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Inter-Industry Linkages in Economy of Himachal Pradesh: Study of Backward and Forward Linkages Using Input-Output Analysis

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Abstract

The industrial sector in Himachal Pradesh has become a powerhouse, contributing significantly to the state's economic growth, with MSMEs playing a dominant role. The state's commendable performance in business rankings and its leadership in the startup ecosystem underscore the crucial significance of its industrial sector in fostering innovation and creating a conducive environment for business growth and development. Understanding inter industry linkages among different sectors is critical for economic growth. Therefore, this research paper investigates the interconnectedness and interdependency among various sectors within the economy of Himachal Pradesh. Drawing upon input-output analysis methodologies, the study explores backward and forward linkages to identify key sectors driving economic development in the region. Utilizing the input-output table from the fiscal year 2017-18, the study employs both Leontief and Ghosh models to assess sectoral connections. The determination of backward and forward linkages was conducted through the application of Rasmussen and Chenery-Watanabe methods, while the identification of key sectors was accomplished using the Hirschman criteria. Findings revealed that significant interconnections are lacking in several primary activities. Industries with predominantly strong backward and forward linkages are mainly concentrated within the manufacturing sector. Examination of inter-industry connections reveals that the forward linkages of services typically demonstrate greater strength compared to their backward linkages.

Keywords: input-output, backward linkages, forward linkages, key sector, Himachal Pradesh.

INTRODUCTION

The significance of any sector within the economy can be assessed by analyzing the interconnectedness between industries. Industries rely on inputs from other sectors for their production processes, showcasing their backward linkages. Conversely, some sectors provide inputs to other industries, demonstrating their forward linkages (Hirschman, 1958). Real production activities contribute to economic growth by continuously improving production methods and discovering new resources, which are essential for efficient resource utilization. While a strong performance across multiple sectors is important for overall economic growth, a sector that attracts diverse economic activities can stimulate other sectors towards real production, providing momentum for sustainable economic growth. Sectors with significant backward and forward linkages are considered pivotal or key sectors, and they hold significant importance in economy's development strategy (Hewings, 1982). Analyzing sectoral linkages assists government in formulating

growth-promoting policies for sectors that generate substantial spillover effects. Additionally, it aids in comprehending the economic framework (Cai & Leung, 2004). To understand how an economy functions, it's important to observe how its various components interact with each other. Economists have been interested in how industries are linked since Hirschman's work in 1958. According to Hirschman, the interdependence of industries is crucial for a country's economic growth. Analyzing how industries are connected within an economy involves utilizing an input-output table. The I-O table is constructed from a thorough examination of the demand and supply of intermediate goods across all sectors. By portraying these relationships, the input-output table reveals the extent to which one economic sector relies on others, showcasing their interdependence. In recent times, analysis of inter-industry linkages has emerged as an effective tool for simulating economic policies (Mehta, 2020). A well-constructed input-output table empowers us to forecast how the expansion of one economic sector influences others (Kumar & Das, 2015). The first-ever input-output table for Himachal Pradesh was constructed for the year 2017-18. Himachal Pradesh has shown significant potential in different industrial sectors over the past few years. The industrial landscape of Himachal Pradesh is dominated by micro, small, and medium enterprises. More than 98 percent of the state industries fall within the MSME sector. The industrial sector in Himachal Pradesh emerges as a vital cornerstone of the state's economy. Accounting for 42.8 percent of the Gross State Value Added (GSVA) in FY2023-24, this sector serves as a primary driver of economic growth and development. Moreover, its role in employment generation is equally noteworthy, with the percentage of working individuals engaged in the industry rising from 19.32 percent to 20.12 percent between 2020–21 and 2021–22, reflecting its capacity to provide livelihoods and opportunities for the state's workforce. Himachal Pradesh's commendable standing in business rankings further underscores the favourable business environment, positioning the state as an "Achiever" in the Ease of Doing Business (EODB) 2020 ratings. Additionally, the state's dominance in the startup ecosystem, as evidenced by its leading position among hilly states and recognition as the "Best Performer" in the B category of the 2022 Startup Ranking, highlights the crucial role of the industrial sector in fostering innovation, entrepreneurship, and economic dynamism in Himachal Pradesh (Economic Survey 23-24). Identifying highly interconnected sectors is crucial for fostering sustainable and robust economic growth in Himachal Pradesh. The aim of the study is to assess the connections and interdependencies among various sectors within the economy of Himachal Pradesh while also identifying the key sectors with backward and forward linkages.

