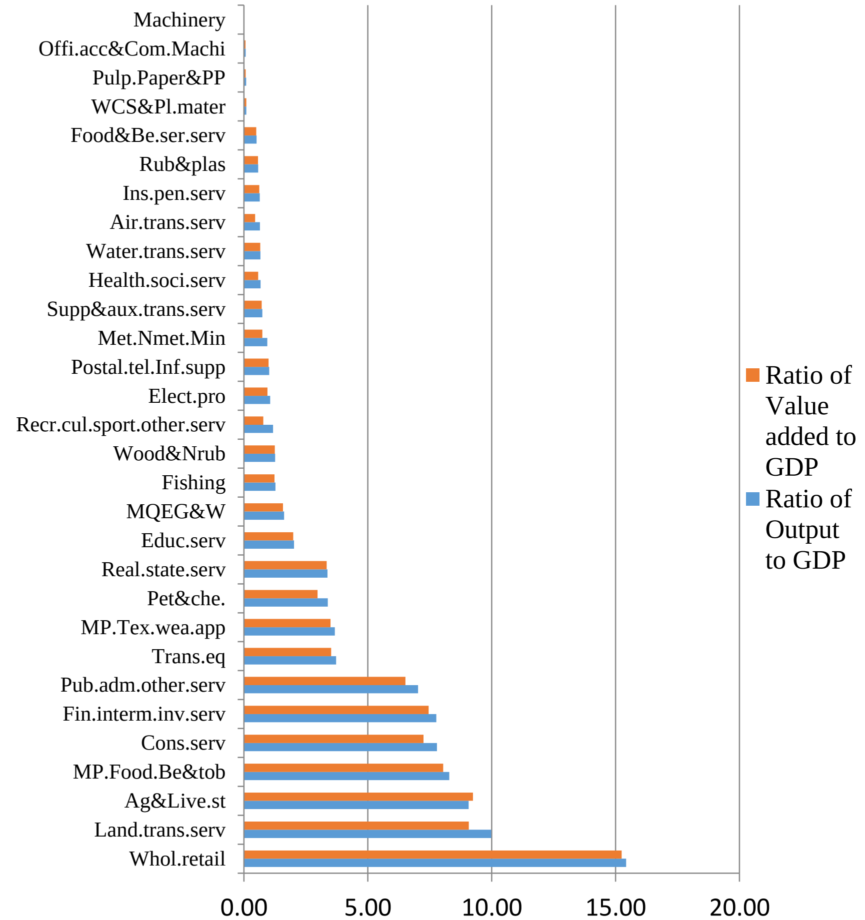
INTRODUCTION

A better understanding of the structure of a national economy is vital for the identification and implementation of an effective development strategy as it emphasizes the need of allocating more resources for sectors that generate more output, income, value-additions, employment, and have linkages with the domestic economy (Frédéric 2010). One of the best ways to develop this understanding is to "build a data base-model (an input-output model) of the economy which uncovers these underline structures and connections" leading to have a complete picture of the economy (Epstein et al 2010: pp 24-25; Frédéric 2010: pp 1). The multipliers (output, value added, income and employment) and linkage measures (upstream and downstream vertical integration of sectors) derived from an input-output model are considered as powerful tools that can be used to measure and assess national productive system and inter-sectoral relationships of an economy (Frédéric 2010).

The input-output model was developed by Professor Wassily Leontief in the late 1930s based on Walras' general equilibrium theory to data for the American economy. In recognition of his pioneering work, he was awarded by the Nobel Prize in Economic Science in 1973. As a result of this useful analytical innovation, researchers, policy analysts and practitioners have used (and still use) input-output models in economic impact analysis and economic development planning specially in the areas such as industrial, agricultural, environmental, energy, construction, transportation, tourism and educational sectors (Xinhao and Rainer 2007: pp 218-272). Miller and Peter (2009, p. 2) have pointed out that "Today, in the USA alone, input–output is routinely applied in national economic analysis by the US Department of Commerce, and in regional economic planning and analysis by states, industry, and the research community". Furthermore, Baumol (2000) considers input-output analysis as one of the most widely used applied methods in economics. However, the studies on the use of input-output models directed at policy related issues in Sri Lanka are, to some extent, limited. Rameezdeen, Zainudeen and Ramachandra (2005, 2008) examine the significance of the construction sector and its relationship between other sectors of the economy based on input-output tables compiled in the period from 1970 to 2000. They argue that construction sector is the key in the economy as the backward and forward linkage measures were significant (above average) in this sector out of forty-eight sectors of the economy in 2000.

Athukorala and Bandara (1989) examine the importance of using net-export earnings in measuring primary exports in the export structure and overall export growth by calculating a simple Leontief inverse using 1981 Input Output table (I-O table). Their findings reveal that using gross-export earnings leads to make misleading conclusions on the significance of export structure and its growth. Hazari and Bandara (1989) estimate linkage indices based on 1981 I-O table to look at the poverty impact in Sri Lanka an innovative way. Bandara and Kelegama (2008) provide an updated survey on the use of Input-output Tables (I-O Tables) and Social Accounting Matrices (SAMs) in Sri Lanka. Bandara (1990) provides a survey on the use of early I-O tables in Sri Lanka to develop CGE Models.

Figure1, Contribution the Output and Value Addition to GDP By Sectors 2006 (%)



Source: Author's calculation based on SIOT compiled by Bandara (2016)

The importance of the use of input-output model for development planning can be justified by inspecting Figure 1 given above. It shows the percentage of contribution made by each sector in terms of output and value addition to the GDP in Sri Lanka in 2006. Apparently, policy makers might misleadingly tend to identify the leading sectors of the economy as the sectors whose ratios of output and value added to GDP are high. Accordingly, they will allocate scare resources to boost sectors such as wholesale and retail trade services, land transport services, agriculture and livestock, manufactured products of food, beverages and tobacco, construction services, financial intermediation services and investment banking, and public administration and other services. However, it is crucial for an effective development policy to identify channels by which a growth of a sector such as mentioned above can support aggregate output, income, value addition and employment creation in the rest of the economy (Frédéric 2010). Therefore, it is essential to identify whether these “growth pulling” sectors have strong upstream and downstream vertical integrations with rest of the other sectors in the economy as it causes to generate high output, income, value added, and employment multipliers in these sectors. For example, a weak upstream vertical integration of a particular sector highlights the poor use of domestic factors of production, domestic inputs as well as capital and financial services for its own production, which in turn will make few opportunities not only for this sector but also for other sectors in the economy to generate additional output, income, value addition and employment avenues.

