Working Paper 329

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ISBN 978-81-7791-185-5

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IDENTIFYING THE HIGH LINKED SECTORS FOR INDIA: AN APPLICATION OF IMPORT-ADJUSTED DOMESTIC INPUT-OUTPUT MATRIX

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Abstract

One of the most important ways to sustain high growth path in any economy is by promoting the high linkage sectors of the economy. However, a high linked sector may also be import intensive. Development of such a sector may create strain on limited foreign exchange resources of a country especially so in case of a developing country. This paper considers an emerging nation like India to identify the key high linkage sectors through measuring the linkage effect (both backward and forward linkages) of each sector separately for the entire economy in a comprehensive manner. Subsequently it constructs an input-output matrix that takes into account import of inputs for each sector. By using this (import-adjusted) domestically produced input based matrix (to be called domestic flow matrix henceforth) for the latest year 2007-08, the exercise next identifies the high linked sectors --development of which can generate substantial impact within the domestic economy though their forward and backward linkage effects without creating strain on foreign exchange reserves. Policy emphasis should, therefore be more on the development of such sectors so as to ensure rapid growth of the overall economy.

Key Words: Key Sectors, Forward and Backward Linkages, Input-Output Analysis, Sustainable Growth.

1. Introduction

Achieving sustainable growth has been one of the major targets of India's 12th five year plan.. After attaining high growth for a few years in the last decade, the economy today is faced with a downturn in growth. Along with the external factors, a number of domestic factors including relatively low productivity growth, infrastructure bottlenecks, limitations of energy (especially crude oil and electricity) and food supply, poor governance are responsible for the slide- down in growth. Even more, the structure of India's growth also is lop-sided since only selected service sectors are playing a major role in generating income in the economy, and more importantly the manufacturing sector which has high inter-linkages with other sectors and has the ability to generate employment for the lower category of populace has suffered considerably during the recent down-turn. In this backdrop, what is needed is a policy thrust to give renewed impetus to the high-linked sectors, as such a policy shift in favour of high linked sectors can automatically impact the interlinked sectors through both forward and backward linkages, and enhance the growth prospectus manifolds, in turn reducing the problem of unemployment, poverty, etc. Thus, an appropriate development strategy should be to use these linkage effects in order to assign priorities to different sectors such that the best prioritized sector would be boosted up through the policy thrust. However, in this context it is also to be kept in mind that a high-linked sector can be heavily dependent on imported inputs. Thus, an analysis which distinguishes the linkage measures based on domestically produced inputs and imported inputs separately is important

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for policy decision. A number of scholars since 18^{th} century have highlighted the beneficial impacts of international trade on economic growth. In practice, however, it is difficult to segregate the trade effects on the inter-sectoral linkages, mainly due to the unavailability of import matrices for many developing countries including India. In this backdrop, this paper attempts to measure the sectoral linkages for Indian economy by constructing an import matrix, and using it to identify the key high linked sectors.

Coming first to the definition of terms, sectoral linkages basically refer to the association among different sectors of an economy. In an interdependent economy, different sectors are linked with each other through several direct (sharing of input, output, etc) and indirect ways. In fact, 'sectoral linkage' describes a sector's association through its direct and indirect intermediate purchases and sales with the rest of the sectors of economy (Saikia, 2011). Thus, the significance of a sector can be explained through measuring the sectoral linkage effects (Aydin, 2007). The two seminal concepts in the sectoral linkage theory, i.e., forward linkage effect and backward linkage effect advocated by Hirschman (1958) as *a "non-primary" activity, i.e., an activity that employs significant amounts of intermediate inputs from other activities, should be expected to induce attempts to supply these inputs through expanding domestic production. This is the backward linkage effect. Again, an activity that is "non-final," i.e., an activity that does not cater exclusively to final demand, should be expected to induce attempts to utilize its outputs as inputs in some new activities. This is the forward linkage effect.* In simpler terms, backward linkage of an industry helps to grow other industries that supply inputs to this first industry, e.g., textile industry enhances the growth of cotton industry through its backward linkage.. On the other hand forward linkage of an industry helps to grow other industries that use its output as input, e.g., machinery industry propels the growth of other industries that use that particular machine as their input.

