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INTERDEPENDENCE OF INDUSTRIES AND KEY ECONOMIC SECTORS BASED ON LINKAGE INDICES: EMPHASIS ON AGRICULTURE

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ABSTRACT

Inter-sectoral linkage using input-output table provides proper strategies for future economic development where the sectors with the highest linkages rouse rapid progress of production, income, and employment. The linkage indices identify the key sectors of the economy that influence efficient application of resources and hence the study will aid the planners and policy makers in resource allocation. The study examined the different empirical measures of inter-industry linkages, inter-dependent of industries and identified the key sectors of an economy. Chenery-Watanabe, Rasmussen, Cella, Harrigan-McGilvray, Dietzenbacher-Van der Linden, and pure linkage techniques were applied for the Bangladesh data. An input output table with 79 sectors constructed and updated by The Bangladesh Institute of Development Studies was used. Agricultural and service sectors showed low backward linkage indices due to input dependence but some of the agro-processing sectors and garments industry occupied higher backward linkage due to heavy dependence on input supplies from the other sectors. Manufacturing sectors were considered as dominant sectors due to higher Rasmussen's 'backward' linkage indices with the least coefficient of variation. Livestock, forestry and cotton were the key agricultural sectors having higher forward linkage indices (1.694, 1.478 and 1.412, respectively) with comparatively low coefficient of variation (2.866, 2.975 and 3.623, respectively). Among the manufacturing industries machinery, other chemicals, fertilizer and readymade garments were the higher ranked backward linkage indices (1.509, 1.443, 1.429 and 1.376, respectively) with low coefficient of variation (4.182, 4.745, 3.335 and 3.538, respectively). The forward linkage indices of Cella and pure linkage methods were very close. Among the service sectors trade, transport, housing and banking were the key sectors according to Cella, Harrigan-McGilvray, Dietzenbacher-Van der Linden, and pure linkage methods. The ranking of sectors was close related for these methods but there was no common sector for both backward (accept rice milling) and forward linkage indices in the comparison of the top ten sectors. Economic impact of the imported inputs embodied in garment export must be evaluated. Investment policy should be made based on inter-industry linkages for adequate employment creation. Interrelationships and relative linkages between agricultural sub sectors should be modeled.

Keywords: Agriculture, backward linkage, forward linkage, indices, input-output, key sectors

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I. INTRODUCTION

Inter-industry linkage is a kind of technical and economic link that exists among the industries, which was first introduced by Hirschman based on the theory of unbalanced development (Hirschman, 1958). With the acceleration of industrialization in developing countries since the mid-nineties, inter-industry linkages have gained extensive attention from academic circles, industrial fields and policymakers. Inter-industry linkage measures the relative importance of industries to identify the key industries for economic development and high-speed growth of the industry. Therefore, an applicable and reasonable method to measure the inter-industry linkages is helpful to recognize the relationship between or among industries, promote the level of balanced development of the entire economic system, and even optimize the industrial structure of the national economy (Liu and Shi, 2020). Over the years, the previous scholars have conducted many research studies on the analysis of inter-industry linkages from different perspectives in two common kinds of methods e.g., the traditional econometric analysis and input-output analysis, which can be used well to describe the interrelatedness of industries. The former is a relatively indirect method which generally first puts forward hypotheses and then usually adopts the econometric model such as the panel data regression model or the vector autoregressive model to search the supporting empirical evidence based on the macro-statistics data of the economic system (Banga and Goldar, 2007; Francois and Woerz, 2008; Tariyal, 2017).

The latter is a relatively direct method, which is first introduced by Leontief (1936), and it quantitatively analyzes or computes the inter-industry linkages or relationships through the input-output data. Firstly, Hirschman (1958), Chenery-Watanabe (1958), and Rasmussen (1956) used input-output data to identify the key sectors by measuring the backward and forward linkages. After that Joshi (1979), Mudahar (1982), Ahn ((1983), Mureithi and Sharma (1984), Rahman (1986), Cai and Leung (2002), Mardzuki et al., (2014), Raupelienė (2017), and Huong (2019) measured backward, and forward linkage indices based on input-output data with special emphasis on agriculture. Agarwal (1996) and Sarker (1997) examined the effect of inter-sectoral growth of the agriculture and manufacturing sector and the degree of interdependence between them using input-output data. Guerrieri and Meliciani (2005) studied empirically the inter-industry linkages based on the input-output data of different developed countries through measuring the backward and forward linkages. Comparing these two kinds of methods the latter is insufficient in terms of data immediacy and availability because input-output data usually are only issued by the official statistics department with a gap of several years, but it can provide a more convictive and micro-view perspective to describe the interrelatedness of inter-industries.

A linkage is an investment opportunity offered by one industry to another (Naerssen, 1980) and is distinguished from the type of induced investment behavior assumed in most macro growth and trade cycle models. Investment in a given industry concentrates linkage inducements on the industries that supply inputs to it or buy output from it. Linkages can be best understood in terms of the theory of external economics, particularly Scitovsky's (1954) distinction between pecuniary and technological externalities. In a developing and growing economy, institutional and policy factors play a prominent role in determining whether apparent linkages are converted into growth impulses or not (Rahman, 1986). It is strongly believed that if resources, especially capital and entrepreneurial skill can be concentrated in key sectors, output and employment in the country or region will grow more rapidly than if these resources were allocated in some alternative way (Bulmer-Thomas, 1978). Linkages will ensure growth impulses if the size of demand and supply pressures induced by linkages is large enough to correspond to the minimum economic size so that the expansion activity is viable (Rahman, 1986). A non-primary activity having high backward linkages is expected to induce attempts to supply its inputs through additional domestic production and having high forward linkages may induce attempts to utilize its outputs as inputs into new activities (Jones, 1976).

The linkage has played an important role as a means of measuring relationships between inter-industries, indicating the degree of structural interdependence in an economy, identifying key industries in the strategy of the country’s development, and knowing the extent to which the growth in the sector stimulates expansion in the others. Linkage indices using an input-output table are helpful to estimate the aggregate growth rate in analyzing the production structure of an economy. The linkage coefficient helps us to identify the key sectors of the economy in the strategy of the country’s development. It also helps us to identify the sectors due to their important position in the inter-industry network, which is significant for initiating or distributing growth impulses. Identifying the key sectors, exports, and imports, the economy-wide impact of balanced trade, and technological adaptation, any program of sectoral development is likely to suffer from major deficiencies in the absence of a comprehensive study of sectoral linkages. The lack of linkage is of course one of the most typical characteristics of underdeveloped economies. The identification of the strategic sectors of the economy is thus a prerequisite for the attainment of the most efficient application of resources about sectoral allocation. This information can be used to provide a quantitative indication of the severity of the constraints those imposed by the structure of the economy. In addition, it is possible to gauge the Government's ability to attain its policy objectives.

The purpose of inter-sectoral linkage is also to assist less developed countries to device agriculture and rural sector policies and programs, the performance of export and import for national perspective, reducing problems of underemployment and low levels of living of the poor. The study of inter-industry linkage helps the

government to design growth-enhancing policies for sectors with large spillover effects and also helps in understanding the structure of an economy (Cai & Leung, 2004), and a proper understanding of sectoral linkages is important for designing long-run strategies (Tariyal, 2017). Inter-sectoral linkage has been recognized as playing a crucial role and providing substantial contributions towards guiding the appropriate strategies for future economic development and it describes a sector's relationship with the rest of the economy through its direct and indirect intermediate purchases and sales (Tariyal, 2017). The sectors with the highest linkages are likely to stimulate rapid growth of production, income, and employment (Hirschman, 1958). On the foundation of the theory of input-output analysis, this study designs several methods for inter-industry linkage analysis based on demand-driven and multi-sector input-output models and applies them in the scenario of 79 sectors of Bangladesh, which helps analyze the interrelatedness between the sectors and identifying the key economic sectors.

A few numbers of research on interdependence of industries have been done in Bangladesh and they have suffered from several theoretical and methodological shortcomings. For example, Alauddin's (1986) study was primarily based on 47 sectors of the Bangladesh economy 1976-77 to identify the key sectors. The import ratio was estimated without export from domestic supplies, which implies that import was re-exported, and the re-export of imports is not true for Bangladesh. Ahmed (1973) tried to priorities the sectors with high employment potential and agricultural sector ranked top, which did not fulfill the need of the planners in absence of further rankings of the sectors according to high linkages. Mujeri and Alauddin (1991) ranked the sectors according to high value of 53 sectors, which was suffered from theoretical shortcomings that why the findings lost the importance of policy implication. In the absence of a comprehensive study identifying sectoral linkages, it is obvious that any program of sectoral development is likely to suffer from major deficiencies. No detailed study has yet been made to measure linkage between the agricultural sub-sectors and among their comparisons for agricultural planning in Bangladesh. With a view to fulfill this gap a comprehensive study using the latest theoretical developments of input output methodology have been undertaken in which a large number of methods of estimation of linkage indices were used. In addition, the comparative results of these methods were shown and identified the bottleneck for the growth of agro-industries. The findings of this research will contribute to device agriculture and rural sector policies and reduce problems of underemployment and low levels of living of the poor in some extent. The analytical results will provide a premise for the planners and policymakers to draw a policy decision both in planning and policy research.