With this context, the aim of this study is to quantitatively measure and assess the industrial interdependence in Sri Lanka to draw policy relevant lessons to find an effective development strategy for the country. The study uses the data from the latest 2006 symmetric input-output table compiled by Bandara (2016) for Sri Lankan economy. The input-output model is constructed for thirty aggregated industrial sectors to have a better understanding of the underline structures and connections of the economy as a whole. We believe that this in turn will help policy makers to formulate an appropriate macroeconomic and sectoral policy to expand prioritized sectors that have strong upstream and downstream vertical integrations with the rest of the economy leading to generate a higher level of output, income, employment and value -added to the economy. The industry multipliers (output, value added, income and employment) and linkage measures (upstream and downstream) to the domestic economy are estimated using both “open” and “closed” (endogenizing households sector) versions of input-output model. All the calculations are done using Input-Output Software Version 1.0.1 (IOW).

The remainder sections of this paper are organized as follows. Section 2 presents the methodology of the study. Section 3 is about results and analysis. Section 4 presents concluding remarks. In Section 5, limitations of the study are given.

METHODOLOGY OF THE STUDY

As noted in the previous section, this study uses a symmetric input-output table (SIOT) for 30 sectors (industries) in the economy for the year 2006.

Table 1: Structure of the Symmetric Input-output Table Used in the Study

Industries / Products (outputs)			Industry 1	Industry 2	…	Industry 30	Final demand (TFC, GCF, TE)	Total prod. (demand)
Intermediate inputs	Products of Industry 1		$x_{1,1}$	$x_{1,2}$	…	$x_{1,30}$	y_1	z_1
	Products of Industry 2		$x_{2,1}$	$x_{2,2}$	…	$x_{2,30}$	y_2	z_2
	...		…	…	…	…	…	…
	Products of Indust. 30		$x_{30,1}$	$x_{30,2}$	…	$x_{30,30}$	y_{30}	z_{30}
			(Intermediate usage)				(Final demand)	
Primary inputs	Final payments	C.E	ce_1	ce_2	..	ce_{30}	(Primary inputs to final demand)	**GDP (IA)**
		G.O.S	os_1	os_2	..	so_{30}		
		Net Tax	nt_1	nt_2	..	nt_{30}		
		Imports	m_1	m_2	---	m_{30}		
			(Primary inputs to production)					
Total production (supply)			q_1	q_2	…	q_{30}	**GDP (EA)**	
Employment			e_1	e_2	-	e_{30}		

Source: constructed based on ABS (2000, p.99) and SIOT complied by Bandara (2016).

The term 'symmetric' means that “the same classifications are used in both rows and columns” (ABS 2000, p. 95). Accordingly, the present study uses industry by industry calcification to make a square table that has industries in the columns and corresponding products in the rows. The Table 1 presents the structure of the SIOT used in the study, which clearly show how the transactions in an input-output table can be used to analytical purposes.

Where: C.E =compensation of employees; G.O.S = gross operational surplus; Net Tax= tax minus subsidies; TFC = total final consumption (government + private); GCF = gross capital formation (gross fixed capital formation +changes in inventory); TE = Total exports; DM =Demand; GDP (EA) = gross domestic product (expenditure approach); and GDP (IA) = gross domestic product (income approach).

Each row in Table 1 shows how the output of each industry is distributed among industries (including its own) and final demanders whereas each column shows the origin of inputs (both primary and intermediate) from other industries (including its own) and institutions into an industry. The row total for an industry is equal to the corresponding column total of the SIOT (that is $q_j= z_i$for all j,i = 1,2,…30) as the output of an industry must be equal to the value of total inputs used in the production process (ABS 2000, p.99). The core of SIOT is the inter-industry transaction matrix shown in the first quadrant (intermediate usage) where production relationships in the economy are depicted by the elements, x_{ij}. For example, element $x_{1, 30}$ shows how much output of 1st industry has been absorbed by 30th industry in its current production. Final demand category made up of elements y_i shows consumption behaviour of households, government, investors and exports. Final payment category includes basically two variables; value added (v_j) (the sum of C.E + G.O.S + Net tax) and imports. The value added vector shows contribution of each sector’s to the GDP.

The data related to these three quadrants in the Table 1 can be conveniently presented using matrix algebra as follows:

$$z_i = \sum_{j=1}^{30} x_{ij} + y_i \qquad (1)$$

$$q_j = \sum_{i=1}^{30} x_{ij} + ce_j + gos_j + nt_j + m_j \qquad (2)$$

Where: z_j in (1) is the total demand for output of i^{th} industry and q_j in (2) is the total supply of j^{th} industry; x_{ij} are sales by sector i to sector j; the row sum of x_{ij} in equation (1) shows the total value of sales of industry i to all industries (including sales of industry i as well); the column sum of x_{ij} in equation (2) is the total value of purchases done by industry 'j' from all other 'i' industries (including purchases of output of industry 'j' as well) in the economy.

The next step is to obtain the direct input-output coefficients matrix A that is made up of elements (a_{ij}). The matrix A is obtained by dividing the elements in the industry transaction matrix (x_{ij}) from respective column totals, q_j. That is,

$$a_{ij} = \frac{x_{ij}}{q_j} \tag{3}$$

Hence,

$$a_{ij} q_j = x_{ij} \tag{4}$$

Substituting $a_{ij} q_j$ for x_{ij} and q_j *for* z_i (on the condition that output of an industry must be equal to the value of total inputs used in the production) in equation (1) yields the following equation:

$$q_j = \sum_{j=1}^{30} a_{ij} q_j + y_i \tag{5}$$

This is just for one sector and for 30 sectors this can be shown in a matrix form considering q_j and y_i represent 30 by 1 output and 30 by 1 final demand vectors respectively. Hence, it takes the form;

$$q_{j(30x1)} = A_{(30X30)} q_{j(30x1)} + y_{i(30x1)} \tag{6}$$

The elements, a_{ij} , in the direct requirement matrix A represent the direct inputs requirements from sector i per 1 million LKR (as the data are given in LKR millions) worth of final demand for the output of industry j.