Based on these concepts of linkage effects one can identify what may be termed as the 'key sectors' of an economy. In other words the key sectors are those which have proven capacity to stimulate the growth of other sectors either through providing their own output to other sectors (*Forward linkage*), or through taking inputs from other sectors (*Backward linkage*). However , some of these high linked sectors may be highly import intensive. If so, development of such sectors may put strain on limited foreign exchange resources of a country. Therefore while computing linkage effects, this aspect needs to be kept in mind. Thus based on the original input output (I-O) matrix we have arrived at the linkage coefficients to identify the key high linked sectors. These coefficients are compared with the linkage coefficients computed based on the import-adjusted domestic input-based matrix (to be called henceforth domestic flow matrix) . Thus the paper identifies two sets of key sectors based on the original input-output matrix and domestic flow matrix. Most papers that deal with linkage effects pertaining to India are based on the original I-O matrix without any reference to the import component of the high linked sector so determined. This paper therefore presents a more comprehensive picture relevant for the policy makers.

In this backdrop, the paper is organized as follows. Section-2 presents a review of literature pertaining to linkage analysis and significance of international trade in the linkage identification. Details of methodology used for identification of key sectors based on a domestic flow matrix are discussed in section-3. In section-4, the linkage measure of each sector is presented using the Import-adjusted domestic Input-Output matrix for the recent year 2007-08. Interpretation of these results as well as their relevance to the existing theory is also discussed in this section. A comparative analysis has been carried out to see whether there is any difference between domestic and total linkage measures. A concluding section follows at the end

2. Literature Review

Given the importance of linkage effects for an economy, there is no dearth of papers that have estimated the linkage coefficients of the sectors for India as well as other countries across the globe. Two strands of literatures are observed: one that deals with the broad sectors of the economy viz., primary, secondary and tertiary, and another that concentrates on the subsectors.

For example, using Input-Output (I-O) and simultaneous equation framework, Sastry, Singh, Bhattacharya & Unnikrishnan (2003) have examined the importance of sectoral linkages among agriculture, industry and services sector for Indian economy for the years 1968-69 to 1993-94. The analysis clearly reveals the fact that in spite of substantial increase in the services sector share in GDP, agricultural sector continues to play a very important role in determining the long run growth of the economy through its strong linkage with other sectors. They point out that although agricultural share has declined overtime, it still creates more demand for other sectors, especially the industrial sector. In Nigerian economy, sectors like agriculture, manufacturing and mining & quarrying are of great importance in sustaining long run growth, as identified by Uzoigwe (2007). Using econometric modeling, the paper has concluded that the sectors such as agriculture, manufacturing and mining & quarrying help to propel other sectors through linkage effects, i.e the proven positive relationship between the above sector's output and over all employment level. Importance of mining & quarrying sector is also established for the Chinese economy in Pan (1997). Using Leontief's I-O framework, this paper argues that mining & quarrying as well as finance & insurance sector have high potential to improve labor productivity growth of other sectors compared manufacturing industry through creating more employment opportunities.

Apart from the primary sector, linkage relation exists between manufacturing and service sectors, which fact has been well established by Kaur, Bordoloi and Rajesh (2009). Saikia (2011) concentrated on interdependence relation between industry and services sector in India, along with specifying the direction of change in agriculture-industry linkages over time**.**

Describing the services sector as a driver of growth, Joshi (2004) has concluded that within the services sector, information technology (IT) and telecom are some of the key sub-sectors to have high linkage with others, which in turn are successful in creating employment opportunities as well as reducing poverty. While the above paper establishes the linkage effect of the services sector for Indian economy,, Francois & Reinert (1996) seek to highlight the importance of the services sector using a cross-country analysis. Significance of services sector is evident in case of the OECD countries as well as the middle income countries. However, for a low income country like India, Sodhi (2010) argues that services sector is not particularly important. Using I-O tables (1968-69, 1973-74, 1978-79, etc.), Sodhi has shown that although services sector share to GDP has increased gradually, the sector has only moderate linkage effect with secondary sector and poor linkage effect with primary sector.