The present study is, therefore, aims to identify and quantify the previously developed methods of inter-industry linkage indices, determine the backward and forward linkages of the input-output table, verify the stated linkage methods by

comparing the values of linkage coefficients, and identify the key economic sectors of the Bangladesh economy that can help determine priority sectors for resource allocation.

II. METHODOLOGY

Theoretical framework of various linkage indices

In this research mainly backward and forward linkage indices were calculated using six different methods. According to the first method (Chenery-Watanabe, 1958), the backward linkage is the ratio of purchased inputs to the value of total production and forward linkage is the ratio of total supplies of the intermediate inputs to total demand. Rasmussen (1958) modified this method for practical application where Leontief's inverse matrix was used. The above two methods are based on input (or output) coefficients and hence termed as the traditional method of linkage measures. The hypothetical extraction method was offered by Cella (1984) and Harrigan and McGilvray (1988) added a hypothetical additional approach that decomposes total linkages into four components. These two approaches are termed the second-generation method of linkage measures. Cella linkage approach was modified by Sonis (1995) is termed as pure linkage approach. Furthermore, a revised extraction approach had devised by Dietzenbacher and Van der Linden (1997), who measure the backward forward linkage separately by using a non-complete extraction method. All the methods of Backward and Forward linkage indices used in this study are as follows.

Chenery-Watanabe method

The 'backward' linkage for any j^{th} sector (L_{Bj}) is defined as the ratio of purchased intermediate output to the total value of production in each sector i.e.

$$L_{B_j} = \frac{\sum_i X_{ij}}{X_j} = \sum_i a_{ij} \quad \text{---------- (1)}$$

Where X_{ij} represents the number of units of commodity i used in the production of X_j units of commodity j, a_{ij} are obtained from Leontief technical input-output coefficient matrix, and X_j is the gross output of sector j.

Correspondingly, 'forward' linkage for any i^{th} sector (L_{Fi}) is defined as:

$$L_{Fi} = \frac{\sum_j X_{ij}}{X_i} = \sum_j a_{ij} \quad \text{---------- (2)}$$

Where Xi is the gross input of sector i.

The above indices only measure the direct impacts.

Rasmussen's method

According to Rasmussen backward linkage (U_j) and forward linkage (U_i) is defined as follows:

$$U_j = \frac{\frac{1}{n}\bar{Z}_{.j}}{\frac{1}{n^2}\sum_{j=1}^{n} Z_{.j}}, \quad (j = 1.2,.....,n) \text{ ---------- (3)}$$

$$U_i = \frac{\frac{1}{n}\bar{Z}_{i.}}{\frac{1}{n^2}\sum_{i=1}^{n} Z_{i.}}, \quad (i = 1,2,.....,n) \text{ ---------- (4)}$$

Where $\sum_{i=1}^{n} Z_{ij} = Z_{.j}$ denotes the total input requirements for a unit increase in the final demand for the jth sector. Similarly, $\sum_{j=1}^{n} Z_{ij} = Z_{i.}$ indicates the increase in the output of sector i. $\frac{1}{n}Z_{.j}$ and $\frac{1}{n}Z_{i.}$ are the averages.

Cella method

Cella defined the Backward and forward as follows:

$$BL = i'[H - B_{11} + B_{22}A_{21}H]F_1 \text{ ---------- (5)}$$

$$FL = i'[HA_{12}B_{22} + B_{22}A_{21}HA_{12}B_{22}]F_2 \text{ ---------- (6)}$$

Where, $A_{11} = [a_{11}]$, $A_{12} = [a_{12}, a_{13}, ..., a_{1n}]$,

$$A_{21} = \begin{bmatrix} a_{21} \\ a_{31} \\ \vdots \\ a_{n1} \end{bmatrix}, \quad \text{and} \quad A_{22} = \begin{bmatrix} a_{22} & a_{23} & . & . & a_{2n} \\ a_{32} & a_{33} & . & . & a_{3n} \\ . & . & . & . & . \\ . & . & . & . & . \\ a_{n2} & a_{n3} & . & . & a_{nn} \end{bmatrix}$$

i' is unit summation vector,

$\mathbf{F_1}$ and $\mathbf{F_2}$ are the final demand vectors of sector j and remaining sectors respectively.

$$H = \{I - A_{11} - A_{12}(I - A_{22})^{-1}A_{21}\}^{-1}$$

$$B_{11} = (I - A_{11})^{-1}$$
$$B_{22} = (I - A_{22})^{-1}$$

Harrigan-McGilvray method

Harrigan and McGilvray proposed another method of linkage index, which is decomposed into four components as follows:

$$\begin{aligned} TL &= [i'B_{11}F_1] \\ &+ [i'B_{22}A_{21}F_1] \\ &+ i'[A_{12}B_{22}]F_2 \\ &+ [i'(H - B_{11} + B_{22}A_{21}(H - I))F_1 + \\ & i'((H - I)A_{12}B_{22} + B_{22}A_{21}HA_{12}B_{22})F_2] \end{aligned}$$ ---------- (7)

= Internal linkage + Backward linkage + Forward linkage + Closed-loop linkage

Pure Linkage method

Pure backward linkage" (PBL) is as follows:

$$PBL = i_{12}(I - A_{22})^{-1} A_{21} x_1$$ ---------- (8)

Where, X_1 = Value of total production in sector j.

Similarly, pure forward linkage as

$$\mathbf{PFL = i'_{11} A_{12} [I - A_{22}]^{-1} x_2}$$ ---------- (9)

Where, X_2 is a column vector of total production in each sector in the rest of the economy.

Dietzenbacher and Van der Linden method

The relative backward linkage of sector j is defined as:

$$\mathbf{BL^D_j = \frac{d(j)}{x_j} x100}$$ ---------- (10)

Where d(j) is normalized by the value of sector j's output and defined as

$$\mathbf{d(j) = [(H - I) + e'_2 B_{22} A_{21} H]F_1 + [(H - I)A_{12}B_{22} + e'_2 B_{22} A_{21} HA_{12} B_{22}]F_2}$$

The relative forward linkage of sector 'i' is defined accordingly as:

$$\mathbf{FL^D_i = \frac{d(i)}{x_i} x100}$$ ---------- (11)

Where,

$$\mathbf{d(i) = v_1[(\hat{H} - I) + \hat{H}B_{12}(1 - B_{22})^{-1}e'_2] + v_2[(1 - B_{22})^{-1}B_{21}(\hat{H} - I) + (1 - B_{22})^{-1}B_{21}\hat{H}B_{12}(1 - B_{22})^{-1}]e'_2}$$

The measures of variability or dispersion developed by Rasmussen for 'backward' and 'forward' linkages are as follows:

$$V_j = \frac{\sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(Z_{ij} - \frac{1}{n}\sum_{i=1}^{n}Z_{ij})^2}}{\frac{1}{n}\sum_{i=1}^{n}Z_{ij}}, \quad (j = 1,2,.....,n) \text{ ---------- (12)}$$

$$V_i = \frac{\sqrt{\frac{1}{n-1}\sum_{j=1}^{n}(Z_{ij} - \frac{1}{n}\sum_{j=1}^{n}Z_{ij})^2}}{\frac{1}{n}\sum_{j=1}^{n}Z_{ij}}, \quad (i = 1,2,...,n) \text{ ---------- (13)}$$

Data source

The Bangladesh Institute of Development Studies (BIDS, 1998) constructed and updated the current input output table consisting of 79 sectors in which the fiscal year 1993-94 was chosen as the base year considering comparatively normal economic conditions and availability of statistical information. A complete listing of these component sectors is provided in Appendix 1 and Appendix II, which shows a relatively well-documented as far as for the agricultural sector is concerned. An input output table was constructed by researchers at Dhaka University and the Bangladesh Institute of Development Studies (BIDS) in 2006-07 consisting of a number of gaps, e.g., a high number of cells across the rows and columns were empty (GHK, 2010). Most of the input output tables provided the incremental input output coefficients related to specific plan period but there has no recent complete input output table. But the input output table used in this study was composed of actual input output coefficient matrix having no shortcomings and represents a better choice in judgment. The source of raw data was generated by the Bangladesh Planning Commission containing 79 sectors of which 20 were in agriculture, 39 in the manufacturing industry, 6 in construction, 3 in energy, and 11 in services. The system of the analytical framework of the input-output equation was expressed in terms of the well-known formulation:

$$\mathbf{Q = [I\text{-}A]^{-1}F}$$

Where, Q is the vector of gross production
I is an identity matrix of the required order
A is the matrix of input-output coefficients
F is the final demand vector

$[I-A]^{-1}$ gives both direct and indirect requirements of inputs. While direct inputs are those purchased by the sector under consideration, indirect inputs are those purchased by all other sectors in which production has to adjust to supply inputs to the specific sector.