Rearranging equation (6), open total requirement matrix (Leontief inverse matrix) can be obtained as follows;

$$q_{j(30x1)} = (I - A_{(30X30)})^{-1} y_{i(30x1)} \qquad (7)$$

or $$q_{j(30x1)} = B_{(30X30)} y_{i(30x1)} \qquad (8)$$

Now the elements, b_{ij} , in the open total requirement matrix B in equation (8) represents the direct and indirect inputs requirements from sector i per 1 million LKR worth of final demand for the output of industry j. Following the same method, but the row vector related to the household sector (compensation of employees) in the primary input matrix and the column vector of household consumption in the final demand matrix are putting into the industry transaction matrix (x_{ij}), closed total requirement matrix is obtained as follows;

$$q^*_{j(31x1)} = B^*_{(31x31)} y^*_{i\ (31x1)} \qquad (9)$$

Both the B in (8) and B^* in (9) matrices are powerful tools that are used to measure the total impact on the economy for changes in final demand vector y. Furthermore, these matrices are also used to derive (open and closed) multipliers (output, value added, income and employment) and (open and closed) the linkage measurers.

Now the elements, b^*_{ij} , in the closed total requirement matrix B^* in equation (9) represents the direct, indirect and consumption induced inputs requirements from sector i per 1 million LKR worth of final demand for the output of industry j. The inclusion (endogenized) of the household sector in the industry transaction matrix is more realistic due to the fact that any increase in income generated from direct and indirect expansion of the level of production in the economy and in turn cause an increase in consumption.

The size of the elements of B^* are larger than that of B due to the impact of consumption induced demand on the level of output. That is, all sectors are required to generate increased output levels to meet the consumption induced demand in the economy. Because of this reason, Type II multipliers are always larger than that of Type I multipliers. However, Miller and Blair (2009, 253) highlighted that "it is generally conceded that Type I multipliers probably underestimate economic impacts (since household activity is absent) and Type II multipliers probably give an overestimate (because of the rigid assumptions about labour incomes and attendant consumer spending)". Miller and Blair (2009, 253) further noted that "some in between figure might be more realistic but deciding exactly where these two limits may be problematic". Therefore, when industries are ranked based on the size of the multipliers to identify key sectors in the economy, both Type I and Type II multipliers are employed.

Deriving Multipliers

Multipliers are used to estimate the effects of exogenous changes in the final demand vector Δy_i or Δy_i^* on: (a) outputs expected to be generated at each sectors in the economy; (b) income expected to be earned by households in each sector because of the new outputs; (c) employment (jobs, in physical terms) expected to be generated in each sector because of the new outputs; and (d) the value added expected to be created by each sector in the economy because of the new outputs (Miller and Peter 2009, p. 244).

Output multipliers for both open and closed models

It is clear that the elements b_{ij} $(or\ b_{ij}^*)$ in the matrix B (or B^*) are industry to industry multipliers combining final demand for the output of industry ' j' to output of industry 'i'. This can be explained using equation (8) or (9);

$$\Delta q_{j(30x1)} = B_{(30X30)} \Delta y_{i(30x1)}$$

$$\begin{bmatrix} \Delta q_1 \\ \Delta q_2 \\ . \\ . \\ \Delta q_{30} \end{bmatrix} = \begin{bmatrix} b_{1,1} & b_{1,2} & ... & b_{1,30} \\ b_{2,1} & b_{2,2} & ... & b_{2,30} \\ . \\ . \\ b_{30,1} & b_{30,2} & ... & b_{30,30} \end{bmatrix} \begin{bmatrix} 1 \\ 0 \\ . \\ . \\ 0 \end{bmatrix} = \begin{bmatrix} b_{1,1} \\ b_{2,1} \\ . \\ . \\ b_{30,1} \end{bmatrix} \quad (10)$$

This shows that increase of LKR one million worth of final demand ($\Delta y_i = 1$) results to increase the volume of $b_{1,1}$ output in the industry one itself, $b_{2,1}$ output increase in industry 2 etc. Unlike the sector to sector multipliers, output multipliers (column sums of B or B^*) are industry to economy multipliers combining final demand for the output of industry 'j' to economy wide output (Miller and Peter 2009, p. 246).

Output multiplier for the open model:

$$Type\ I\ Mult_{output}(j) = i^{/} \Delta q_j = \sum_{i=1}^{30} b_{ij} \quad where\ i^{/}_{(1x30)} = (1,1,.........1)$$

(11)

Therefore, the output multiplier for industry 'j' is the sum of column 'j' in B matrix over all industries from i =1 to i=30. For example, this means that LKR one million worth of final demand ($\Delta y_i = 1$) for the output of industry one has created LKR $\sum_{i=1}^{30} b_{i1}$ worth of output in the economy. That is the value of the total output generated by all sectors (including the sector one output) in the economy to meet LKR one million worth of demand for output in industry one is the summation of the first column in the matrix B

Output multiplier for the original 30 sectors based on the closed model:

$$Type\ II\ \ Mult_{output}(j) = i^{/}\Delta q_j^{*}\ \ = \sum_{i=1}^{30} b_{ij}^{*}\quad where\ i_{(1x30)}^{/} = (1,1,.........1)$$

(12)

Income Multiplier

Combining the output multiplier (equation 11 or 12) with technical coefficient for income (employee compensation) output ratio, income multiplier can be derived as follows;

$$Type\ I\ \ Mult_{income}(j) = \sum_{i=1}^{30} (\frac{ce_j}{q_j})_i\, b_{ij} \qquad (13)$$

Income multiplier for the original 30 sectors based on the closed model:

$$Type\ II\ \ Mult_{income}(j) = \sum_{i=1}^{30} (\frac{ce_j}{q_j})_i\, b_{ij}^{*} \qquad (14)$$

Income multiplier for industry ‘j’ measures the total value of household income generated from all the sectors in the economy when producers increase their productions to meet the LKR one million worth of final demand for the output of industry ‘j’.

Value added multiplier

The value added multiplier can be derived by combining the output multiplier (equation 11 or 12) with technical coefficient for value added (v_j) output ratio. Then,

$$Type\ I\ \ Mult_{VA}(j) = \sum_{i=1}^{30} (\frac{v_j}{q_j})_i\, b_{ij} \qquad (15)$$

Value added multiplier for the original 30 sectors based on the closed model:

$$Type\ II\ \ Mult_{VA}(j) = \sum_{i=1}^{30} (\frac{v_j}{q_j})_i\, b_{ij}^{*} \tag{16}$$

Value added multiplier for industry ‘j’ measures the total value additions by each sectors in the economy when they increase their productions to meet the LKR one million worth of final demand for the output of industry ‘j’.