Review of literature

The goal of inter-industry linkage analysis is to identify the complex relationships that exist between the many industries that are involved in the conversion of resources into commodities and services. There are two types of inter-industry links: forward and backward. Backward linkages occur when an industrial sector stimulates the production of necessary inputs domestically, fostering a self-reliant ecosystem within the economy. Conversely, forward linkages emerge when the output of an industry is integrated into the operations of other domestic production activities, fostering interconnectedness and mutual dependence among sectors within the economy (Hirschman, 1958). With the introduction of input-output tables for the American economy by Wassily Leontief in 1936, input-output analysis emerged as the principal technique for investigating inter-sectoral relationships. Input-output tables gained early popularity as Rasmussen (1956) and Chenery and Watanabe (1958) used them to explore the connections between various economic sectors. In 1958, Hirschman expanded on the concept of inter-industry linkages within the I/O framework, establishing a connection between these linkages and economic development and provided the criteria for

identifying priority sectors, which have since undergone various modifications. The study by Hewings (1982) emphasizes the importance of sectoral analysis in economic development. Additionally, Jones (1970) and Schultz (1977) have highlighted the relevance of key sectors in shaping economic policies and strategies. Hazari's (1970) work also contributes to discussions on the significance of key sectors in various economies.

Three distinct methodologies are employed in assessing linkages, namely, those proposed by Chenery and Watanabe in 1958, Yotopoulos and Nugent in 1976, and Rasmussen in 1958. For measuring direct backward and forward links, C-W recommended using the row and column total of the technical coefficient matrix, respectively, while Rasmussen determined backward connections as the column total of the Leontief inverse matrix.

Several studies in India have examined inter-sectoral linkages, including research conducted by Rao (1989), Bhardwaj & Chaddha (1991), Dhawan & Saxena (1992), Hansda (2001), Bhattacharya & Unnikrishnan (2003), Munjal (2007), Mitra and Schmid (2008), Saikia (2011), Uchikawa (2011), Bhattacharya and Rajeev (2014), and Kumar and Das (2015), Tariyal (2017), and Mehta (2020). The factors influencing India's industrial progress have been examined in these studies, diving in-depth into multiple sectors' interactions and shedding light on inter-industry linkages within the overall economy. The Leontief demand-oriented model was utilized by Dhawan and Saxena (1992) to evaluate backward links, whereas the Ghosh (1958) supply-oriented model was deployed to estimate forward connections. The importance of sectoral links between the agricultural, industries, and services sectors for the Indian economy from 1968–69 to 1993–94 was examined by Bhattacharya & Unnikrishnan (2003). It was found that even with a significant increase in the services sector's GDP share, the agriculture sector's strong ties to other sectors mean that it still has a significant impact on the economy's long-term growth. Tondon & Ahmed (2015) assessed the strength of sectoral linkages by analyzing the connections between material inputs and outputs within each sector using input-output models. Additionally, the interdependencies among industries were examined through the multiplier product matrix. The main findings revealed a significant transformation in the energy landscape of the economy. Kaur et al. (2009) examined the link between long-term equilibrium between the primary, secondary, and tertiary sectors. A strong long-term equilibrium link between these sectors was discovered. It has been noted that comprehending sectoral linkages is crucial for understanding the relationships between various sectors in the economy.

However, it has also been found that there is a scarcity of literature on inter-industry linkages in Himachal Pradesh, with all existing research focusing on the national level. Considering the remarkable growth experienced by Himachal Pradesh in recent years, it becomes imperative to identify key sectors within the state for further development. This study aims to bridge this gap by analyzing the interdependencies among various industries within Himachal Pradesh, thereby providing insights that can guide policymakers and stakeholders in fostering the state's continued growth and prosperity.

Objectives

1. To measure the inter-industry linkages among sectors in the economy of Himachal Pradesh.
2. To identify the key sectors in the economy of Himachal Pradesh.

Methodology

The current research predominantly relies on the Input - Output table of economy of Himachal Pradesh

for the fiscal year 2017-18. This particular table, compiled by the National Council of Applied Economic Research (NCAER) and released in 2022, serves as the most recent and only available dataset for analysis. This paper employs the demand-driven model proposed by Leontief in 1936 and the supply-driven model introduced by Ghosh in 1958.

Input-Output Model:

The examination of input-output table, pioneered by Leontief in 1936, highlights the interconnectedness between production and consumption within an economy. This analytical framework, known as the input - output model, is structured as a set of linear equations, enabling representation in mathematical form. Within this model, inter-sectoral transactions are quantified in monetary terms for a specific period, reflecting the exchange of intermediate goods and services between sectors.

$$X_i = \sum a_{ij} X_j + F_i, \quad i = 1,2,3,.....n \qquad (1)$$

In the equation provided, 'X_i' represents the total output of sector i, while 'F_i' denotes the final demand. Within Equation 1, the variable 'a_{ij}' signifies the technical coefficient, indicating the input necessity of sector i in sector j. This coefficient is derived using the formula ($a_{ij} = (X_{ij} / X_j)$.

In matrix form, equation (1) can be expressed as:

$$X = (I-A)^{-1} *F \qquad (2)$$

Here, $(I-A)^{-1}$ is referred to as the Leontief Inverse or matrix multiplier. It encompasses both direct and indirect input requirements. Consequently, by computing the input-output coefficient matrix (A) and the final demand vector (F), one can ascertain the output value of any given sector.