Concentrating on the subsectors, several authors have examined the linkage effects of the construction sector. For example, Polenske and Sivitanides (1990) have proved the existence of large backward linkage for the construction sector compared to other sectors for almost all countries, including India, Malaysia, Indonesiaand Philippines. Rameezdeen, Zainudeen and Ramachandra (2008) have also arrived at similar results for the Sri Lankan economy. Apart from the construction sector, another major high linkage sector is the transport sector, which helps to boost growth of other sectors through its linkage effect. Using the data from ESCAP Secretariat and Louis Berger International, Inc. (1979), research has shown that with transport improvement cost of moving agricultural products to markets will decrease, which in turn will increase cultivation along with improving the welfare and efficiency of the economy as well as alleviating poverty. Linkage relation between transport and automobile sectors has been established by Cullinane & Elsevier (2002) for Hong Kong. Automobile sector also plays a major role in determining the development process of most economies through its linkage effects, which has been clearly identified by Litman and Laube (2002).

Concentrating on the subsectors within the services sector, Khan (2010) has argued that different industries like real estate, training, recruitment, transport, tourism are directly influenced by the Information technology (IT) and IT enabled services (ITES) industry, and that they are growing significantly because of the linkage effect of IT and ITES industry. Similarly, linkage effect of tourism sector has been discussed by McDavid (2003).

Significance of international trade has received the attention of several researchers. . Sikdar & Chakraborty (2011) have examined the bilateral trade relations between India and Sri Lanka; using 2003-04 Indian I-O table and Sri Lankan I-O table for the year 2000, they empirically tested the Hecksher-Ohlin theorem and showed the existence of capital intensive exports from India to Sri Lanka, and labor intensive imports from Sri Lanka to India. Besides Goldberg et. al (2008) have also analysed the importance of imported intermediate inputs in the production process along with the gains of trade.

The above review however, clearly reveals that the existing studies have a pre-conceive notion about linkages of certain sectors and thus have examined the linkage effect of those specified sector only, while the current research allows the data to speak by computing the extent of linkages of all possible major sectors. Thus, the current research is broader in scope than what was done earlier. Another major point of departure is that most of the linkage measures have been calculated by the scholars using the total input-output transaction matrix given by CSO, which includes both domestic and imported products used. Thus, the total use table incorporates the imported products along with the domestically produced goods. In this backdrop, it is imperative to measure the linkage effects using the domestic flow matrix since the forward and backward linkages in terms of domestically produced goods are more meaningful than that of imported products, as it is treated as leakages in the economy. In addition, a comparative analysis of domestic and total linkage coefficients helps to identify the sectors in terms of whether they are more *domestically linked, or they have higher total linkage with others. Undoubtedly, the key sector determination and the extent- of- linkage analysis could be made more meaningful by considering this domestic flow matrix. Our paper begins with a highly disaggregated analysis, which is followed with a certain level of consolidation by merging similar sectors. The paper next identifies the key sectors considering the extent of forward and backward linkage, using the import-adjusted domestic I-O table. Accordingly, the current research seeks to fill the gaps in the existing literature by capturing the impact of international trade both through backward and forward sectoral linkages, by first constructing and then comparing the domestic I-O matrix with that of the total I-O matrix for all sectors of the economy.*

3. Methodology for Identifying Key Sectors

Our broad methodology is the traditional Input-Output (I-O) Approach, which is used for identification of the key sectors.

Basic Input-Output Model:

An Input-Output (I-O) Table, which is also called "Transactions Table" or "Inter-Industry Table" or "Flow Matrix" shows the flows of goods and services from each branch (called sector) of the economy to different branches of the economy over a specified period of time, usually a year. For producing the output in any sector of the economy, different types of raw materials, capital equipment along with labor are needed, which come from other sectors, thus creating interdependence among different sectors. Similarly, the produced output may be distributed either for intermediate use (i.e, as input for further production of goods and services by other sectors as well as by the same sector) or for final use (i.e, direct utilization of the output by the final consumers, such as private or government consumption, capital formation, exports, imports, etc), which again create interdependence among the sectors.
The mathematical framework of I-O model is presented in the appendix A.1.