The input structures of the agriculture sector were the self-input and other production and processing inputs including harvesting, carrying, drying, marketing, and other operations. Information on different inputs was collected from various sources. The final demand was partitioned into private consumption, public consumption, investment, stocks of commodities, and exports.

Analytical procedure

Estimation of linkage indices and their rankings

Inter-industry linkage indices were calculated using the above input-output table. Applying traditional methods of Chenery-Watanabe and Rasmussen, and the second-generation methods like Cella, Harrigan-McGilvray, pure linkage, and Dietzenbacher-Van der Linden backward and forward linkage indices were computed using a separate computer program in SPSS Syntax software. Based on the values of linkage indices, sectors were ranked in descending order of magnitude for both the cases in each method. The analysis of the correlation between rank orderings may give a better picture of interactions in the structure of linkages and hence Spearman's rank correlation coefficients of backward and forward linkage indices were computed.

Identification of key sectors

The determination of inter-industry linkage is useful for the empirical identification of key sectors and hence key sectors were determined using four techniques like Hirschman's technique, indices of coefficient of variation (equation 12 and equation 13), the average value of linkage indices, and top ten linkage indices for different methods.

Hirschman's technique: According to Hirschman's development strategy (1958), the highest priority should be given to those sectors, which possess high backward and forward linkages and the lowest priority to sectors, which possess low backward and forward linkages. The second priority goes to the sectors having high backward and low forward linkages and the third priority to the sectors having low backward and high forward linkages. Thus, the sectors were classified as high and low depending on whether their indices (only for the Chenery-Watanabe method) are above or below the average value of linkage indices of the whole economy and were arranged in quadrants I, II, III, and IV.

Use of indices of coefficient of variation: Hirschman defined a key sector as one, which has a high backward as well as forward linkage i.e., any industry in which backward linkage index (U_j) and forward linkage index (U_i) is greater than unity.

Hazari (1970) considered the indices of coefficient of variation with linkage measures to select the key sectors. Thus, a key sector was defined as one in which both 'backward' and 'forward' linkage indices of the Rasmussen method are greater than unity (i.e., $U_j > 1$, $U_i > 1$) and both the indices of coefficient of variation (V_j and V_i) are relatively low.

Based on the average value of linkage indices: Using this technique of identifying key sectors all the methods of estimating linkage indices can be compared (O'Callagham and Yue, 2000). According to the size of the various linkage indices, all the sectors of an economy may be grouped into four categories. Thus, the classification of the backward and forward linkages' results as follows: (1) Key sector (abbreviated by a letter K)**,** where both the backward and forward linkage high (>1); (2) Strong backward linkage sector **(**B), where backward linkage high (>1) but forward linkage law (<1); (3) Strong forward linkage sector (F), where forward linkage high (>1) but backward linkage low (<1); and (4) Weak linkages sector (W), where low backward and forward linkages i.e. less than 1.

Top ten linkage indices: Another method for identification of key sectors was used in this study termed as 'top ten ranking method' where the sectors were identified based on the different methods of linkages that may be regarded as 'key sectors'.

III. RESULTS AND DISCUSSION

The empirical analysis of input-output data of Bangladesh applying six methods of linkage measures has been made and verified the different methods of linkages, comparing the values of linkage indices and identifying the key economic sectors using these methods.

Linkage indices and their ranks in different methods

The backward and forward linkage indices and their ranks of 79 sectors estimated with six different methods are presented in Appendix I and Appendix II, respectively. The manufacturing sectors, especially, leather finishing (0.884), fertilizer (0.878), jute bailing (0.874), rice milling (0.847), machinery (0.814), readymade garments (0.813), and iron/steel industry (0.808) possessed highest ranked forward linkage indices for Chenery-Watanabe method. While trade service (6.687), iron/steel industry (5.678), other chemicals (4.396), machinery (3.209), transport service (2.899) and livestock (1.694) possessed highest ranked forward linkage indices for Rasmussen method. On the other hand, cotton (6.240), transport equipment (5.347), other chemical (5.280), machinery (4.802), bricks/tiles/clay (4.679) retained highest ranked backward linkage indices for Cheneryz.,-Watanabe method and iron/steel industry (1.951), other construction (1.514), machinery (1.509), construction of electricity (1.487) and other chemicals (1.443) retained backward linkage indices for Rasmussen method. Manufacturing sectors like machinery, iron/steel industry and other chemicals had higher ranked forward

linkage indices whereas the agricultural sectors like other grains, potato, vegetables, pulses and tea had lower ranked forward linkage indices for all the six methods (Appendix II). Similarly, Petroleum products and machinery had higher ranked backward linkage indices whereas fruits, pottery and gas had lower ranked backward linkage indices for all the six methods (Appendix I).

Agricultural sectors, in general, had a very low ranking concerning direct backward linkage using the Chenery-Watanabe method, as they are very low input dependence compared to other sectors of the economy. The sectors with low backward linkage indices were concentrated among the service sectors (0.022 for health service and 0.001 for education service) since these had a very high labor component in their production. High backward linkage was largely occupied by most manufacturing industries (5.347 for equipment, 5.280 for other chemicals, 4.802 for machinery, 4.365 for cement, etc.) due to heavy dependence on input supplies from other sectors. Among them, transport equipment, machinery, other chemicals, bricks/tiles, cement, mill cloth, and glass products had the highest input dependence. Backward linkages were the strongest in trade service (0.826), iron & sleet industry (1.893), other chemicals (5.280), machinery, transport service, and livestock ranked very high backward linkages (Appendix I). Some of the agro-processing sectors (rice milling, sugar, leather finishing, jute bailing, and jute textile), and garments industry (handloom cloth, readymade garments, and hosiery) had very low rankings by backward linkages but had higher rankings by forwarding linkages. Fertilizer and iron/steel industry are manufactured principally for intermediate supplies and hence they had relatively higher ranking by forward linkages (Appendix II) than that by backward linkages. Spearman's rank correlation coefficient between backward and forward linkages was very low (-0.078) implies that sectors having large dependence on other sectors for inputs are not input suppliers and their products largely go to final demand. Bekhet (2010) also found very weak and insignificant rank correlation coefficients between forward and backward linkage indices and a high dependency on the primary sectors such as oil palm, rubber, and wood sectors.

It is seen that the values of forward linkages computed by the Rasmussen method for most of the agricultural and service sectors were comparatively higher than that of backward linkage may be due to heavy reliance on one or few industries. The agricultural crop production sectors (1 to 20) excluding wheat had the lower values of backward linkages (less than 1) of which pulses, fruits, and spices had the least backward linkages. Similarly, agricultural sectors had high forward and low backward linkages indices (Sivakumar et al., (1999). Other than agriculture, electricity, gas, trade service, education service, banking and insurance, communication, and other services shows very low values of backward linkages. The values of linkage indices show that almost all of the manufacturing sectors (numbered from 21 to 59) excluding salt, cigarettes, bidi, saw/ planning mills, pottery/earthenware, bricks, and miscellaneous industries had backward linkage

greater than 1. The leather and leather products, handloom cloth, readymade garments, knitting and hosiery, fertilizer, construction of electricity, and other construction sectors may be considered as notable dominant sectors with the higher backward linkage index may be due to heavy demand from few industries. The iron and steel industry had the highest backward linkage index (1.951) but the value of the coefficient of variation was also higher. Greater values of backward linkage indices occurred for other food, leather product, readymade garments, and fertilizer. This suggests that sectors, which draw heavily on other industries, do so across a broad spectrum of supplying industries. The trade service sector ranks uniquely having the highest rank, followed broadly by iron and steel industry, other chemicals machinery, transport service, and livestock sector. Construction, rural road, and jute bailing had the least values of forward linkage.

A few agricultural sectors (wheat, other grain, oilseeds, cotton, tobacco, tea), and nineteen manufacturing sectors out of thirty-nine had backward linkage greater than 1. This implies that these sectors had a high dependence on intermediate goods, which are typically capital-intensive. Education, health, profession, and other services had a lower rank in terms of both backward and forward linkages because they are very labor-intensive in production, and those supply all of their output to final consumers. The dependence of the manufacturing sector on agriculture sector is heavier than the dependence of the agriculture on the manufacturing sector (Namboodiri, 1979). Agriculture, in general, possessed weak linkages as compared to the industrial sector whereas agriculture processing induced strong backward and medium-weak forward linkages (Mudahar, 1982). Among the key agricultural and agro-based manufacturing sectors other agriculture and oils and fats were import-intensive (Rahman, 1985). The west Malaysian economy interpret those agricultural industries had comparatively large aggregate primary input requirements and rubber, rice, oil palm, and livestock were the leading industries in terms of value-added (Rahman, 1987). Alauddin and Tistell (1988) expressed that most agricultural industries were quite appropriate to Bangladesh in terms of their capital-to-labor requirements. In most of the primary sectors, especially in agriculture, the strong linkage was absent which revealed a weak technological position of agriculture in the existing development process (Mujeri and Alauddin, 1994). Forestry, livestock, other industries, trade, chemicals, and transport service deserve priority along with other sectors having strong backward linkages (Salimullah, 1998).