Ghoshian Allocation system: The supply-driven model, pioneered by Ghosh in 1958, establishes a connection between sectoral output and primary inputs, which comprise various value-added components. Central to the Ghosh allocation system is the assumption that the distribution patterns of output among industries are proportionally determined by their sectoral origins. This model provides an alternative to Leontief's (demand-side) input-output model and is frequently employed to examine the forward linkages of various sectors within the economy. In supply-driven model proposed by Ghosh in 1958, the following equation is taken into consideration:

$$X_j = \sum b_{ij} X_i + V_j \qquad (3)$$

In this equation, 'X_j' represents the total input for sector j, 'V_j' denotes the primary input of same sector, and 'bij' represents the output coefficient indicating the amount of output from sector j used as an input in sector i calculated as $b_{ij} = (X_{ij} / X_j)$. This expression can be rearranged into matrix form as follows:

$$X' = (I-B)^{-1} *V \qquad (4)$$

Where, $(I-B)^{-1}$ is referred as Ghosh inverse, as defined by Ghosh in 1958.

Backward and Forward Linkages

Various methods exist for assessing linkages in economic measurement. To assess both forward and backward linkage effects, the demand-driven Leontief model (1941) to calculate backward linkage coefficients and the supply-driven Ghosh model (1958) to measure forward linkage coefficients have been employed. For both models, Chenery-Watanabe method (1958) has been utilised to quantify direct linkage effects. Additionally, indirect linkage effects were calculated using the Rasmussen method (1956). Specifically, the technical coefficient matrix (A) and the allocation coefficient matrix (B) were used to evaluate direct backward and forward linkage effects, respectively. Direct and indirect backward and forward linkage effects were determined using inverse matrices $(I-A)^{-1}$ and $(I-B)^{-1}$.

Chenery and Watanabe method

C-W proposed a method utilizing the sums of columns and rows in the technical coefficient matrix 'A' and the allocation coefficient matrix 'B' to assess backward and forward linkages, respectively. The backward linkage in the C-W model corresponds to the total of a specific column in the technical coefficient matrix A. These coefficients represent the source of production materials used by a given sector. The degree of backward linkages for a sector j is defined as:

$$BL_j = \sum X_{ij} / X_j = \sum a_{ij} \quad (5)$$

BL_j signifies the direct backward linkage, determined simply as the summation of columns in the technical coefficient matrix "A". 'X_{ij}' represents the amount of commodity i needed to produce Xj units of commodity j. The values of 'a_{ij}' are derived from the technical coefficient matrix 'A'. 'X_{ij}' represents the ij^{th} element of the flow matrix, while X_j represents the gross output of sector j. Consequently, the strength of forward linkage for any sector i is represented as:

$$FL_j = \sum X_{ij} / X_j = \sum b_{ij} \quad (6)$$

FL_j represents the direct forward linkage, calculated simply as the summation of rows in the allocation coefficient matrix "B".

The indices mentioned above solely capture direct impacts and do not encompass indirect effects. Therefore, to incorporate indirect effects, Rasmussen's (1958) measures of backward and forward linkage indices has been used.

Rasmussen method

To facilitate comparison among industries, Rasmussen's backward linkage measure can be constructed by creating an index of backward linkage in the following manner:

$$BL = (1/N) \sum_j a_{ij} / (1/N^2) \sum^N{}_{j=1} a_{ij} \quad (7)$$

BL represents both direct and indirect backward linkage, calculated as the ratio of the average column sum to the average of the entire $(I-A)^{-1}$ matrix.

Rasmussen's measures consider indirect effects, but there remains an issue regarding his forward linkage. Jones (1976) asserted that it evaluates the direct and indirect impacts on supplier industries but overlooks the effects on user industries, specifically forward linkages. So, to measure forward linkage, Ghosh inverse matrix $(I-B)^{-1}$ has been employed.

$$FL = (1/N) \sum_i b_{ij} / (1/N^2) \sum^N{}_{i=1} b_{ij} \quad (8)$$

FL represents both direct as well as indirect forward linkage, calculated as the ratio of average row sum to the average of the entire $(I-B)^{-1}$ matrix.

Analysis and Results

The analysis aims to understand the underlying framework of connections between industries by examining the results obtained from various measures of linkages. Linkage analysis has been conducted for economy of Himachal Pradesh, utilizing data derived from the symmetric input-output table 2017-18. The sectors within an economy can be classified into four groups according to the magnitude of their linkage indicators. If both the backward and forward linkages of a sector surpass the respective average values (normalized values greater than 1), the sector is categorized as a "key" sector. If only the backward linkages exceed the average, the sector is classified as having strong backward linkages. Similarly, if only the forward linkages surpass the average, the sector is categorized as having strong forward linkages. The fourth category applies to sectors with weak linkages, where both backward and forward linkages are

below the averages (normalized values smaller than one).

Table 1 displays the outcomes using the CW technique, while Table 2 presents the findings following the Rasmussen approach. Table 3 presents the ultimate results, indicating whether the sector is a key sector or possesses strong forward as well as backward linkages.