Employment Multiplier

Combining the output multiplier (equation 11 or 12) with technical coefficient for employment (e_j) output ratio, employment multiplier is derived as follows;

$$Type\ I\ \ Mult_{EM}(j) = \sum_{i=1}^{30} (\frac{e_j}{q_j})_i\, b_{ij} \tag{17}$$

Employment multiplier for the original 30 sectors based on the closed model:

$$Type\ II\ \ Mult_{EM}(j) = \sum_{i=1}^{30} (\frac{e_j}{q_j})_i\, b_{ij}^{*} \tag{18}$$

Employment multiplier for industry ‘j’ measures the total number of employment opportunities generated in all the sectors in the economy when they increase their productions to meet the LKR one million worth of final demand for the output of industry ‘j’.

Based on the multipliers (Type I and II) derived above, the significance of industries on the overall economic performance (leading sectors) is determined based on the criterion that average value of both Type I and Type II multipliers for each industry should be above its overall average (Raufdeen et al 2005). This criterion is justifiable as its value always lays in between both Type I and Type II multipliers. However, the sizes of the multipliers depend on the degree that the upstream and downstream vertical integrations of the sectors with the rest of the other sectors in the economy. This will be discussed in the following section.

Derivation of the backward and forward linkages

Based on the data of input-output model, it is possible to measure two kinds of economic effects of an industry effects on other sectors of the economy. First, if industry ‘j’ expands its production, it does mean that the industry ‘j’ will demand more outputs from other sectors as inputs for its production. This kind of interconnection of industry ‘j’ with other sectors is called a “backward linkage” that captures the interconnectedness of this sector with upstream industries (sectors from which sector ‘j’ purchases inputs) in the economy (Miller and Blair 2009, p.555). Second, increase the output of industry ‘j’ also means that there are additional outputs (supply) in industry ‘j’ that can be used for other sectors as inputs for their own productions. This kind of interconnection of industry ‘j’ with other sectors in the economy is called a “forward linkage” that captures the interconnectedness of this sector with downstream industries to which sector ‘j’ sells its output.

Backward linkage for each 30 sectors based on the open model:

$$BL(j) = i^{/} B = \sum_{i=1}^{30} b_{ij} \quad where\ i^{/} = (1,1,.........1) \qquad (19)$$

Forward linkage for each 30 sectors based on the open model:

$$FL(i) = B.i = \sum_{i=1}^{30} b_{ij} \quad where\ i = (1,1,.........1)^{/} \qquad (20)$$

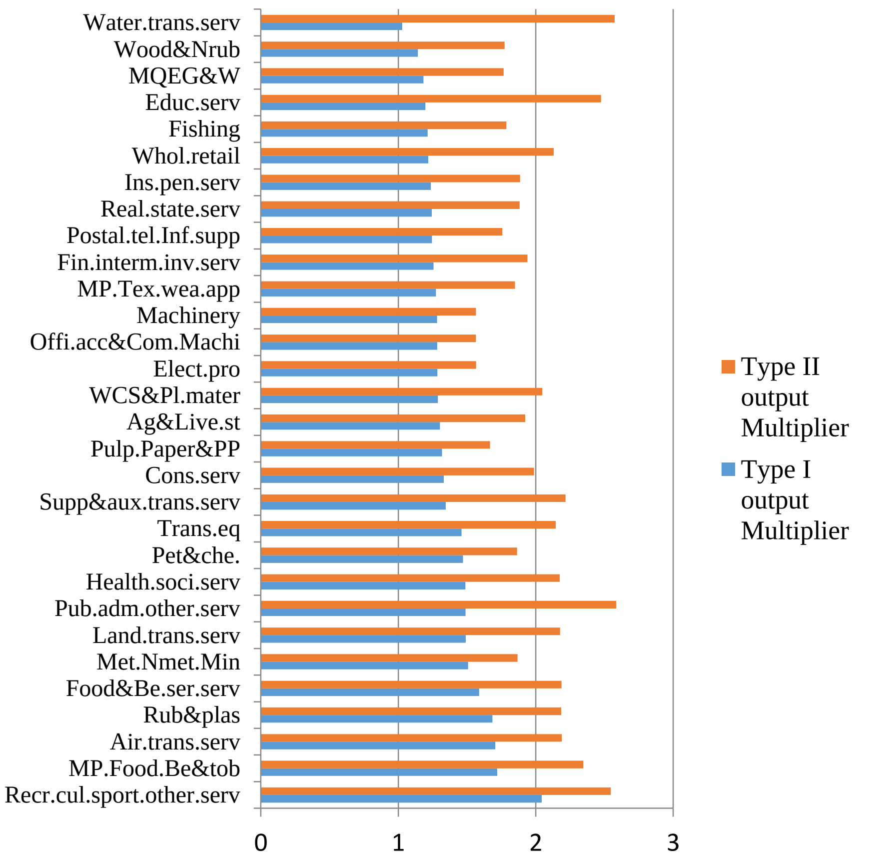
Relevance of linkage measures for policy making is very high compared to that of multipliers. Miller and Blair (2009, p.555) note that “comparisons of the strengths of backward and forward linkages for the sectors in a single economy provide one mechanism for identifying “key” or “leading” sectors in that economy (those sectors that are most connected and therefore, in some sense, most “important”)”.

Therefore, a sector is identified as a key industry in the economy if the measures in both the backward and forward linkages are greater than one. Backward and forward linkages are normalized to one such that the estimated values of each linkage related to a sector above one, means that the sector is above average heavily dependent on domestic sectors for its input requirements (backward oriented) and domestic sectors that are above the average dependent are in question for their input requirements (forward oriented) respectively (Gravino 2012).

RESULTS AND ANALYSIS

To begin, it is worthy to present the analysis of results obtained for multipliers in first.