Rice milling (0.0931 for Cella method and 0.0928 for Harrigan-McGilvray method ranked 1), rural building (0.1482 for Dietzenbacher and Van der Linden method ranked 4), transport service (0.0361 for pure linkage method and 0.1660 for Dietzenbacher and Van der Linden method ranked 2), and handloom cloth are considered notable dominant sectors with the high backward linkage index based on all the methods of second-generation linkages. The agricultural crop production sectors excluding other fish, forestry, rice, and livestock had the lower values of

backward linkage. Trade service had the highest and the paddy had the second-highest value of forward linkage index. Besides these two sectors, transport service, yarn, petroleum products, other chemicals, and livestock possessed higher value of forward linkage index. Fish processing, leather products, handloom cloth, readymade garments, knitting and hosiery, bidi, and construction sectors had possessed very low value of forward linkage. It can be seen that Cella's backward linkage is either equal to or greater than the Harrigan-McGilvray linkage. Paddy, livestock, forestry, rice milling, handloom cloth, rural building, mining/quarrying, trade service, transport service, and professional service were the dominant sectors for the backward Dietzenbacher and Van der Linden method. Whereas jute bailing, readymade garments, other textiles, china/ceramic, electricity, and other constructions possessed very low values of backward linkages. On the other hand, rice milling, yarn, other chemicals, petroleum products, iron/steel, fabricated metal, electricity, transport, and trade services were the dominant sectors for the forward Dietzenbacher and Van der Linden method and poor in wheat, shrimp, poultry, and edible oil.

It can be seen that the pure backward linkage indices were greater than the Cella backward linkage indices as well as the Harrigan-McGilvray backward linkage indices. The forward linkage indices of the two methods (Cella & Pure) were very close and for a few sectors were the same. Spearman's rank correlation coefficient between the Cella and Pure linkage was 0.989, which was highly significant. Similarly, the backward and forward linkages between the above two methods were also highly significant. The linkage indices between the backward and forward pure methods were also highly correlated. Like Cella linkage, rice milling, rural building, trade service, and handloom clothes are the dominant sectors with the high backward linkage index for the other methods of second-generation. A few sectors such as paddy, livestock, and forestry under the agricultural production sectors were also the next dominant sectors for the pure and Dietzenbacher and Van der Linden methods. Some agricultural sectors (other grains, tobacco, tea, major spices, and shrimp), and some manufacturing sectors (salt, jute bailing other textiles, and glass products) possessed very low value of backward linkage. Paddy, forestry, livestock, other chemicals, petroleum products, iron/steel industry, transport service, trade service, and banking/insurance are the dominant sectors with the high forward linkage index.

Comparison of the results given by the different methods

To undertake the comparative analysis, the linkage indices computed from the input-output and their ranks were used. It was found that there are obvious differences between the rankings of the linkage indices for the six methods. For example, the backward linkage for edible oil ranked at position 11 according to the Rasmussen method, but according to Cella, Harrigan-McGilvry, Pure and Dietzenbacher-Van der linden methods, the positions were 15, 16, 17, and 18

respectively (Appendix I). The ranking of linkage indices given by the Cella and Harrigan-McGilvray methods were same for most of the sectors and much closer for the other sectors in both the cases of backward and forward linkages. The ranking of pure linkage indices was very close to the ranking of the Dietzenbacher-Van der linden method and also close to Cella and Haregan-McGilvray linkages. The ranking of Dietzenbacher-Van der linden linkage indices (especially backward linkages) was also much closer to the above linkages. Rasmussen forward linkage indices were also closer to Cella and Harrigan-McGilvray method mainly for the manufacturing and some of the service sectors (Appendix II).

A comparison of the backward linkage indices shows that Rasmussen linkage indices had a small variance in their values. The values of the Cella linkage indices were close to the Harrigan-McGilvray linkage indices, with the exception of sector petroleum products. This confirms that the definition of backward linkage made by Cella is close to the definition presented in the Harrigan-McGilvray backward linkage. The Rasmussen indices show a much larger spectrum of the variance for the forward linkage indices than their backward linkage indices. The index of Cella had a higher value than the Harrigan-McGilvray linkage indices. The Rasmussen method is based on the ratio of each sector's effects to the output of the sectors. So, some sectors producing primary products and intermediate products, such as the iron/steel industry, machinery, chemicals, fertilizer, petroleum products, fabricated metal products, etc., would have relatively high forward linkages. On the other hand, the relatively high output would induce a lower linkage in some sectors such as other grains, vegetables, pulses, fruits, etc. However, it is not held in the Cella, Pure, and Dietzenbacher and Van der Linden linkage methods. So, they consider the share of each sector in final demand and primary inputs, while eliminating the self-impact of each sector. Therefore, some sectors that had relatively high shares in final demand (or primary inputs) would have higher backward linkages (or forward linkages).

Identification of key sectors

The sectors in quadrants II and IV in Table 1 had high backward linkages. These sectors rely heavily on other sectors, which provide them with intermediate inputs and can be termed as secondary production sectors. Similarly, sectors in quadrants III and I had low backward linkages and can be termed as primary sectors. The primary input content of these sectors tends to be high. Other things being equal, an expansion of output in sectors in quadrants II and IV will have a greater impact on the economy than output expansion in other sectors. Backward linkage indices for agricultural and non-tradable sectors were low because their supply chains were not large whereas forward linkage indices of the most modern and dynamic service sectors were high those can stimulate general output when associated with manufacturing production and that demands high value-added services (Marconi et al., 2016). Sectors in quadrants III and IV with high forward linkages will be

affected more by a change in overall economic activity than those sectors in quadrants II and I. The industries in quadrant IV are the key and priority sectors in the Bangladesh economy, where both the backward and forward linkages were above the average value of the whole economy. These sectors will play the most prominent role in the sense that these sectors are more responsive than other sectors to change in economic activity of the whole economy as well as exerting more impact on the rest of the economy.

Table 1. Classification of inter-industries according to low or high backward and forward linkages

	Low Backward		High Backward
L	3 Other grains	40 Cigarettes	1 Paddy
O	5 Sugarcane	41 Bidi	4 Jute
W	6 Potato	42 Saw and planning mills	11 Cotton
	7 Vegetables	50 Pottery & earthen	16 Livestock
F	8 Pulses	53 Bricks, tiles & clay	20 Forestry
O	9 Oilseeds	61 Rural building	59 Misc. industries
R	10 Fruits	63 Construction: rural road	66 Electricity
W	12 Tobacco	71 Housing service	67 Gas
A	13 Tea	72 Health service	68 Mining & quarrying
R	14 Major spices	73 Education service	69 Trade service
D	15 Other crops	74 Public admin. & defense	70 Transport service
	17 Poultry	76 Professional service	75 Banking & insurance
	18 Shrimp	78 Communications	
	19 Other fish	79 Others service	
	27 Salt		
	Quadrant I		***Quadrant II***
H	2 Wheat	37 Readymade garments	25 Sugar & Gur
I	21 Rice milling	38 Knitting & hosiery	33 Yarn
G	22 Ata & flour milling	39 Other textiles	44 Pulp, paper & bond
H	23 Fish processing	43 Wooden/furniture	45 Printing & publishing
	24 Edible oil	46 Drugs & pharmaceuticals	47 Fertilizer
F	26 Tea processing	51 China & ceramic	48 Other chemicals
O	28 Other food	52 Glass & glass products	49 Petroleum products
R	29 Leather finishing	54 Cement	55 Iron & steel industry
W	30 Leather products	58 Transport equipment	56 Fab. Metal products
A	31 Jute bailing	62 Construction: electricity	57 Machinery
R	32 Jute textile	64 Construction: transport	60 Urban building
D	34 Mill cloth	65 Other construction	
	35 Handloom cloth	77 Hotels & restaurants	
	36 Dyeing/ bleaching		
	Quadrant III		***Quadrant IV***

The sectors of quadrant I had low backward and forward linkages indicate that these sectors are relatively less dependent on other sectors for their input requirements and the disposition of their products. These sectors had more direct links between final demand and primary factors of production. Fourteen of them belong to agriculture and the others tend to be labor-intensive services or manufacturing activities (Table 1), which produce consumer goods. Some of the agricultural sectors such as paddy, jute, cotton, livestock, and forestry possessed high backward linkages as they were equipped with modern technology, but they possessed low forward linkages due to the lack of processing. Valdosh (2017) identified 6 key sectors, 25 weak sectors, 4 strong backward linkage sectors, and 10 strong forward linkage sectors of the economy of 45 sectors. The priority sectors in terms of the investment were 'food, beverages & tobacco', 'textiles', 'wood & wood products', 'paper & paper products', 'leather & plastic products', 'chemicals' and 'machinery' (Bhattacharya and Rajeev, 2014) having both forward and backward linkage greater than unity. An increase in both backward and forward linkages was recorded for the manufacturing industries in Slovenia in the immediate aftermath of the global financial crisis (Geršak and Muhaj, 2016). The sectors showing high backward linkage indices and forward linkage indices estimated by the Rasmussen method along with their corresponding indices of low coefficient of variation are shown in Table 2. The study indicates that the sectors pulp/paper/board, fertilizer, other chemicals, fabricated metal products, and machinery were the key sectors having fulfilled the requirements prescribed in the definition of the key sectors. On the other hand, handloom cloth, readymade garments, knitting/hosiery, leather finishing, construction of electricity and other construction were the key sectors with a strong backward linkage index as they depend on input supplies from other sectors. Livestock, yarn, petroleum products, trade service, transport service, and banking/insurance were the key sectors with a strong forward linkage as they produced more for intermediate demand.