Key sectors (BL >1 and FL >1): Findings derived from Table 3 showed that Grain mill products & animal feeds, Metal & Metal products, Wood & wood products except furniture, Paper, paper products & newsprint, Publishing & printing, Furniture & fixtures other manufacturing, other manufacturing, Gas, Water supply, Hotels & restaurants, Air transport, Storage & warehousing, and Communication services emerge as pivotal sectors according to both CW and Rasmussen methodologies. Repair & installation of machinery & equipment stands out as a key sector under the CW method, while it demonstrates robust forward linkages according to the Rasmussen approach. Additionally, Business services and Other non-metallic mineral products identified as a key sector by the Rasmussen method, exhibits strong forward linkages under CW method, enhancing their significance within the economic landscape.

Sectors with strong Forward Linkages (BL<1 and FL>1: This category shows that sector with strong forward linkages. Table 3 reveals that Limestone and other minor mineral extraction, Readymade garments production, Petroleum and coal tar derivatives, Electricity generation, and Supportive & Auxiliary transport activities are sectors exhibiting robust forward linkages according to both analytical methods. Financial, legal & insurance services, Real estate services, renting of machinery & equipment also demonstrate significant forward linkages under both methodologies. Notably, Other non-metallic mineral products and Business services display strong forward linkages according to the CW method, whereas they are identified as key sectors under the Rasmussen approach.

Sectors with strong Backward linkages (BL>1 and FL<1): Table 3 shows that Livestock, processed meat, fish, fruits, vegetables, oils and fats, tobacco products, textiles & cotton ginning, leather & leather products, electronic equipment, electrical equipment, machinery & equipment, transport equipment, rubber & plastic products, construction, land transport, health, and computer-related services all exhibit significant forward linkages according to both methods. Under the CW method, other food products display strong backward linkages, whereas they are classified as weak sectors according to the Rasmussen method.

Weak sectors (BL<1 and FL<1): Sectors having weak linkages include Apples, Agriculture (other than apples), Forestry and logging, Fishing & Aquaculture, Dairy products, Beverages, Inorganic & organic chemicals, Drugs and medicine, Trade, Railway transport, Ownership of dwellings, Education, Community, social & personal services, other services, public administration & defence as can be seen from Table 3. Under the Rasmussen method, other food products are classified as weaker sectors, whereas they demonstrate strong backward linkages under the CW method.

Table 4 depicts the ranking of various sectors from highest to lowest backward and forward linkages according to both CW and Rasmussen methodologies. Health is at the forefront, followed by Grain mill products and animal feeds, Publishing & printing exhibits the strongest backward linkages according to the CW method, while Paper, paper products & newsprint, followed by Publishing & printing, Gas, demonstrate strong backward linkages under Rasmussen method. In the Rasmussen method, Publishing and printing demonstrates the second strongest backward linkages, whereas it holds the third position for backward linkages in the CW method. Electricity has the weakest backward linkages under both methods. Renting of machinery & equipment stands out as the sector with the highest forward linkages according to both methods, whereas Ownership of dwellings and public administration & defence are positioned at

the bottom in terms of forward linkages under both methodologies.

Conclusion and policy recommendations

This study has examined the production framework and interconnections between sectors within the Himachal Pradesh economy, utilizing data from the year 2017-18. This research endeavours to identify key sectors and inter-industry connections through empirical analysis. The research suggests that in various primary activities, there is a lack of significant interconnections, indicating a deficiency in technologically-driven processes within the sector. Agriculture exhibits weak backward and forward linkages. This underscores the importance of modernizing the agricultural sector through advancements in technology and research development. The apple sector, a significant agricultural sector in Himachal Pradesh, demonstrates weak backward and forward linkages. Policy measures for the apple industry in Himachal Pradesh should focus on infrastructure development, technology adoption, value addition, market access facilitation, and financial support. These measures will enhance productivity, reduce losses, expand market reach, and improve competitiveness. Industries with predominantly high backward and forward linkages are primarily concentrated within the manufacturing sector. This phenomenon arises because the manufacturing sector sources its inputs from both the agricultural and services sectors. Therefore, collaborative efforts between the government and private entities to enhance infrastructure within this sector can drive broader economic growth. Analysis of inter-industry connections indicates that the forward linkages of services tend to be more robust compared to their backward linkages. Given the services sector's reliance on inputs from other sectors, the development of other sectors is crucial to prevent supply constraints. Strengthening inter-industry linkages is vital for fostering economic resilience and driving sustainable growth. To achieve this, policymakers should prioritize the establishment of collaborative frameworks that facilitate partnerships between diverse sectors.

References

1. Andreosso-O'Callaghan, B., & Yue, G. (2004). Intersectoral linkages and key sectors in China, 1987–1997. Asian economic journal, 18(2), 165-183.
2. Bhardwaj, R. N., & Chadha, R. (1991). Sources of growth and inter-industry linkages in Indian economy with special reference to the manufacturing sector. Indian Economic Review, 189-219.
3. Bhattacharya, T., & Rajeev, M. (2014). Identifying the High-linked Sectors for India: An Application of Import-adjusted Domestic Input-output Matrix. Institute for Social and Economic Change.
4. Chenery, H. B., & Taylor, L. (1968). Development patterns: among countries and over time. The Review of Economics and Statistics, 391-416.
5. Chenery, H. B., & Watanabe, T. (1958). International comparisons of the structure of production. Econometrica: Journal of the Econometric Society, 487-521.
6. Dhawan, S., & Saxena, K. K. (1992). Sectoral linkages and key sectors of the Indian economy. Indian Economic Review, 195-210.
7. Cai, J., & Leung, P. (2004). Linkage measures: a revisit and a suggested alternative. Technology Analysis & Strategic Management, 16(1), 63-83.
8. Dietzenbacher, E. (1992). The measurement of interindustry linkages: key sectors in the Netherlands. Economic Modelling, 9(4), 419-437.
9. Economic Survey (2023-24), Economics and Statistics Department, Govt of Himachal Pradesh
10. Ghosh, A. (1958). Input-output approach in an allocation system. Economica, 25(97), 58-64.