Figure 2: Type I and Type II output multipliers of 30 industries in Sri Lanka



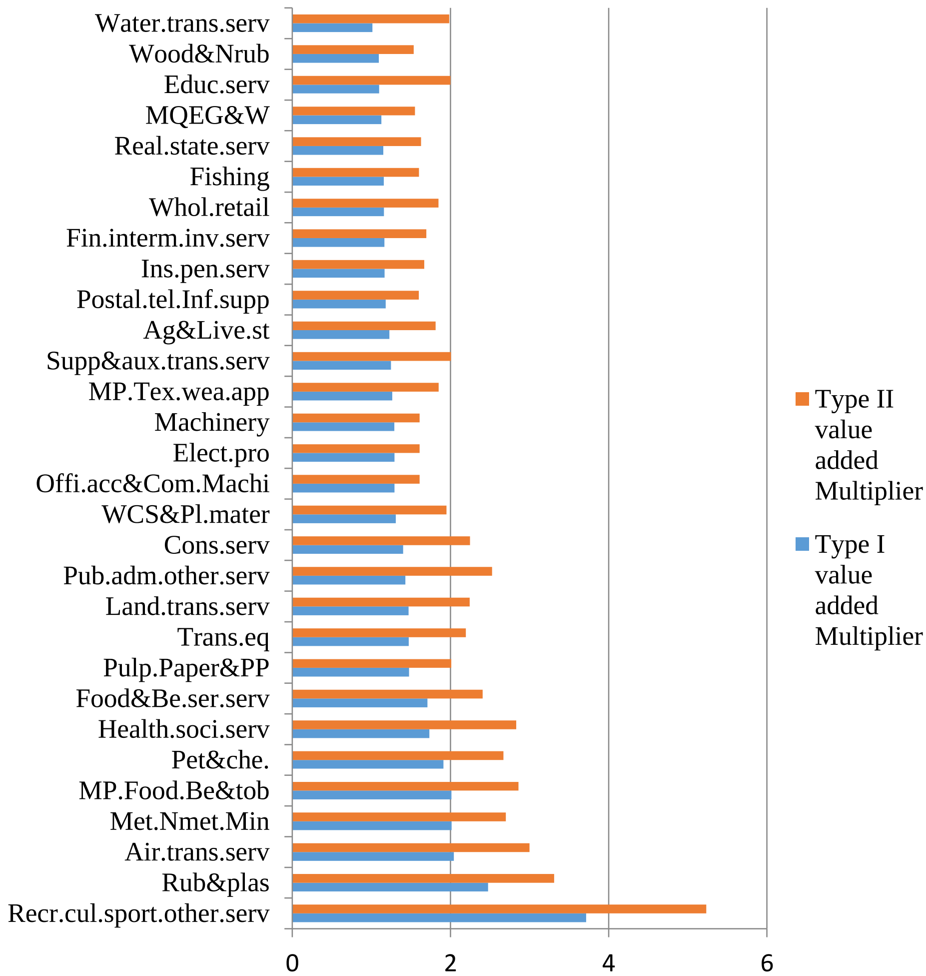
Source: Author's calculation based on SIOT compiled by Bandara (2016).

Figure 2 shows the relative contribution of each industry to economy wide output based on the ranking of Type I output multiplier. As it was expected, Type II multipliers are always larger than its Type I counterpart implying that each industries produces an increased amount of output in the economy to meet the consumption induced demand. Figure 2 reveals further that output multipliers for 30 sectors, meaning that LKR one million worth of increase in the demand for any sector's output would generate LKR one million worth plus some additional value of output in the economy. The largest output multiplier (Type I is 2.0 and Type II is 2.5) is reported from 'recreational, cultural, sporting services and other services'.

This means that LKR one million worth of final demand for the output of this industry would generate LKR 1 million and LKR 1.5 million worth of additional output in the economy. The second largest output multiplier (ranked based on Type I) is reported from 'manufactured products of food, beverages and tobacco sector' followed by 'air transport services' etc. The water transport service sector reports the lowest output multiplier of which the value of Type I is 1.03 whereas the value of Type II is 2.57 implying that LKR one million worth of final demand for the output of this industry would generate LKR 0.03 million and 1.57 million worth of additional output in the economy. One of the striking features that can be observed in Figure 2 is that the values of Type II multipliers are relatively higher for 3 sectors as; public administration and other services, education services, and water transport services. The reason for the presence of these higher values can be explained with the fact that the sectors are more labour incentive compared to other sectors resulting high consumption induced impacts.

Figure 3 shows the relative contribution of each industry to economy wide value addition based on the ranking of Type I value added multipliers. Figure 3 reveals that the value added multipliers for 30 sectors are above one, meaning that LKR one million worth of increase in the demand for any sector's output would generate a total impact on the country's GDP which is greater than LKR one million. The largest value added multiplier (Type I is 3.72 and Type II is 5.23) is reported from 'recreational, cultural, sporting services and other services' which means that LKR one million worth of final demand for the output of this industry would generate LKR 2.72 million and 4.23 million worth of additional value added in the economy. The second largest multiplier (ranked based on Type I) is reported from 'rubber & plastic products', followed by 'air transport services', and then 'metallic, non-metallic and mineral products', followed by 'manufactured products of food, beverages and tobacco sector' so on respectively.

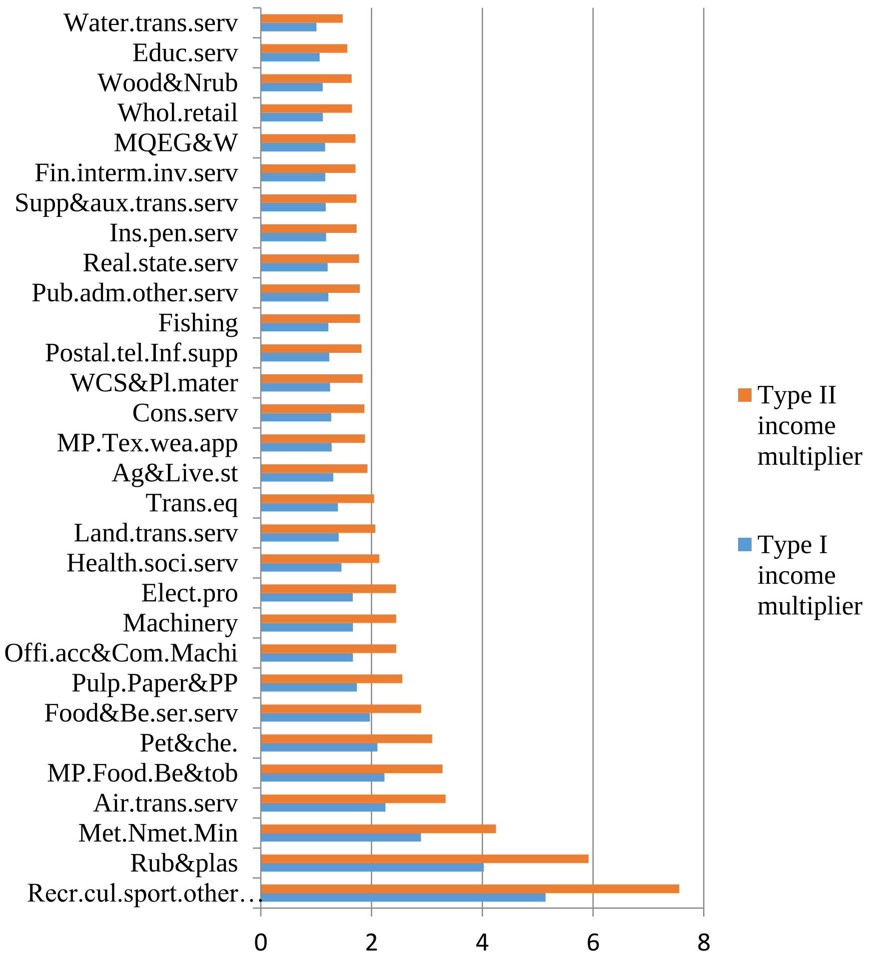
Figure 3: Type I and Type II Value Added Multipliers of 30 Industries in Sri Lanka



Source: Author's calculation based on SIOT compiled by Bandara (2016).