Table 3 summarizes the categorization results for each method based on the average value of linkage indices. The pair of indices (backward and forward) falls in one of the four categories. The letters in this table indicate which category a sector belongs to. There are certain similarities between the results of Cella, Harrigan-McGilvray, Pure linkage and Dietzenbacher-Van der Linden methods, and the sectors livestock, forestry, trade service, transport service, and housing service were the key sectors for each of these four methods. But there were obvious differences between these results as reported by the six methods, especially, in the category of key sectors. Chenery-Watanabe, Pure linkage and Dietzenbacher-Van der Linden methods have exhibited a higher number of key sectors (15, 13 and 14 respectively). A large number of sectors (other grains, jute, sugarcane, potato, vegetables, major spices, other crops, poultry, shrimp, cigarettes, bidi, health service, and other services) show weak linkages for each of the methods, but there were no common sectors as a key sector, strong backward, or strong forward linkages for each of the methods.

Table 2. Sectors showing high backward and forward linkage and low coefficient of variation

Backward Linkage				Forward Linkage			
Sector	U_j	R	V_j	Sector	U_i	R	V_i
21 Rice Milling	1.1631	23	4.0922	11 Cotton	1.4121	13	3.6236
22 Ata & Fl. Milling	1.1953	20	4.0450	16 Livestock	1.6942	6	2.8666
25 Sugar and Gur	1.2171	17	3.6584	20 Forestry	1.4778	12	2.9753
28 Other Food	1.2674	12	3.2601	33 Yarn	1.5746	9	3.6731
29 Leather Finishing	1.2893	10	3.6765	44 Pulp/Paper Board	1.1200	20	3.9686
30 Leather Products	1.2551	14	3.4403	45 Printing &Publish.	1.1723	18	3.6371
34 Mill Cloth	1.1977	19	3.8871	47 Fertilizer	1.2241	15	3.3402
35 Handloom Cloth	1.2954	8	3.6232	48 Other Chemicals	4.3965	3	1.6616
37 Ready. Garments	1.3759	7	3.5386	49 Petrol Products	1.5804	8	2.9127
38 Knitting/ Hosiery	1.2938	9	3.7826	55 Iron-Steel Industry	5.6784	2	2.0856
43 Wooden/Furniture	1.2221	16	3.7588	56 Fab Metal Product	4.5185	10	2.8290
44 Pulp/Paper Board	1.2468	15	3.7389	57 Machinery	3.2098	4	1.8521
47 Fertilizer	1.4294	6	3.3350	59 Misc. Industries	1.4895	11	2.8188
48 Other Chemicals	1.4433	5	4.7449	60 Urban Building	1.1446	19	3.4503
51 China & Ceramic	1.1795	21	3.6237	66 Electricity	1.2068	16	3.2434
56 Fab Metal Prod.	1.2557	13	4.7046	67 Gas	1.0724	21	3.6862
57 Machinery	1.5097	3	4.1821	68 Mining/Quarrying	1.4009	14	3.1367
62 Const. Electricity	1.4870	4	3.6372	69 Trade Service	6.6870	1	0.6947
64 Const. Transport	1.1739	22	3.8124	70 Transport Service	2.8994	5	1.4170
65 Other Const.	1.5140	2	3.6310	75 Banking/Insurance	1.6354	7	2.4386

U_j = Backward linkage index, U_i = Forward linkage index, R = Rank, V_j and V_i indicate co-efficient of variation

Based on the method of top ten key sectors, other chemicals, iron/steel industry and machinery were the key sectors both for backward and forward linkage indices in the case of Rasmussen linkage indices. Whereas handloom cloth, readymade garments, fertilizer, construction of electricity, and other construction were the key sectors for backward linkage indices, and livestock, yarn, petroleum products, fabricated metal products, trade service, and transport services were the key sectors for forward linkage indices (Table 4). The ranking of ten sectors was closely related for the Cella, Harrigan-McGilvray, Pure linkage, and Dietzenbacher-Van der Linden methods. The backward linkages of second-generation methods (above four linkage methods) had consisted of seven consistently high-ranking sectors. They were forestry, rice milling, rural buildings, transport service, handloom cloth, professional service, and housing service. The forward linkage using all the methods of second-generation included six sectors like forestry, trade service, transport service, iron/ steel industry, petroleum products, and other chemicals of which iron/ steel industry, and other chemicals were the common sectors for all the six methods.

Table 3. Categorization of sectors for the six methods of linkage estimation

Sector	W	R	C	H	P	D	Sector	W	R	C	H	P	D
1 Paddy	L	F	K	K	K	B	41 Bidi	L	L	L	L	L	L
2 Wheat	K	B	L	L	L	L	42 Saw/Planning Mills	K	L	L	L	L	L
3 Other Grains	L	L	L	L	L	L	43 Wooden /Furniture	F	B	B	B	L	F
4 Jute	L	L	L	L	L	L	44 Pulp, Paper & Board	K	K	L	L	L	L
5 Sugarcane	L	L	L	L	L	L	45 Printing/ Publishing	K	K	L	L	F	L
6 Potato	L	L	L	L	L	L	46 Drugs/ Pharmaceutical	F	B	L	L	L	L
7 Vegetables	L	L	L	L	L	L	47 Fertilizer	K	K	F	F	F	L
8 Pulses	L	L	F	F	F	L	48 Other Chemicals	K	K	F	F	F	F
9 Oilseeds	B	L	L	L	L	L	49 Petroleum Products	K	K	K	F	K	K
10 Fruits	L	L	L	L	L	L	50 Pottery & Earthen	F	L	L	L	L	L
11 Cotton	B	F	F	F	F	L	51 China & Ceramic	F	B	L	L	L	L
12 Tobacco	B	L	L	L	L	L	52 Glass/ Gl. Products	K	B	L	L	L	F
13 Tea	L	L	L	L	L	L	53 Bricks, Tiles & Clay	B	L	F	L	L	L
14 Major Spices	L	L	L	L	L	L	54 Cement	K	B	L	L	L	L
15 Other Crops	L	L	L	L	L	L	55 Iron/ Steel Industry	K	K	F	F	F	K
16 Livestock	L	F	K	K	K	K	56 Fab Metal Products	K	K	F	F	K	K
17 Poultry	L	L	L	L	L	L	57 Machinery	K	K	F	F	K	K
18 Shrimp	L	L	L	L	L	L	58 Trans. Equipment	B	B	F	F	F	L
19 Other Fish	L	L	B	B	B	B	59 Miscellaneous indus.	B	F	F	F	F	L
20 Forestry	F	F	K	K	K	K	60 Urban Building	F	K	K	K	K	B
21 Rice Milling	F	B	B	L	L	K	61 Rural Building	L	L	K	K	K	B
22 Ata & Fl. Milling	F	B	L	B	B	F	62 Const.: Electricity	F	B	L	L	L	L
23 Fish Processing	F	B	L	L	L	L	63 Const.: Rural Road	F	L	L	L	L	L
24 Edible Oil	F	B	B	B	B	B	64 Const.: Transport	F	B	L	L	L	L
25 Sugar and Gur	F	B	B	B	B	L	65 Other Construction	F	B	L	L	L	L
26 Tea Processing	F	B	L	L	L	F	66 Electricity	L	F	B	F	F	F
27 Salt	B	L	L	L	L	F	67 Gas	L	F	L	L	F	F
28 Other Food	F	B	L	L	L	F	68 Mining & Quarrying	B	F	F	F	F	K
29 Leather Finishing	F	B	L	L	L	L	69 Trade Service	L	F	K	K	K	K
30 Leather Products	F	B	L	L	L	L	70 Transport Service	L	F	K	K	K	K
31 Jute Baling	F	B	L	L	L	L	71 Housing Service	L	L	K	K	K	K
32 Jute Textile	F	B	L	L	L	L	72 Health Service	L	L	L	L	L	L
33 Yarn	K	K	F	L	K	K	73 Education Service	L	L	B	B	L	L
34 Mill Cloth	K	B	L	L	L	F	74 Public Ad/ Defense	L	L	B	K	K	L
35 Handloom Cloth	F	B	B	B	B	B	75 Banking/ Insurance	L	F	F	F	F	F
36 Dyeing/Bleaching	L	B	L	L	L	L	76 Professional Service	L	F	B	B	B	K
37 Ready. Garments	F	B	L	L	L	L	77 Hotels/ Restaurants	F	B	B	B	B	K
38 Knitting/ Hosiery	F	B	L	L	L	F	78 Communications	L	L	L	L	L	F
39 Other Textiles	K	B	L	L	L	L	79 Other Services	L	L	L	L	L	L
40 Cigarettes	L	L	L	L	L	L							