11. Hansda, S. K. (2001). Sustainability of services-led growth: An input - output analysis of Indian economy. Reserve Bank of India Occasional Working Paper Series. Vol. 22 Nos. 1, 2, and 3. New Delhi: Reserve Bank of India.
12. Hazari, B. R. (1970). Empirical identification of key sectors in the Indian economy. The review of economics and statistics, 301-305.
13. Hewings, G. J. (1982). The empirical identification of key sectors in an economy: a regional perspective. The developing economies, 20(2), 173-195.
14. Hirschman, A. O. (1958). The strategy of economic development.
15. Jones, L. P. (1976). The measurement of Hirschmanian linkages. The quarterly journal of economics, 90(2), 323-333.
16. Kumar, S., & Das, S. (2015). Sector analysis on Make in India. Indian Journal of Applied Research, 5(11), 143-153.
17. Kaur, G., Bordoloi, S., & Rajesh, R. (2009). An empirical investigation on the inter-sectoral linkages in India.
18. Leontief, W. W. (1936). Quantitative input and output relations in the economic systems of the United States. The review of economic statistics, 105-125.
19. Munjal, P. (2007). Structural changes in Indian economy: An input-output analysis. Indian Economic Review, 77-95.
20. Mitra, A., & Schmid, J. P. (2008). Growth and poverty in India: emerging dimensions of the tertiary sector. The Service Industries Journal, 28(8), 1055-1076.
21. Mehta, B. S. (2020). Inter-industry linkages of ICT sector in India. Indian Journal of Human Development, 14(1), 42-61.
22. National Council of Applied Economic Research (NCAER). 2017-18. Input output transactions table. Himachal Pradesh, https://www.ncaer.org/publication/input-output-transactions-table-2017-18-himachal-pradesh
23. Rasmussens, P. N. (1958). Studies in inter-sectoral relations. Amsterdam: North Holland Publishing Company
24. Rao, G. U. K. (1989). Inter-Sectoral Linkages: Agriculture and Industry. SEDME (Small Enterprises Development, Management & Extension Journal), 16(4), 1-11.
25. Saikia, D. (2011). Analyzing inter-sectoral linkages in India. African Journal of Agricultural Research, 6(33), 6766-6775.
26. Song, Y., Liu, C., & Langston, C. (2005). A linkage measure framework for the real estate sector. International Journal of Strategic Property Management, 9(3), 121-143.
27. Song, Y., Liu, C., & Langston, C. (2006). Linkage measures of the construction sector using the hypothetical extraction method. Construction management and Economics, 24(6), 579-589.
28. Schultz, S. (1977). Approaches to identifying key sectors empirically by means of input-output analysis. The Journal of development studies, 14(1), 77-96.
29. Tariyal, P. (2017). A study on intersectoral linkages in Indian economy. Arthshastra Indian Journal of Economics & Research, 6(1), 23-34.
30. Tandon, A., & Ahmed, S. (2015). Measuring Energy Linkages in the Indian Economy: An Input-Output Analysis. Available at SSRN 2762309.
31. Uchikawa, S. (2011). Linkage between organised and unorganised sectors in Indian machinery industry. Economic and Political Weekly, 45-54.

32. Yotopoulos, P. A., & Nugent, J. B. (1976). In defense of a test of the linkage hypothesis. The Quarterly Journal of Economics, 90(2), 334-343

Table 1. Backward and Forward Linkages Using Chenery-Watanabe Method

	Activities	BL	BL coefficient	Category	FL	FL coefficient	Category
1.	Apples	0.062	0.176	wB	0.170	0.394	wF
2.	Agriculture (other than apples)	0.144	0.407	wB	0.232	0.539	wF
3.	Livestock	0.524	1.481	sB	0.309	0.719	wF
4.	Forestry and logging	0.114	0.324	wB	0.126	0.292	wF
5.	Fishing & Aquaculture	0.066	0.186	wB	0.101	0.236	wF
6.	Limestone and other minor minerals	0.270	0.765	wB	0.924	2.148	sF
7.	Processed meat, fish, fruit, vegetables, oil and fats	0.502	1.419	sB	0.334	0.777	wF
8.	Dairy products	0.306	0.866	wB	0.296	0.689	wF
9.	Grain mill products and animal feeds	0.725	2.048	sB	0.460	1.070	sF
10.	Other food products	0.354	1.000	sB	0.282	0.656	wF
11.	Beverages	0.288	0.813	wB	0.324	0.753	wF
12.	Tobacco products	0.487	1.377	sB	0.154	0.357	wF
13.	Textiles & cotton ginning	0.517	1.462	sB	0.328	0.761	wF
14.	Readymade garments	0.266	0.751	wB	0.671	1.560	sF
15.	Leather & leather products	0.425	1.202	sB	0.136	0.318	wF
16.	Metal & Metal products	0.467	1.321	sB	0.608	1.413	sF
17.	Electronic equipment	0.454	1.283	sB	0.319	0.742	wF
18.	Electrical equipment	0.548	1.549	sB	0.309	0.718	wF
19.	Machinery & equipment	0.389	1.100	sB	0.278	0.646	wF