Linkage Effects:

Two important concepts related to linkages, namely, forward and backward linkages will be utilized in the paper. Needless to say, these linkage coefficients are useful for the process of identification of key sectors, since higher value of linkage coefficient for a sector implies the importance of that sector as compared to the others. However, theoretically, we will be using the demand driven standard Leontief model (1936) for measuring the backward linkage co-efficient, while supply driven model of Ghosh (1958) will be used for measuring the forward linkage coefficients. For both these models, we have broadly used Chenery-Watanabe method (1958) and Rasmussen method (1956) in order to find the direct as well as indirect forward and backward linkage coefficients using the technical coefficient matrix (A), allocation co-efficient matrix (B) and Leontief inverse matrix $(I-A)^{-1}$, $(I-B)^{-1}$, which in turn help to identify the high linkage sectors in the Indian economy.

Measurement of Linkages Considering Domestic I-O Table:

For Indian economy, the transaction matrix ((X_{ij})) provided by the Central Statistical Organization (CSO) doesn't give the import flow matrices separately. It gives figures of inter-industry usage of resources as inputs and final consumption of these resources. These inputs in turn may have import components, which are not separately shown, although the aggregate import of the respective sector is provided by CSO as an exogenous entry. In the absence of such disaggregation, one needs to estimate the value of import of each resource going to each sector separately. To do so, we have used the following approximation: In the first step, we need to distribute the total import separately for the inter-industry usage of resources. If for sector 'i', total import is 'M_i' (value of which is provided in the I-O table), the proportions of 'M_i' utilized for different inter-industry use have been first estimated, and subsequently that proportion is allocated across different sectors 'j' in the following ratio:

$(M_i/\sum X_{ij})* X_{ij}$ [where m_i = (Inter-industry use/Gross value of output)* M_i]

More precisely, out of X_{ij} amount of input of 'i' used in the production of sector 'j', $(M_i/\sum X_{ij})* X_{ij}$ is estimated to be the imported component. Subsequently, using this import matrix, we constructed the domestic transaction matrix (subtracting the created import flow matrix from the total transaction matrix given by the CSO) in order to find the linkage co-efficient. Thus the impact of trade can be captured in the I-O framework through comparison of linkage coefficients both domestically as well as by factoring in international trade.

In this backdrop, our objective is to arrive at the direct and indirect linkage coefficients for different sectors of the Indian economy by considering trade aspect as well. Standard algebraic method is used for this purpose, and computation of the import matrix along with the linkage procedures are delineated in the Appendix A.2.

4. Linkage Measures using the I-O Table

Linkage Measures (Domestic vs. Total):

In this section, we present the linkage measures considering the commodity*commodity I-O table given by CSO for the year 2007-08.

Measurement for the year 2007-08 with 21 sectors

Having done the highly disaggregated analysis with 130 sectors for 2007-08, we further consolidated the matrix by merging similar sectors and finally came up with 21 sectors in order to measure the linkages of sectors in a somewhat aggregative manner. It is to be noted here that we had considered the domestic transaction matrix for 21 sectors, and then presented a comparison of the domestic as well as total linkage coefficients using the original unadjusted I- O matrix.

Table A in the appendix shows the sectors that have been merged together for presenting a consolidated picture. Table 1 presents the forward as well as backward linkages for 21 sectors for the year 2007-08.

Table 1: Domestic Forward & Backward Linkage Coefficient for the year 2007-08 (for 21 sectors)