The water transport service sector reports the lowest valued added multiplier of which the value of Type I is 1.01 and Type II is 1.98 implying that LKR one million worth of final demand for this industry would generate LKR 0.01 million and .98 million worth of additional value added in the economy.

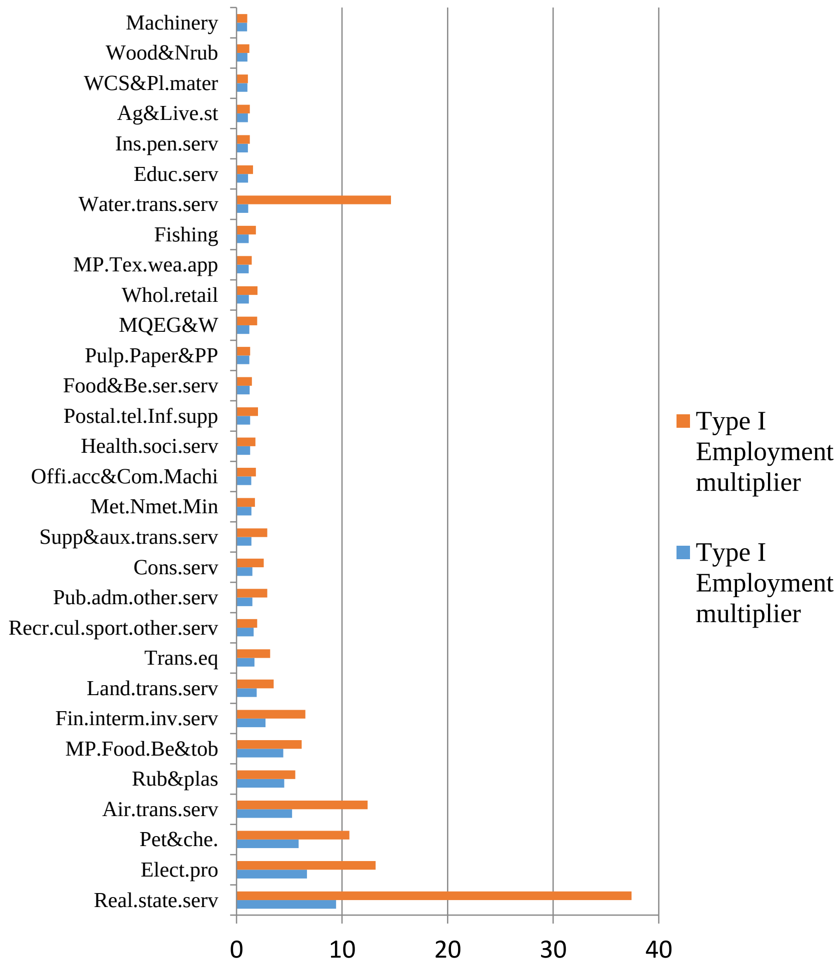
Figure 4: Type I and Type II Income Multipliers of 30 Industries in Sri Lanka



Source: Author's calculation based on SIOT compiled by Bandara (2016).

Information are in Figure 4 shows the relative contribution of each industry to economy wide income (compensation of employees) based on the ranking of Type I income multiplier. Figure 4 further reveals that income multipliers for 30 sectors are above one, meaning that LKR one million worth of increase in the demand for any sector's output would generate LKR one million worth plus some additional labour income in the economy. It is highest in sectors such as 'recreational, cultural, sporting services and other services', 'rubber & plastic products' followed by 'air transport services', and then 'metallic, non-metallic and mineral products', and then 'manufactured products of food, beverages and tobacco sector' so on respectively. It means that all these five sectors are relatively labour incentive reflecting that high ratio of wages to total output of those sectors. The sectors such as 'water transport service', 'education services', 'wood & natural rubber', and 'wholesale and retail' have low income multipliers which reflect the fact that their wage shares in total industry output are at low levels

Figure 5: Type I and Type II Employment Multipliers of 30 Industries in Sri Lanka



Source: Author's calculation based on SIOT compiled by Bandara (2016).

Figure 5 depicts the relative contribution of each industry to economy in respect of employment generation, based on the ranking of Type I employment multiplier. The employment multipliers are highest in the sectors: real estate services, electrical products, petroleum & chemical products, and rubber & plastic products industries. According to the Type I (Type II) employment multipliers, a total of 9(37), 7(13), 6(11), and 5(12) new employment opportunities would be in the economy as a result of increasing the LKR one million worth of output in these industries.

The direct coefficient matrix (not shown here) shows that the ratio of employment to gross output is lowest (less than one) in these sectors implying that any expansion of their production would have a high potential of generating relatively a larger number of additional job opportunities. The lowest employment opportunities are reported from 22 sectors (out of 30) where the Type I employment multipliers are at around one. It means that expansion of the production of each industry by LKR one million would possibly only to generate one employment opportunity in the economy. The striking feature that can be observed from this analysis is that the ratios of employment to gross output in these industries are ranking above one and it means that they are running at full capacity of labour on the one hand and an expansion of the production of these sectors would have the less potential of generating additional job opportunities on the other. For example, the ratio of employment to gross output in machinery sector is at around 40. This means that each additional LKR one million worth of output in this sector will create a forty employment opportunities. As a result of this higher labour incentive technology, machinery sector has the lowest employment multiplier (Type I is 1.01 and Type II is 1.02) out of all the sectors (see Figure 5). These findings suggest a necessity of adopting the appropriate policies into these sectors to improve the productivity for an expansion of these sectors and to generate additional employment opportunities in the future.