20.	Transport equipment	0.428	1.210	sB	0.297	0.690	wF
21.	Petroleum and coal tar products	0.119	0.337	wB	0.665	1.546	sF
22.	Inorganic & organic chemicals	0.204	0.578	wB	0.425	0.988	wF
23.	Drugs and medicine	0.106	0.300	wB	0.274	0.637	wF
24.	Rubber & plastic products	0.474	1.340	sB	0.384	0.892	wF
25.	Other non-metallic mineral products	0.299	0.846	wB	0.643	1.494	sF
26.	Wood & wood products except furniture	0.545	1.541	sB	0.571	1.327	sF
27.	Paper, paper products & newsprint	0.601	1.700	sB	0.793	1.842	sF
28.	Publishing & printing	0.652	1.841	sB	0.623	1.449	sF

Table 1 (cont). Backward and Forward Linkages Using Chenery-Watanabe Method

29.	Furniture & fixtures	0.498	1.407	sB	0.584	1.358	sF
30.	Other manufacturing	0.406	1.148	sB	0.518	1.203	sF
31.	Repair & installation of machinery & equipment	0.377	1.065	sB	0.654	1.520	sF
32.	Construction	0.406	1.148	sB	0.084	0.197	wF
33.	Electricity	0.006	0.018	wB	0.782	1.816	sF
34.	Gas	0.645	1.824	sB	0.489	1.136	sF
35.	Water supply	0.391	1.106	sB	0.947	2.200	sF
36.	Trade	0.188	0.532	wB	0.417	0.970	wF
37.	Hotels & restaurants	0.413	1.168	sB	0.444	1.032	sF
38.	Railway transport	0.240	0.679	wB	0.360	0.836	wF
39.	Land transport	0.371	1.047	sB	0.352	0.819	wF
40.	Air transport	0.545	1.540	sB	0.986	2.292	sF

41.	Supportive & Auxiliary transport activities	0.237	0.670	wB	0.454	1.056	sF
42.	Storage & warehousing	0.407	1.150	sB	0.996	2.315	sF
43.	Communication services	0.635	1.795	sB	0.663	1.541	sF
44.	Financial, legal & insurance services	0.211	0.596	wB	0.628	1.459	sF
45.	Ownership of dwellings	0.033	0.094	wB	0	0	wF
46.	Education	0.216	0.611	wB	0.018	0.041	wF
47.	Health	0.744	2.103	sB	0.004	0.009	wF
48.	Computer related services	0.423	1.195	sB	0.040	0.093	wF
49.	Business services	0.260	0.735	wB	0.716	1.66	sF
50.	Real estate services	0.102	0.288	wB	0.960	2.232	sF
51.	Renting of machinery & equipment	0.244	0.690	wB	1.000	2.322	sF
52.	Community, social & personal services	0.252	0.712	wB	0.000	0.001	wF
53.	Other services	0.288	0.815	wB	0.090	0.210	wF
54.	Public administration & defence	0.218	0.616	wB	0	0	wF

Table 2. Backward and Forward Linkages Using Rasmussen Method

	Activities	BL	BL coefficient	Category	FL	FL coefficient	Category
1	Apples	1.08	0.693	wB	1.263	0.753	wF
2	Agriculture (other than apples)	1.183	0.760	wB	1.315	0.784	wF
3	Livestock	1.763	1.132	sB	1.455	0.868	wF
4	Forestry and logging	1.181	0.758	wB	1.166	0.6956	wF
5	Fishing & Aquaculture	1.099	0.706	wB	1.167	0.6959	wF