Sector Code	Sectors in the I-O Table	Backward Linkage Coefficient (domestic)	Forward Linkage Coefficient (domestic)
1	Agriculture	0.90	1.22
2	Mining and quarrying	0.76	-3.30
3	Food, beverages & tobacco	1.39	1.01
4	Textiles	1.31	1.03
5	Wood & wood products	1.12	1.14
6	Paper, paper products	1.23	1.65
7	Printing & publishing	1.26	1.21
8	Leather & plastic products	1.26	1.30
9	Petroleum products	0.10	1.35
10	Chemicals	1.10	1.53
11	Non-metallic mineral products	0.95	1.47
12	Metals	0.96	1.47
13	Machinery	1.15	1.03
14	Transport equipment & parts	1.25	1.06
15	Other miscellaneous manufacturing	1.04	0.91
16	Construction	1.11	0.87
17	Electricity & water supply	0.86	1.64
18	Transport, storage & communication	0.92	1.21
19	Trade, hotels & restaurant	0.85	1.30
20	Financing, insurance, real estate & business services	0.73	1.12
21	Other community, social & personal services	0.73	0.78

Source: Author's estimation by using I-O table for 2007-08 in CSO (2012).

Table 1 makes it clear that 'paper & paper products' has the highest domestic forward linkage, whereas 'electricity & water supply' is holding the second position. In addition, 'chemicals' (third highest) and 'non-metallic mineral products' and 'metals' (jointly rank fourth highest) also reveal high forward linkage, whereas 'mining & quarrying' hold the lowest position. In case of backward linkage coefficient, 'food, beverages & tobacco' has the highest domestic backward linkage, followed by 'textiles'. In addition, 'printing & publishing', 'leather & plastic products', 'transport equipment & parts', 'paper, paper products', etc. show high backward linkage. On the other hand, 'petroleum products' has the lowest domestic backward linkage coefficient.

Using linkage coefficients for identification of key sectors:

Having measured the domestic forward as well as backward linkage coefficients for the year 2007-08, we are now in a position to identify the key sectors by using these linkage coefficients. In terms of the identification criteria of the key sectors as proposed by Hirschman (1958), the priority sectors of an economy are those set of sectors that exhibit high values of backward as well as forward linkages, more precisely, sectors for which the values of both forward and backward linkage coefficients are greater than unity. The next set of key sectors exhibit strong backward linkage, but weak forward linkage, i.e, backward linkage coefficient is greater than unity, while forward linkage coefficient is less than unity. Hirschman (1958) gives priority to backward linkages given the fact that the pressure of backward linkage is more powerful than forward linkage, especially in developing countries. The next group of sectors in terms of priority are those having low backward (i.e, backward linkage coefficient having less than unity) and high forward (i.e, forward linkage coefficient having greater than unity) linkage, while the last group consists low forward as well as backward linkages, i.e, the sectors whose both backward and forward linkage coefficients are less than unity. Thus, we get a 2*2 table, showing forward and backward linkage coefficients in terms of the priority of the sectors.

Table 2: Domestic Forward & Backward Linkage Coefficient for 2007-08

FORWARD LINKAGE (FL) ↓	**BACKWARD LINKAGE (BL) →**	
	BL >1	**BL <1**
FL >1	food, beverages & tobacco, textiles, wood & wood products, Paper & paper products, printing & publishing, leather & plastic products, chemicals, machinery, transport equipment & parts	Agriculture, petroleum products, non-metallic mineral products, metals, electricity & water ss., transport, storage & communication, trade, hotels & restaurant, financing, insurance, real estate & business
FL <1	Other miscellaneous manufacturing, construction	Mining & quarrying, other community, social & personal services

Note: FL: Forward Linkage; BL: Backward Linkage

Source: Author's estimation by using I-O table for 2007-08 in CSO (2012)

Table 2, segregates the sectors with forward as well as backward linkage greater than and less than unity, which in turn reflect the importance of the sectors. As per our findings, the first set of sectors which should receive priority in terms of investment are 'food, beverages & tobacco', 'textiles', 'wood & wood products', 'paper & paper products', 'leather & plastic products', 'chemicals', 'machinery', etc. to their having both forward and backward linkage greater than unity. Thus they can be identified as key sectors which can impact other sectors through their high domestic forward and backward linkages. Again, from Table 2 we observe that 'construction' sector possesses high backward linkage. In contrast, the sectors like; 'mining & quarrying', 'other community, social & personal services', etc. have not performed very well, due to their weak domestic forward and backward linkages.