***** W = Chenery and Watanable method, R = Rasmussen method, C = Cella method, H = Harrigan and McGilvray method, P = Pure linkage method, D = Dietzenbacher and Van der Linden method, K = Key sector, B = Strong backward linkage, F = Strong forward linkage and L = Weak linkage

Table 4. Top ten highest ranking sectors for the six methods (ranked from highest to lowest)

P	Chenery-Watanabe	Rasmussen	Cella	Harrigan-McGilvray	Pure	Dietzenbacher-Van der Linden
	Backward Linkage					
1	11 Cotton	55 Iron/Steel Industry	21 Rice Milling	21 Rice Milling	21 Rice Milling	21 Rice Milling
2	58 Transport Equipment	65 Other Construction	61 Rural Building	61 Rural Building	70 Transport Service	70 Transport Service
3	48 Other Chemicals	57 Machinery	70 Transport Service	70 Transport Service	61 Rural Building	1 Paddy
4	57 Machinery	62 Const. Electricity	35 Handloom Cloth	35 Handloom Cloth	1 Paddy	61 Rural Building
5	53 Bricks/Tiles	48 Other Chemicals	76 Professional Service	76 Professional Service	69 Trade Service	68 Mining/Quarrying
6	54 Cement	47 Fertilizer	19 Other Fish	19 Other Fish	35 Handloom Cloth	69 Trade Service
7	34 Mill Cloth	37 Ready Garments	71 Housing Service	71 Housing Service	76 Professional Service	35 Handloom Cloth
8	52 Glass/G. Products	35 Handloom Cloth	20 Forestry	20 Forestry	20 Forestry	76 Profess. Service
9	42 Saw & Planning Mill	38 Knitting/Hosiery	77 Hotels/Restaurants	77 Hotels/Restaurants	16 Livestock	20 Forestry
10	33 Yarn	29 Leather Finishing	60 Urban Building	60 Urban Building	71 Housing Service	16 Livestock
	Forward Linkage					
1	29 Leather Finishing	69 Trade Service	69 Trade Service	69 Trade Service	69 Trade Service	66 Electricity
2	47 Fertilizer	55 Iron/Steel Industry	1 Paddy	1 Paddy	1 Paddy	21 Rice Milling
3	31 Jute Bailing	48 Other Chemicals	70 Transport Service	70 Transport Service	70 Transport Service	56 Fab. Met. Products
4	21 Rice Milling	57 Machinery	33 Yarn	20 Forestry	75 Banking/ Insurance	48 Other Chemicals
5	57 Machinery	70 Transport Service	20 Forestry	49 Petroleum Products	20 Forestry	33 Yarn
6	37 Ready Garments	16 Livestock	55 Iron/Steel Industry	55 Iron/Steel Industry	16 Livestock	70 Transport Service
7	55 Iron/Steel Industry	75 Banking/Insurance	49 Petroleum Products	16 Livestock	48 Other Chemicals	55 Iron/Steel Industry
8	48 Other Chemicals	49 Petroleum Prod.	48 Other Chemicals	75 Banking/Insurance	55 Iron/Steel Industry	69 Trade Service
9	25 Sugar & Gur	33 Yarn	16 Livestock	66 Electricity	49 Petroleum Products	49 Petroleum Prod.
10	38 Knitting & Hosiery	56 F. Metal Products	75 Banking/Insurance	48 Other Chemicals	66 Electricity	20 Forestry

* P = position

IV. CONCLUSION AND POLICY RECOMMENDATIONS

The Rasmussen linkage indices recognize potential impacts from changes in any sector, while the other indices inspect effects through their consideration of the volume of activity. The difference between the Cella and Harrigan-McGilvray index is slight and is equal to the internal linkage. Harrigan-McGilvray method simply examines the effect on total economy whereas Dietzenbacher and Van der Linden method is the combination of direct attributes of all other techniques. Pure linkage method shows the status of agriculture and services sectors for the economy. Sectors with very high total output tend to dominate the Chenery-Watanabe and Rasmussen linkage indices. Strong linkages were absent in most of the primary sectors, which related a weak technological position of agriculture. Two important social sectors (health and education) and service sectors emerge as the key sectors. There is no strong structural interdependence between agriculture and the rest of the economy. Agricultural production sectors like paddy, livestock and forestry are the key sectors by the Cella, Harrigan-McGilvray and Pure linkage methods. Among agro-industries rice milling as being key sector by Dietzenbacher and Van der Linden method and strong backward linkage in most of the cases. Agricultural sectors possessed, relatively, weak backward and medium-strong forward linkages, whereas agro-processing sectors induce strong backward and medium-weak forward linkages due to lack of public investment and modern farm technology.

There are a number of technical and conceptual limitations to the use of empirically derived linkages as a planning tool. One should be very careful in interpreting linkage indices and using them as a guide for sectoral planning as the input-output tables are based on highly aggregated data. Results should be generalized carefully because they may be less relevant or even misleading owing to basic differences in production patterns, trade pattern, demand composition and resource endowments. The whole host of supportive government policies should be designed to facilitate the growth of industries induced by high linkages. Linkage analysis has been done using various methods, which gave different results due to the intrinsic nature of each method. In some instances, they might have different policy options including various government policy instruments like taxes, tariffs and foreign trade controls.

Following policies can be made on the basis of major findings of the research. (1) Key sectors should be identified on the basis of the trade linkage where the sectors are based on imported inputs with high export potential. (2) There is a need to increase modern technology, research on agricultural modernization and import-substitution and export-promotion policies dealing with modern farm inputs and processed agriculture. (3) The readymade garments sector is uniquely identified as the most booming sector in the economy and hence government must evaluate the economy-wide adverse impact of imported inputs embodied in garment exports on

the linked sectors. (4) Investment policy is to be made on the basis of technological linkages for adequate employment and income generated sectors like livestock, poultry, wheat, oilseeds, paddy and processing sectors. (5) Study on inter-industry linkage should be considered with subtracting the amount of output that has been lost due to the circumstances like labor strike, political strike or unavoidable situations for some times. (6) More studies on interrelations and relative linkages between sub-sectors of agriculture should be taken up with a view to developing appropriate model for agricultural sector of the economy of Bangladesh.