6	Limestone and other minor minerals	1.438	0.923	wB	2.426	1.446	sF
7	Processed meat, fish, fruit, vegetables, oil and fats	1.693	1.087	sB	1.504	0.897	wF
8	Dairy products	1.497	0.961	wB	1.422	0.848	wF
9	Grain mill products and animal feeds	2.032	1.305	sB	1.742	1.038	sF
1	Other food products	1.540	0.989	wB	1.419	0.846	wF
1	Beverages	1.470	0.944	wB	1.438	0.857	wF
1	Tobacco products	1.701	1.092	sB	1.230	0.733	wF
1	Textiles & cotton ginning	1.794	1.152	sB	1.498	0.893	wF
1	Readymade garments	1.425	0.915	wB	2.100	1.252	sF
1	Leather & leather products	1.675	1.076	sB	1.178	0.702	wF
1	Metal & Metal products	1.654	1.062	sB	1.894	1.129	sF
1	Electronic equipment	1.971	1.265	sB	1.513	0.902	wF
1	Electrical equipment	1.924	1.236	sB	1.489	0.888	wF
1	Machinery & equipment	1.846	1.185	sB	1.433	0.8549	wF
2	Transport equipment	1.725	1.107	sB	1.433	0.8545	wF
2	Petroleum and coal tar products	1.157	0.743	wB	2.134	1.272	sF
2	Inorganic & organic chemicals	1.313	0.843	wB	1.639	0.977	wF
2	Drugs and medicine	1.139	0.731	wB	1.350	0.805	wF
2	Rubber & plastic products	1.685	1.082	sB	1.550	0.924	wF
2	Other non-metallic mineral products	1.587	1.019	sB	1.935	1.154	sF

2	Wood & wood products except furniture	1.953	1.254	sB	1.922	1.146	sF
2	Paper, paper products & newsprint	2.121	1.362	sB	2.688	1.603	sF
2	Publishing & printing	2.061	1.323	sB	2.210	1.317	sF
2	Furniture & fixtures	1.872	1.202	sB	1.877	1.119	sF
3	Other manufacturing	1.701	1.092	sB	1.793	1.069	sF
3	Repair & installation of machinery & equipment	1.275	0.819	wB	2.088	1.245	sF
3	Construction	1.637	1.051	sB	1.121	0.668	wF
3	Electricity	1.009	0.648	wB	2.345	1.398	sF
3	Gas	2.037	1.308	sB	1.729	1.031	sF
3	Water supply	1.602	1.028	sB	2.332	1.390	sF
3	Trade	1.275	0.819	wB	1.625	0.969	wF
3	Hotels & restaurants	1.680	1.078	sB	1.710	1.019	sF
3	Railway transport	1.366	0.877	wB	1.572	0.937	wF
3	Land transport	1.616	1.038	sB	1.527	0.910	wF
4	Air transport	1.819	1.168	sB	2.496	1.488	sF
4	Supportive & Auxiliary transport activities	1.377	0.884	wB	1.719	1.025	sF
4	Storage & warehousing	1.617	1.038	sB	2.275	1.356	sF
4	Communication services	2.028	1.302	sB	2.087	1.244	sF
4	Financial, legal & insurance services	1.314	0.843	wB	2.028	1.209	sF
4	Ownership of dwellings	1.052	0.676	wB	1	0.596	wF
4	Education	1.324	0.850	wB	1.024	0.610	wF

4	Health	1.872	1.202	sB	1.005	0.599	wF
4	Computer related services	1.647	1.058	sB	1.058	0.631	wF
4	Business services	1.581	1.015	sB	2.191	1.306	sF
5	Real estate services	1.149	0.737	wB	2.374	1.415	sF
5	Renting of machinery & equipment	1.369	0.879	wB	2.919	1.740	sF
5	Community, social & personal services	1.382	0.887	wB	1.001	0.596	wF
5	Other services	1.440	0.925	wB	1.133	0.675	wF
5	Public administration & defence	1.321	0.848	wB	1	0.596	wF

Table 3. Key sectors (K), Sectors with strong Backward linkages (sB), Sectors with Strong Forward Linkages (sF), Sectors with weak linkages (W)

		CW			Rasmussen		
		BL	FL	Results	BL	FL	Results
1.	Apples	wB	wF	W	wB	wF	W
2.	Agriculture (other than apples)	wB	wF	W	wB	wF	W
3.	Livestock	sB	wF	sB	sB	wF	sB
4.	Forestry and logging	wB	wF	W	wB	wF	W
5.	Fishing & Aquaculture	wB	wF	W	wB	wF	W
6.	Limestone and other minor minerals	wB	sF	sF	wB	sF	sF
7.	Processed meat, fish, fruit, vegetables, oil and fats	sB	wF	sB	sB	wF	sB
8.	Dairy products	wB	wF	W	wB	wF	W
9.	Grain mill products and animal feeds	sB	sF	K	sB	sF	K
10.	Other food products	sB	wF	sB	wB	wF	W
11.	Beverages	wB	wF	W	wB	wF	W
12.	Tobacco products	sB	wF	sB	sB	wF	sB
13.	Textiles & cotton ginning	sB	wF	sB	sB	wF	sB
14.	Readymade garments	wB	sF	sF	wB	sF	sF
15.	Leather & leather products	sB	wF	sB	sB	wF	sB
16.	Metal & Metal products	sB	sF	K	sB	sF	K
17.	Electronic equipment	sB	wF	sB	sB	wF	sB
18.	Electrical equipment	sB	wF	sB	sB	wF	sB
19.	Machinery & equipment	sB	wF	sB	sB	wF	sB