After measuring the domestic forward and backward linkage coefficients, for comparison purpose , we now present the total linkage (domestic plus imports) measures based on unadjusted I-O matrix. These total linkage measures are derived using the original total transaction matrix given by

CSO. I other words while computing these total linkage measures, we have not considered the import flow matrix separately; the import effect is only implicitly incorporated here. Result of total linkage analysis is presented in Table 3 together with the domestic linkage coefficients, which helps to get a clear comparative picture.

Table 3: Domestic & Total Linkage Coefficient for the year 2007-08 (with 21 sectors)

Sector Code	Sectors in the I-O Table	Backward Linkage Coefficient (domestic)	Backward Linkage Coefficient (total)	BL (total-domestic) (import effect)	Forward Linkage Coefficient (domestic)	Forward Linkage Coefficient (total)	FL (total-domestic) (import effect)
1	Agriculture	0.90	0.72	-0.18	1.22	0.77	-0.45
2	Mining and quarrying	0.76	0.66	-0.10	-3.30	3.31	6.61
3	Food, beverages & tobacco	1.39	1.13	-0.26	1.01	0.64	-0.37
4	Textiles	1.31	1.14	-0.17	1.03	0.66	-0.38
5	Wood & wood products	1.12	0.95	-0.18	1.14	0.77	-0.37
6	Paper, paper products	1.23	1.15	-0.08	1.65	1.26	-0.38
7	Printing & publishing	1.26	1.17	-0.09	1.21	0.82	-0.39
8	Leather & plastic products	1.26	1.19	-0.07	1.30	0.91	-0.39
9	Petroleum products	0.10	1.01	0.92	1.35	1.00	-0.35
10	Chemicals	1.10	1.20	0.10	1.53	1.37	-0.15
11	Non-metallic mineral products	0.95	1.03	0.09	1.47	0.95	-0.52
12	Metals	0.96	1.14	0.19	1.47	1.27	-0.19
13	Machinery	1.15	1.25	0.10	1.03	0.95	-0.08
14	Transport equipment & parts	1.25	1.32	0.07	1.06	0.75	-0.31
15	Other miscellaneous manufacturing	1.04	1.18	0.14	0.91	0.76	-0.15
16	Construction	1.11	1.04	-0.07	0.87	0.56	-0.32
17	Electricity & water supply	0.86	0.95	0.08	1.64	1.22	-0.43
18	Transport, storage & communication	0.92	0.92	-0.01	1.21	0.85	-0.35
19	Trade, hotels & restaurant	0.85	0.69	-0.16	1.30	0.86	-0.43
20	Financing, insurance, real estate & business services	0.73	0.57	-0.16	1.12	0.81	-0.31
21	Other community, social & personal services	0.73	0.58	-0.15	0.78	0.51	-0.27

Source: Author's estimation by using I-O table for 2007-08 in CSO (2012)

Table 3 clearly shows the difference between the domestic and total linkage coefficients and thus the effect of consideration of import effect on the linkage coefficients for the respective sectors. In case of backward linkage, we have found some sectors, like, 'petroleum products', 'chemicals', 'non-metallic mineral products', 'metals', 'machinery', etc., that posses less domestic backward linkage coefficient as compared to total backward linkage. The reason for this could be the dependence of these sectors on imported inputs, which in turn reduces the domestic backward linkage as compared to the total backward linkage. In case of forward linkage, some sectors, like, 'electricity & water supply', 'transport, storage & communication' and 'trade, hotels & restaurant' have high domestic forward linkage coefficient than that of total forward linkage. One reasonable argument for this phenomenon may be that these are mostly non-tradable commodities or services, generating output within the domestic economy without much of import components. . Thus this table captures the difference between domestic and total linkage coefficients for each sector in the year 2007-08. The table clearly presents the sectors with high total linkage coefficients but relatively low domestic linkage coefficients. These are the import dependent sectors and the policy makers may take a careful view regarding development of these sector.