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APPENDIX

Appendix I: Backward linkage indices and rank order using different approaches

Sectors	CWM		RM		CM		HM		PL		DM	
	Index	R	Index	R	Index	R	Index	R	Index	R	Index	R
1 Paddy	0.814	32	0.869	51	0.0070	14	.0062	13	.0316	4	.1483	3
2 Wheat	1.470	20	1.014	38	0.0003	57	.0003	56	.0022	54	.0102	53
3 Other Grains	1.044	24	0.878	49	0.0001	75	.0000	75	.0002	76	.0009	75
4 Jute	0.862	30	0.813	61	0.0003	56	.0003	55	.0012	61	.0051	60
5 Sugarcane	0.911	28	0.849	56	0.0003	58	.0020	57	.0018	57	.0093	56
6 Potato	0.283	46	0.861	53	0.0016	42	.0012	44	.0016	58	.0126	47
7 Vegetables	0.068	58	0.853	54	0.0027	33	.0026	31	.0028	49	.0117	51
8 Pulses	0.132	55	0.725	69	0.0025	34	.0023	37	.0026	50	.0134	43
9 Oilseeds	1.826	17	0.927	45	0.0006	77	.0005	77	.0029	46	.0128	46
10 Fruits	0.036	65	0.719	70	0.0018	40	.0018	40	.0019	56	.0082	57
11 Cotton	6.240	1	0.809	62	0.0006	78	.0006	78	.0029	47	.0120	49
12 Tobacco	1.634	19	0.875	50	0.0001	76	.0001	76	.0005	71	.0021	72
13 Tea	1.000	26	0.866	52	0.0000	73	0000	73	.0002	75	.0003	77
14 Major Spices	0.593	37	0.787	66	0.0002	59	.0002	59	.0003	73	.0026	69
15 Other Crops	0.257	49	0.841	57	0.0029	29	.0024	33	.0031	42	.0180	38
16 Livestock	0.564	39	0.889	47	0.0090	12	.0085	11	.0158	9	.0670	10
17 Poultry	0.193	51	0.965	39	0.0043	22	.0040	23	.0049	31	.0227	28
18 Shrimp	0.718	34	0.952	41	0.0028	79	.0024	79	.0023	79	.0117	50
19 Other Fish	0.061	60	0.806	63	0.0138	6	.0136	6	.0143	12	.0600	13
20 Forestry	0.444	40	0.822	59	0.0101	8	.0100	8	.0188	8	.0774	9
21 Rice Milling	0.024	66	1.163	23	0.0931	1	.0928	1	.0946	1	.3879	1
22 Ata & Flour Milling	0.428	42	1.195	20	0.0034	27	.0034	27	.0057	24	.0235	26
23 Fish Processing	0.003	73	1.103	28	0.0019	39	.0019	39	.0019	55	.0078	58
24 Edible Oil	0.569	38	1.270	11	0.0068	15	.0054	16	.0087	17	.0436	18
25 Sugar and Molasses	0.114	57	1.217	17	0.0071	13	.0071	12	.0080	20	.0327	23
26 Tea Processing	0.051	61	1.015	37	0.0009	46	.0009	47	.0010	62	.0042	62
27 Salt	1.322	22	0.545	78	0.0002	60	.0002	58	.0003	72	.0014	73
28 Other Food	0.661	36	1.267	12	0.0027	31	.0027	29	.0053	27	.0218	30
29 Leather Finishing	0.061	59	1.289	10	0.0024	35	.0024	34	.0025	51	.0103	52
30 Leather Products	0.014	69	1.255	14	0.0007	50	.0007	50	.0007	65	.0031	66
31 Jute Baling	0.001	78	1.159	24	0.0000	73	.0000	73	.0000	78	.000	79
32 Jute Textile	0.162	54	1.137	25	0.0036	26	.0036	24	.0045	34	.0185	36
33 Yarn	2.714	10	1.086	29	0.0001	62	.0001	61	.0129	13	.0528	15
34 Mill Cloth	3.827	7	1.197	19	0.0015	44	.0014	43	.0033	39	.0138	41
35 Handloom Cloth	0.001	76	1.295	8	0.0233	4	.0233	4	.0233	6	.0955	7
36 Dyeing & Bleaching	1.000	25	1.036	34	0.0000	68	.0000	67	.0007	67	.0027	67
37 Readymade Garments	0.009	70	1.376	7	0.0023	36	.0023	35	.0023	53	.0097	54
38 Knitting & Hosiery	0.001	77	1.294	9	0.0039	24	.0040	23	.0039	37	.0163	40
39 Other Textiles	2.351	12	1.073	32	0.0000	69	.0000	68	.0002	77	.0008	76
40 Cigarettes	0.022	67	0.892	46	0.0023	37	.0023	36	.0023	52	.0096	55
41 Bidi	0.009	71	0.832	58	0.0009	48	.0009	48	.0009	64	.0038	64
42 Saw & Planning Mills	2.869	9	0.930	44	0.0001	67	.0000	65	.0029	45	.0120	48
43 Wooden /Furniture	0.260	48	1.222	16	0.0055	17	.0055	15	.0069	22	.0234	27
44 Pulp, Paper & Board	1.163	23	1.247	15	0.0011	45	.0009	45	.0042	36	.0182	37
45 Printing &Publishing	2.113	15	1.103	27	0.0001	65	.0000	65	.0030	43	.0133	44

Sectors	CWM		RM		CM		HM		PL		DM	
	Index	R	Index	R	Index	R	Index	R	Index	R	Index	R
46 Drugs & Pharmaceuticals	0.417	43	1.209	18	0.0030	28	.0025	32	.0037	38	.0195	34
47 Fertilizer	1.765	18	1.429	6	0.0000	73	.0000	73	.0066	23	.0272	24
48 Other Chemicals	5.280	3	1.443	5	0.0001	63	.0001	63	.0071	21	.0414	20
49 Petroleum Products	2.504	11	1.019	36	0.0094	11	.0043	21	.0119	14	.0588	14
50 Pottery & Earthen work	0.040	63	0.945	43	0.0009	47	.0009	47	.0009	63	.0039	63
51 China & Ceramic	0.207	50	1.179	21	0.0006	51	.0006	51	.0006	67	.0027	68
52 Glass & Gl. Products	2.950	8	1.081	31	0.0001	64	.0001	63	.0003	74	.0012	74
53 Bricks, Tiles & Clay	4.679	5	0.852	55	0.0000	73	.0000	73	.0033	40	.0134	42
54 Cement	4.365	6	1.118	26	0.0005	54	.0005	70	.0012	60	.0051	61
55 Iron & Steel Industry	1.893	16	1.951	1	0.0006	52	.0003	54	.0054	26	.0508	16
56 Fabricated Metal Products	2.182	13	1.256	13	0.0038	25	.0035	25	.0081	18	.0367	21
57 Machinery	4.802	4	1.509	3	0.0039	23	.0034	26	.0098	16	.0459	17
58 Transport Equipment	5.347	2	1.034	35	0.0019	38	.0019	38	.0053	28	.0222	29
59 Miscellaneous Industries	1.417	21	0.945	42	0.0017	41	.0016	41	.0054	25	.0236	25
60 Urban Building	0.326	44	1.071	33	0.0096	10	.0095	10	.0146	11	.0601	12
61 Rural Building	0.118	56	0.882	48	0.0314	2	.0314	2	.0354	3	.1482	4
62 Construction: Electricity	0.000	79	1.487	4	0.0028	30	.0028	28	.0028	49	.0000	79
63 Construction: Rural Road	0.002	74	0.962	40	0.0016	43	.0016	42	.0016	59	.0065	59
64 Construction: Transports	0.005	72	1.174	22	0.0049	20	.0049	19	.0049	32	.0201	33
65 Other Construction	0.431	41	1.514	2	0.0004	55	.0004	54	.0006	68	.0024	70
66 Electricity	0.884	29	0.705	71	0.0005	54	.0005	52	.0042	35	.0174	39
67 Gas	0.704	35	0.529	79	0.0002	61	.0001	60	.0006	70	.0023	71
68 Mining & Quarrying	2.118	14	0.785	65	0.0000	70	.0000	69	.0030	44	.1230	5
69 Trade Service	0.826	31	0.649	74	0.0054	18	.0049	18	.0281	5	.1227	6
70 Transport Service	0.294	45	0.730	68	0.0273	3	.0256	3	.0361	2	.1660	2
71 Housing Service	0.179	52	0.632	75	0.0129	7	.0126	7	.0149	10	.0624	11
72 Health Service	0.022	68	0.815	60	0.0049	21	.0046	20	.0047	33	.0192	35
73 Education Service	0.001	75	0.691	73	0.0050	19	.0050	17	.0050	30	.0205	32
74 Public Ad & Defense	0.280	47	0.746	67	0.0061	16	.0059	14	.0081	19	.0352	22
75 Banking & Insurance	0.795	33	0.693	72	0.0008	49	.0008	49	.0051	29	.0212	31
76 Professional Service	0.039	64	0.793	64	0.0212	5	.0212	5	.0220	7	.0904	8
77 Hotels & Restaurants	0.046	62	1.084	30	0.0097	9	.0097	9	.0102	15	.0418	19
78 Communications	0.959	27	0.570	76	0.0000	66	.0000	66	.0006	70	.0037	65
79 Other Services	0.167	53	0.555	77	0.0027	32	.0027	30	.0032	41	.0131	45

Note: CWM = Chenery-Watanabe Method, RM = Rasmussen Method, CM = Cella Method, H = Harrigan-McGilvray Method, PL = Pure Linkage, DM = Dietzenbacher and van der Linden Method, R = Rank