Another important finding found in this study is that, as it was expected, the Type II multipliers have always been high compared to its Type I counterpart. It is natural for the Type II multipliers to have large values as it is assumed that the household sector is neither imposed taxes nor they save money from their wages. Therefore, as explained before, Type II multipliers captured by direct, indirect and consumption induced impacts tend to overestimate the true multipliers while it's Type I counterpart captured by direct and indirect impacts tend to underestimate the true multipliers. Thus, any value between the values of these two multipliers can be expected to show a realistic picture.

Table 2: Identification of Leading Sectors in the Economy (Based on Estimated Output Multipliers)

Industry	Average output Multiplier [(Type I + II)/2]	Rank based on average output multiplier
Recreational, cultural, sporting services and other services	2.29	1
Public administration and other services to the community as a whole	2.04	2
Manufactured products of food, beverages and tobacco	2.03	3
Air transport	1.95	4
Manufacture of Rubber & Plastic Products	1.94	5
Hotel and restaurants	1.89	6
Education	1.84	7
Land transport; transport via pipelines	1.83	8
Health and social work	1.83	9
Transport equipment	1.80	10
Water transport	1.80	11
Supporting and auxiliary transport activities; activities of travel agencies	1.78	12
Average output multiplier (Type I and II) for 30 sectors	**1.70**	

Source: Author's calculation based on SIOT compiled by Bandara (2016).

As can be seen in Table 2, 12 sectors are only satisfied with the criteria that designed to identify the key sectors in the economy. The highest average output multiplier (2.29) is reporting from the sector called recreational, cultural, sporting services and other services. For example, increase of LKR one million worth of output for final demand in this sector would generate an additional LKR 1.29 million worth of output in the economy. The second leading sector in the economy is 'the public administration and other services to the community' followed by 'manufactured products of food, beverages and tobacco' and then air transport so on. In the ranking of key sectors in the economy, the education and health sector rank at 7th and 9th

places respectively. The significance of these sectors to generate the output in the economy mainly rooted from the consumption induced impact.

Table 3: Identification of Leading Sectors in the Economy (Based on Estimated Value Added and Income Multipliers)

Industry/Sectors	Value added multipliers		Income multipliers	
	Average (Type I +Type II)/2	Rank	Average (Type I + Type II)/2	Rank
Recreational, cultural, sporting services and other services	4.47	1	6.35	1
Manufacture of Rubber & Plastic Products	2.90	2	4.97	2
Air transport	2.52	3	2.79	4
Manufactured products of food, beverages and tobacco	2.44	4	2.76	5
Health and social work	2.42	5	-	12
Manufacture of metallic, non-metallic and mineral products	2.33	6	3.57	3
Petroleum & chemical products	2.20	7	2.60	6
Public administration and defence; compulsory social security	2.12	8	-	21
Hotels and restaurants	1.94	9	2.43	7
Construction	1.86	10	-	17
Land transport; transport via pipelines	1.86	11	-	13
Manufacture of paper and paper products & Printing	-	13	2.15	8
Average value added and income multipliers for 30 sectors	**1.85**		**2.08**	

Source: Author’s calculation based on SIOT compiled by Bandara (2016).

Table 3 shows that the ranking of leading sectors based on the average values of both the value added and income multipliers. Accordingly, the highest average value added and income multipliers are reported from 'recreational, cultural, sporting services and other services' and then followed by 'manufacture of rubber & plastic products'. Hence, these two sectors deserve to consider as leading sectors of Sri Lankan economy. The average value added multiplier of 'manufacture of paper and paper products & printing' is lower than its overall average value and it is greater than in case of overall average value of income multiplier. This implies that this sector is the leading sector in terms of impact of income multiplier. According to the value added multipliers along, four key sectors can be identified in the economy. These are the: health and social work; public administration and defence; construction; and land transport. In the case sector's contribution to the value addition, these sectors would be given priority in allocating resources to expand their capacity.

Table 4: Identification of Leading Sectors in the Economy (Based on Estimated Employment Multipliers)

Industry/Sector	Average employment Multiplier (Type I and II)/2	Rank based on average employment multiplier
Real estate activities	23.43	1
Manufacture of electric motors & electrical equipment	9.93	2
Air transport	8.84	3
Manufacture of petroleum & chemical products	8.29	4
Water transport	7.88	5
Manufactured products of food, beverages and tobacco	5.30	6
Manufacture of rubber & plastic products	5.04	7
Financial intermediation and investment banking	4.63	8
Average employment multiplier (for 30 sectors	**3.62**	

Source: Author's calculation based on SIOT compiled by Bandara (2016).

Table 4 ranks the key sectors based on the values of average employment multipliers. By contrast to the ranking of sectors based on the output, value addition and income multipliers, the real estate activities become the leading sector of the economy in terms of generation of employment opportunities. The second key sector is the 'manufacture of electric motors & electrical equipment' and then 'air transport followed by manufacture of petroleum & chemical products' so on. It is worthy to note that some sectors become key sectors in terms of output, value addition and income multipliers however, less important in terms of generation of employment opportunities in the economy. Such type of sectors are: recreational, cultural, sporting services and other services; public administration and defence; health and social work; manufacture of metallic, non-metallic and mineral products; petroleum & chemical products; construction sector; land transport; and lastly manufacture of paper and paper products & printing sector.

Linkage analysis

The results presented in Table 5 show that there are five industries (sectors) which have strong upstream and downstream vertical integrations with the rest of the other sectors in the economy. These sectors are: (1) recreational, cultural, sporting services and other services, (2) manufacture of rubber & plastic products, (3) hotels and restaurants, (4) manufacture of metallic, non-metallic and mineral products, and (5) petroleum & chemical products respectively. The sectors with strong upstream and downstream linkages with other industries mean that they not only utilize a large amount of domestically produced outputs as inputs in their production processes but also their outputs are used in a greater extent by other sectors in the economy as inputs to produce final goods and services. Based on the results of average coefficient of variations (not shown here) with regard to backward and forward linkages, it is found that relatively low variations are reported from sector 5, sector 3 and sector 1 respectively. This implies that the stimuli generated by investment in these three sectors are relatively evenly shared amongst all sectors in the economy. As the lowest average coefficient of variation is reported from the sector called petroleum & chemical products, higher prices charged on products such as petrol, diesel etc. in this sector would probably result in higher costs to most other sectors in the economy relatively equally.