Conclusion

This paper, by measuring forward and backward linkage coefficients, identifies the key sectors that are critical for the rapid growth of Indian economy. Following the measurement of linkage coefficient,, we have found that the sectors such as 'food, beverages & tobacco', 'textiles', 'wood & wood products', 'paper & paper products', 'leather & plastic products', 'chemicals', 'machinery', etc. having both domestic forward and backward linkages greater than unity, thus posses strong inter-sectoral linkages. It is also seen that 'construction' sector possesses high backward linkage which is in conformity with the findings in existing literature (see Polenske and Sivitanides (1990), Rameezdeen, Zainudeen and Ramachandra (2008). Also, the findings of above studies in regard to countries across the globe are identical. . A comparison of domestic and total linkage measures, has revealed that some sectors like, 'electricity & water supply', 'transport, storage & communication' and 'trade, hotels & restaurant' have higher domestic forward linkage coefficients than the total linkage, probably due its non-tradable nature. In contrast, 'petroleum products', 'chemicals', 'non-metallic mineral products', 'metals', 'machinery' possess less domestic backward linkage than the total, due to the greater use of imported inputs. It is therefore s necessary to give the maximum possible impetus to the identified high linked sectors that are not highly import dependent.

Any standard methodology is based on certain assumptions which in a sense are also its limitations. Input-Output multiplier analysis considers the interdependence relation among the industries through their trading pattern of the products, rather ignoring other interdependence indicators, such as, changes in commodity prices, factors of production, etc. Due to the fixed allocation do not get incorporated in the input-output multiplier. Input-output multiplier analysis is also incapable to capture supply side constraints. Further, in the input-output model, the intermediate inputs used in the production process are assume to remain fixed proportions regardless of scale of production , due to which changes in production technologies do not play any role in impact assessment.

Notwithstanding these limitations of the standard I-O technique the current exercise provides important inputs for the policy makers by distinguishing the total and imported input adjusted linkage coefficients for different sectors of Indian economy. If a policy maker is interested in growth through linkage effects but also concerned about saving foreign exchange then the paper identifies the sectors in which he/she should concentrate.

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Appendices

Appendix A.1

Mathematical Framework of Input-Output (I-O) Model:

Under the I-O approach, economy has a number of homogeneous sectors, represented by a row and a column. The entry in the cell of the i^{th} row and j^{th} column is the quantity of output of sector 'i' consumed as input by sector 'j', and which is denoted by X_{ij} (Pradhan, Saluja & Singh, 2006). Accordingly, the mathematical representation of the model consists of 'n' sectors in the economy and thus the following equation holds good in this model:

$$X_i = \sum_j X_{ij} + F_i \text{ , } i=1,2,\ldots,n \qquad \text{----------- (i)}$$

Where, X_i = output of sector 'i'

$\sum_j X_{ij}$ = total intermediate demand for the output of sector 'i'

F_i = final demand for sector 'i's output.

Thus, a sector's output is the summation of total intermediate demand and the final demand for producing that output.

Now, according to the above assumption above (assumption 2)2, we get the following relation:

$$X_{ij} = a_{ij} X_j \qquad \text{----------- (ii)}$$

Therefore, $a_{ij} = (X_{ij} / X_j)$, where, a_{ij}'s are known as the structural or technical coefficient, also called the input-output ratio. Thus, a_{ij} gives the direct input requirement of the i^{th} sector for producing one unit of output of the j^{th} sector. But, it doesn't include the indirect effects involving in the production process (Pradhan, Saluja & Singh, 2006).

Now, with the help of this relation (ii), we can write equation (i) as follows:

$$X_i = \sum_j a_{ij} X_j + F_i \text{ , } i=1,2,\ldots,n \qquad \text{----------- (iii)}$$

In matrix notation, equation (iii) can be written as:

$(I - A)X = F$ ----------- (iv)

Where, I = Identity matrix

A = (n,n) I-O coefficient matrix

X = vector of outputs

F = vector comprising of total final demand.

From (iv), we can also write the following equation:

$X = (I - A)^{-1} F = R * F$, where, $R = [r_{ij}]$, known as Leontief inverse matrix. As compared to a_{ij}, r_{ij} represents the amount of output of sector 'i' required directly as well as indirectly for one unit of final demand of sector 'j'.

Thus, if the I-O coefficient matrix 'A' and final demand vector 'F' can be calculated, then the equilibrium value of output of any sector can be determined.