Appendix II: Forward linkage indices and rank order using different approaches

Sector	CWM		RM		CM		HM		PL		DM	
	Index	R	Index	R	Index	R	Index	R	Index	R	Index	R
1 Paddy	.4526	60	1.1824	17	.07256	2	.04405	2	.04729	2	.09126	61
2 Wheat	0.5758	36	0.9954	23	.00476	31	.00260	32	.00426	33	.00013	79
3 Other Grains	0.3737	66	0.4734	59	.00055	54	.00033	54	.00040	55	.05065	65
4 Jute	0.4600	58	1.0099	22	.00247	38	.00153	37	.00198	39	.04958	66
5 Sugarcane	0.4958	50	0.7689	33	.00476	30	.00282	30	.00333	34	.01856	72
6 Potato	0.4670	56	0.6098	40	.00014	64	.00008	64	.00009	65	.01491	73
7 Vegetables	0.4975	49	0.4607	63	.00034	60	.00020	60	.00022	60	.18279	55
8 Pulses	0.3842	65	0.5048	54	.00043	58	.00028	57	00033	59	.03265	69
9 Oilseeds	0.5327	44	0.9046	24	.00851	21	.00474	21	.00757	25	.03624	67
10 Fruits	0.3329	70	0.4584	64	.00010	67	.00007	66	.00008	67	.10250	60
11 Cotton	0.4588	59	0.4121	13	.00994	17	.00637	16	.01321	13	.29152	44
12 Tobacco	0.5424	42	0.6403	36	.00153	44	.00090	44	.00092	48	.32352	42
13 Tea	0.3558	67	0.5836	45	.00055	54	.00034	53	.00037	56	.20151	53
14 Major Spices	0.4055	64	0.6164	37	.00044	57	.00028	57	.00033	59	.01325	74
15 Other Crops	0.4923	52	0.5743	48	.00098	51	.00058	51	.00097	46	.01055	78
16 Livestock	0.4755	55	1.6942	6	.01800	9	.01060	7	.01903	6	1.2424	17
17 Poultry	0.5572	41	0.5282	51	.00141	47	.00077	47	.00086	50	.03025	71
18 Shrimp	0.5371	43	0.7739	32	.00141	48	.00082	46	.00082	51	.01256	76
19 Other Fish	0.5172	47	0.5220	52	.00111	49	.00069	49	.00077	52	.36124	41
20 Forestry	0.5624	40	1.4778	12	.02269	5	.01382	4	.02028	5	2.2942	10
21 Rice Milling	0.8474	4	0.5845	44	.00319	37	.00149	39	.00240	37	3.6914	2
22 Ata & Flour Milling	0.7819	17	0.6700	35	.00507	28	.00273	31	.00444	32	.92015	27
23 Fish Processing	0.7283	22	0.4424	75	.00001	73	.00000	78	.00000	77	.21014	52
24 Edible Oil	0.7961	13	0.7805	27	.00422	33	.00177	34	.00285	35	.01115	77
25 Sugar and Gur	0.8012	9	0.5712	49	.00152	45	.00069	49	.00120	44	.56005	36
26 Tea Processing	0.6209	30	0.4472	68	.00016	63	.00009	63	.00009	65	1.2018	20
27 Salt	0.1110	77	0.5106	53	.00107	55	.00093	43	.00201	38	.97445	25
28 Other Food	0.7350	20	0.6153	38	.00500	29	.00240	33	.00454	31	1.1616	22
29 Leather Finishing	0.8842	1	0.5586	50	.00024	62	.00010	62	.00011	63	.76256	32
30 Leather Products	0.6943	25	0.4433	73	.00003	71	.00001	71	.00003	71	.23253	48
31 Jute Baling	0.8737	3	0.4420	78	.00000	77	.00000	75	.00000	77	.60895	35
32 Jute Textile	0.7980	12	0.5031	56	.00175	42	.00084	45	.00123	43	.54145	37
33 Yarn	0.7464	19	1.5746	9	.02451	4	.00171	35	.01271	14	3.2011	5
34 Mill Cloth	0.7186	23	0.8975	25	.00346	36	.00155	36	.00186	40	.92041	26
35 Handloom Cloth	0.7998	11	0.4427	74	.00001	72	.00000	75	.00001	73	.81117	29
36 Dyeing & Bleaching	0.4918	53	0.4693	60	.00174	43	.00107	41	.00107	45	.27258	46
37 Readymade Garments	0.8128	6	0.4462	69	.00000	77	.00000	76	.00000	77	.29194	43
38 Knitting & Hosiery	0.7999	10	0.4423	76	.00000	77	.00000	76	.00000	77	1.8818	12
39 Other Textiles	0.6477	29	0.5002	57	.00040	59	.00021	59	.00021	61	.18285	54
40 Cigarettes	0.5227	46	0.4443	71	.00012	65	.00007	65	.00009	65	.2222	51
41 Bidi	0.4314	61	0.4462	70	.00000	77	.00000	76	.00000	77	.23132	49
42 Saw & Planning Mills	0.5779	35	0.7863	31	.00616	27	.00324	29	.00465	30	.79052	30
43 Wooden /Furniture	0.7787	18	0.5046	55	.00243	39	.00103	42	.00166	41	.99256	24
44 Pulp, Paper & Board	0.7326	21	1.1200	20	.00661	26	.00325	28	.00609	27	.03332	68
45 Printing &Publishing	0.5704	39	1.1723	18	.00735	24	.00411	24	.00820	22	.03232	70
46 Drugs/Pharmaceuticals	0.6779	27	0.7219	34	00203	41	.00108	40	.00146	42	.01256	76
47 Fertilizer	0.8778	2	1.2241	15	00127	13	.00608	17	.01204	17	.64295	33

Sector	CWM		RM		CM		HM		PL		DM	
	Index	R	Index	R	Index	R	Index	R	Index	R	Index	R
48 Other Chemicals	0.8073	8	4.3965	3	.01933	8	.00935	10	.01889	7	3.2212	4
49 Petroleum Products	0.5723	38	1.5804	8	.0199	7	.01135	5	.01822	9	2.4621	9
50 Pottery & Earthen	0.6124	31	0.4474	67	.00007	68	.00004	69	.00007	69	.12141	59
51 China & Ceramic	0.6948	24	0.4480	66	.00011	66	.00006	67	.00007	69	.40025	39
52 Glass & Gl. Products	0.5726	37	0.5828	46	.00054	55	.00032	55	.00067	53	1.2002	21
53 Bricks, Tiles & Clay	0.5163	48	0.6074	41	.00753	23	.00424	23	.00521	29	.47413	38
54 Cement	0.7831	15	0.5896	42	.00143	46	.00067	50	.00089	49	.38164	40
55 Iron & Steel Industry	0.8077	7	5.6784	2	.02242	6	.01129	6	.01861	8	2.8226	7
56 Fabricated M Products	0.5862	33	4.5185	10	.01144	15	.00662	15	.01238	16	3.6717	3
57 Machinery	0.8146	5	3.2098	4	.01385	11	.00703	13	.01381	11	1.6815	14
58 Transport Equipment	0.4603	57	0.8347	30	.00938	20	.00592	18	.00909	20	.23123	50
59 Miscellaneous Industries	0.5289	45	1.4895	11	.00944	19	.00551	19	.01041	18	.05105	64
60 Urban Building	0.5938	32	1.1446	19	.01223	14	.00713	12	.01239	15	.78178	31
61 Rural Building	0.4286	62	0.5796	47	.01094	16	.00690	14	.00795	24	.28181	45
62 Construction: Electricity	0.7830	16	0.4420	79	.00000	77	.00000	76	.00000	77	.06612	63
63 Construction: R Road	0.5788	34	0.4422	77	.00001	74	.00000	76	.00001	73	.17175	56
64 Construction: Transports	0.6719	28	0.4434	72	.00005	70	.00003	70	.00004	70	.08182	62
65 Other Construction	0.7912	14	0.4670	61	.00051	56	.00027	58	.00054	54	.24158	47
66 Electricity	0.3288	71	1.2068	16	.01331	12	.00955	9	.01510	10	4.9519	1
67 Gas	0.1002	79	1.0724	21	.00414	34	.00371	26	.00875	21	1.7114	13
68 Mining & Quarrying	0.4943	51	1.4009	14	.00810	22	.00507	20	.00952	19	1.0112	23
69 Trade Service	0.2415	75	6.6870	1	.09882	1	.07422	1	.11440	1	2.4725	8
70 Transport Service	0.3375	69	2.8994	5	.03548	3	.02494	3	.04091	3	2.8748	6
71 Housing Service	0.2464	74	0.8714	26	.00959	18	.00722	11	.01338	12	1.3816	15
72 Health Service	0.4805	54	0.4642	62	.00028	61	.00018	61	.00036	57	.62261	34
73 Education Service	0.2974	73	0.4548	65	.00006	69	.00005	68	.00013	62	.13145	58
74 Public Ad & Defense	0.3254	72	0.8482	28	.00670	25	.00454	22	.00818	23	.14424	57
75 Banking & Insurance	0.3444	68	1.6354	7	.01462	10	.01024	8	.02178	4	2.2323	11
76 Professional Service	0.4271	63	0.6148	39	.00237	40	.00152	38	.00263	36	1.2623	16
77 Hotels & Restaurants	0.6901	26	0.4777	58	.00097	52	.00046	52	.00092	48	1.2112	19
78 Communications	0.1778	76	0.8348	29	.00461	32	.00375	25	.00720	26	1.2125	18
79 Other Services	0.1098	78	0.5882	43	.00387	35	.00338	27	.00560	28	.82671	28

Note: CWM = Chenery-Watanabe Method, RM = Rasmussen Method, CM = Cella Method, H = Harrigan-McGilvray Method, PL = Pure Linkage, DM = Dietzenbacher and van der Linden Method, R = Rank