Table 5: Identification of Key Industries in Sri Lanka (Based on the Backward and Forward Linkage Measures)

Criteria	Industries/Sectors	Decision
Both backward linkage (BL) and forward linkage measures (FL) >1	Recreational, cultural, sporting services and other services Manufacture of rubber & plastic products Hotels and restaurants Manufacture of metallic, non-metallic and mineral products Petroleum & chemical products	**Generally dependent**
BL >1 but FL < 1	Manufactured products of food, beverages and tobacco Air transport Health and social work Transport equipment Land transport; transport via pipelines Public administration and other services to the community as a whole	**Dependent on inter-industry supply**
FL>1 but BL < 1	Manufacture of products of wood, cork, straw and plaiting materials Agriculture & Livestock Machinery Financial intermediation services, and investment banking, Insurance and pension services Mining and quarrying, electricity, gas and water Forestry: wood & natural rubber	**Dependent on inter-industry demand**
Both BL and FL < 1	Construction Manufacture of paper and paper products & printing Manufacture of electric motors & electrical equipment Manufacturing of textile and wearing apparel Real estate activities Post and telecommunications Wholesale and retail trade Fishing Education Water transport Supporting and auxiliary transport activities; activities of travel agencies Manufacture of office, accounting and computing machinery	**Generally, independe nt**

Source: Author's calculation based on SIOT compiled by Bandara (2016).

Therefore, these sectors could be considered leading sectors in the economy as they are most connected with all industries in such a way that their output, employment, and value added multipliers would be influenced by strong domestic linkages, although other sector-specific factors such as the use of imported inputs, labour intensity of production, technology, and the level of productivity could also influence the size of these multipliers. For example, sector 4 and 5 mentioned above have relatively strong upstream and downstream linkages to other industries. However, as these sectors use more than one thirds of imported inputs (about 33% and 34% respectively) in their production process, this will reduce the domestic impact of these sectors on the Sri Lankan economy. A less dependency on imported inputs is reported from sector 3 (5.1%), sector 2 (6.2%) and sector 1(13%). As a result, the domestic impacts of these sectors on the Sri Lankan economy are relatively high.

As can be seen in Table 5, sectors with strong downstream linkages include (1) manufacture of products of wood, (2) agriculture & livestock, (3) machinery, (4) financial intermediation services and investment banking, (5) insurance and pension services, (6) mining and quarrying, electricity, gas and water, and (7) forestry: wood & natural rubber. Output of these sectors' are utilized by other sectors as inputs in their production processes. Therefore, the successes of the sectors depend on the supply of inputs from other sectors, which in turn affect the successes of the later. This implies the importance of strengthening industries which have either upstream or downstream linkages or both. As the sector 6 mentioned above has strong downstream linkages to other sectors in the economy, higher prices (or taxes) charged on electricity and water would probably result in higher costs to most other sectors in the economy.

The results presented in Table 5 also show that there are 12 sectors in the economy which are weakly connected to the other sectors of the economy. There include such sectors as education whose output cannot be used as direct inputs for many sectors in the economy. Therefore, based on the linkage measures or multiplier analysis deciding whether a sector is a key one or not should be done very carefully.

CONCLUSION

This paper is aimed at measuring industrial interdependence in Sri Lanka, using a symmetric input-output table for the data 2006 to draw policy relevant lessons to find an effective development strategy for the country. Five key industries of the Sri Lankan economy have been identified from the study in terms of output, value added and income multipliers. These include: (1) recreational, cultural, sporting services and other services; (2) manufactured products of food, beverages and tobacco sector; (3) air transport services; (4) rubber & plastic products; and (5) metallic, non-metallic and mineral products. The sectors such as 'water transport service', 'education services', 'wood & natural rubber', and 'wholesale and retail' have lower income multipliers, reflecting the fact that their wage shares in total industry output are at lower levels. The employment multipliers are highest in the sectors such as: (1) real estate services; (2) electrical products; (3) petroleum & chemical products; and (4) rubber & plastic products industries. Unlike the ranking of sectors based on the output, value addition and income multipliers, real estate activities become the leading sector of the economy in terms of generation of employment opportunities.

There are five industries (sectors) which have strong upstream and downstream vertical integrations among other sectors in the economy. These sectors are: (1) the recreational, cultural, sporting services and other services; (2) manufacture of rubber & plastic products; (3) hotels and restaurants; (4) manufacture of metallic, non-metallic and mineral products; and (5) petroleum & chemical products respectively. The sectors with strong upstream and downstream linkages with other industries mean that they not only utilize a large amount of domestically produced outputs as inputs in their production processes but also their outputs are used in a greater extent by other sectors in the economy as inputs so as to produce the final goods and services. However, as sector 4 and 5 are using more than one thirds of imported inputs (about 33% and 34% respectively) in their production process, it leads to reduce the domestic impact by these sectors in the Sri Lankan economy. A less dependency on imported inputs is reported from the sectors: 3 (5.1%); 2 (6.2%); and 1(13%). It means that these sectors have relatively higher domestic impacts into the Sri Lankan economy.

Based on the results of average coefficient of variations (not shown here) with regard to backward and forward linkages, it is found that relatively lower variations in three sectors: 5, 3 and 1 respectively. This implies that the stimuli generated by investment in these three sectors are relatively evenly shared amongst all sectors in the economy. A lowest average coefficient of variation is reported from the petroleum & chemical products. Higher prices charged on products such as petrol, diesel etc. in this sector results in higher costs to most of other sectors in the economy.

The sector: 'mining and quarrying, electricity, gas and water', has strong downstream linkages to other sectors in the economy, higher prices (or taxes) charged on electricity and water would probably result in higher costs to most of other sectors in the economy. These results emphasises the importance of strengthening the industries which have either upstream or downstream linkages or both. When compared the information given in Figure 1 with the results in input-output analysis, it is very clear that industries should be prioritized based on an input-output analysis rather than just depending on the information provided by percentage of contribution in output and value addition to GDP by the sectors. However, the results should be interpreted very carefully as the impact of some sectors such as education difficulty to be practically measured in monetary terms based on an input-output model.

In implication, the study evolves with some limitations. First, IO analysis ignores the supply-side and capacity constraints of the economy. Second, it ignores price changes of both commodities and factors of production. Because of these reasons, results obtained might to be overestimated the “true” impact. Third, it ignores the economies of scale in the production process. Finally, it is based on highly aggregated versions of sectors (30) which could in turn lead to underestimate or overestimate of the real situation of an economy. Nevertheless these limitations, this input-output analysis will be very useful in development planning and sectorial policy designing processes.

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