Appendix A.2

Steps for the Identification of the Key Sectors through linkage effects:

In order to identify the key sectors or high linkage sectors from the broad sectoral classification, here we have used the commodity*commodity I-O table for the year 2007-08.

After discussing the nature of the I-O table that we have used, we now come to the steps taken for identification of the key sectors, which are as follows:

1) We have used commodity*commodity I-O table, in which there are 130 sectors for 2007-08.
2) To get a clearer picture, we club similar sectors from the aggregated sectors, and finally arrive at 21 major sectors.
3) Subsequently, we constructed the Input-Output Coefficient Matrix or Technical or Structural Coefficient Matrix (A) by dividing different components of the corresponding column of the given matrix by the total output of the sector to which the column belongs, i.e, simply dividing the input structure of the sector by the total output, which notationally means $a_{ij} = (X_{ij} / X_j)$, a_{ij}'s being the structural or technical coefficient.
4) After obtaining 'A' matrix, we have constructed the Allocation or Supply Coefficient Matrix (B), which means $b_{ij} = (X_{ij} / X_i)$, b_{ij}'s is the allocation coefficient.
5) After obtaining 'A' and 'B' matrix, we have computed the Direct Backward Linkage from 'A' and Direct Forward Linkage from 'B'. Here we have used the Chenery-Watanabe method (1958) for computing the direct linkage effects. For computing Direct Backward Linkage we are just summing over the columns of the matrix 'A' ($\sum_j$, sum over j-th column), whereas, Direct Forward Linkage is calculated through summing over the row of the 'B' matrix ($\sum_i$, sum over i-th row). -
6) But, using Chenery-Watanabe method, we could get only direct effects through direct I-O coefficients. Next, for obtaining indirect effects also we need the interdependence coefficients, for getting which we have used the Rasmussen method (1956) and arrived at the higher order effects. For that, first we computed the Identity Matrix (I) and then the (I-A) and subsequently (I-B) matrices. After obtaining (I-A) and (I-B) matrices, we invert them to get the Leontief Inverse Matrices.

7) Next, we use Rasmussen's method (1956) for measuring linkages. Thus, by summing up the columns of the inverted (I-A) matrix, i.e, Leontief inverse matrix, we have derived the Direct and Indirect Backward Linkage, whereas, by summing up the row of the inverted (I-B) matrix, we have derived the Direct and Indirect Forward Linkage.

These are the possible steps in the identification of the key sectors of the economy. Obviously, high value of these linkage coefficients shows the importance of that sector as compared to others and therefore by focus on high value sectors will help the entire economy grow at a faster rate.

Steps for Constructing the Domestic Transaction Matrix:

For constructing the domestic transaction matrix, first we have to construct an import flow matrix. For that, we distributed the (gross value of output + import - export) within each inter-industry allocation of the sectors, using the following two formulae:

1. (IIUSE/GVO)*import ------ assume this as M1
2. (X11/IIUSE)*M1

Using the above formulae, we constructed the import flow matrix, subsequently, by subtracting that from the total, we have obtained the domestic transaction matrix.

Table A: Merging Sectors

Sector Code	17 Sectors in the Consolidated I-O Table	Code of Sectors to Merge
1	Agriculture	1-26
2	Mining and quarrying	27-37
3	Food, beverages & tobacco	38-45
4	Textiles	.46-54
5	Wood & wood products	55-56
6	Paper, paper products	57
7	Printing & publishing	58
8	Leather & plastic products	59-62
9	Petroleum products	63
10	Chemicals	64-73
11	Non-metallic mineral products	74-76
12	Metals	77-82
13	Machinery	83-94
14	Transport equipment & parts	95-100
15	Other miscellaneous manufacturing	101-105
16	Construction	106
17	Electricity & water supply	107-108
18	Transport, storage & communication	109-115
19	Trade, hotels & restaurant	116-117
20	Financing, insurance, real estate & business services	118-120, 123, 126
21	Other community, social & personal services	121-122, 124-125, 127-130

Source: Author's estimation by using the I-O table for 2007-08 in CSO (2012).

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