20.	Transport equipment	sB	wF	sB	sB	wF	sB
21.	Petroleum and coal tar products	wB	sF	sF	wB	sF	sF
22.	Inorganic & organic chemicals	wB	wF	W	wB	wF	W
23.	Drugs and medicine	wB	wF	W	wB	wF	W
24.	Rubber & plastic products	sB	wF	sB	sB	wF	sB
25.	Other non-metallic mineral products	wB	sF	sF	sB	sF	K
26.	Wood & wood products except furniture	sB	sF	K	sB	sF	K
27.	Paper, paper products & newsprint	sB	sF	K	sB	sF	K
28.	Publishing & printing	sB	sF	K	sB	sF	K
29.	Furniture & fixtures	sB	sF	K	sB	sF	K
30.	Other manufacturing	sB	sF	K	sB	sF	K
31.	Repair & installation of machinery & equipment	sB	sF	K	wB	sF	sF
32.	Construction	sB	wF	sB	sB	wF	sB
33.	Electricity	wB	sF	sF	wB	sF	sF
34.	Gas	sB	sF	K	sB	sF	K
35.	Water supply	sB	sF	K	sB	sF	K
36.	Trade	wB	wF	W	wB	wF	W
37.	Hotels & restaurants	sB	sF	K	sB	sF	K
38.	Railway transport	wB	wF	W	wB	wF	W
39.	Land transport	sB	wF	sB	sB	wF	sB
40.	Air transport	sB	sF	K	sB	sF	K
41.	Supportive & Auxiliary transport activities	wB	sF	sF	wB	sF	sF
42.	Storage & warehousing	sB	sF	K	sB	sF	K
43.	Communication services	sB	sF	K	sB	sF	K
44.	Financial, legal & insurance services	wB	sF	sF	wB	sF	sF
45.	Ownership of dwellings	wB	wF	W	wB	wF	W
46.	Education	wB	wF	W	wB	wF	W
47.	Health	sB	wF	sB	sB	wF	sB
48.	Computer related services	sB	wF	sB	sB	wF	sB
49.	Business services	wB	sF	sF	sB	sF	K
50.	Real estate services	wB	sF	sF	wB	sF	sF
51.	Renting of machinery & equipment	wB	sF	sF	wB	sF	sF
52.	Community, social & personal services	wB	wF	W	wB	wF	W
53.	Other services	wB	wF	W	wB	wF	W
54.	Public administration & defence	wB	wF	W	wB	wF	W

Table 4. Ranking of Backward and forward linkages

		CW		Rasmussen		CW		Rasmussen	
		BL	Rank	BL	Rank	FL	Rank	FL	Rank
1.	Apples	0.176	52	0.693	52	0.394	42	0.753	42

2.	Agriculture (other than apples)	0.407	46	0.760	46	0.539	40	0.784	41
3.	Livestock	1.481	10	1.132	14	0.719	33	0.868	34
4.	Forestry and logging	0.324	48	0.758	47	0.292	45	0.6956	46
5.	Fishing & Aquaculture	0.186	51	0.706	51	0.236	46	0.6959	45
6.	Limestone and other minor minerals	0.765	34	0.923	34	2.148	6	1.446	4
7.	Processed meat, fish, fruit, vegetables, oil and fats	1.419	12	1.087	18	0.777	29	0.897	31
8.	Dairy products	0.866	30	0.961	31	0.689	36	0.848	38
9.	Grain mill products and animal feeds	2.048	2	1.305	4	0.430	41	1.038	21
10	Other food products	1.000	29	0.989	30	0.656	37	0.846	39
11	Beverages	0.813	33	0.944	32	0.753	31	0.857	35
12	Tobacco products	1.377	14	1.092	17	0.357	43	0.733	43
13	Textiles & cotton ginning	1.462	11	1.152	13	0.761	30	0.893	32
14	Readymade garments	0.751	35	0.915	35	1.560	10	1.252	12
15	Leather & leather products	1.202	19	1.076	21	0.318	44	0.702	44
16	Metal & Metal products	1.321	16	1.062	22	1.413	17	1.129	18
17	Electronic equipment	1.283	17	1.265	6	0.742	32	0.902	30
18	Electrical equipment	1.549	7	1.236	8	0.718	34	0.888	33
19	Machinery & equipment	1.100	26	1.185	11	0.646	38	0.854	36
20	Transport equipment	1.210	18	1.107	15	0.690	35	0.854	37
21	Petroleum and coal tar products	0.337	47	0.743	48	1.546	11	1.272	11

22	Inorganic & organic chemicals	0.578	44	0.843	43	0.988	24	0.977	25
23	Drugs and medicine	0.300	49	0.731	50	0.637	39	0.805	40
24	Rubber & plastic products	1.340	15	1.082	19	0.892	26	0.924	28
25	Other non-metallic mineral products	0.846	31	1.019	28	1.494	14	1.154	16
26	Wood & wood products except furniture	1.541	8	1.254	7	1.327	19	1.146	17
27	Paper, paper products & newsprint	1.700	6	1.362	1	1.842	7	1.603	2
28	Publishing & printing	1.841	3	1.323	2	1.449	16	1.317	9
29	Furniture & fixtures	1.407	13	1.202	9	1.358	18	1.119	19

Table 4 (cont.). Ranking of Backward and forward linkages

30.	Other manufacturing	1.148	23	1.092	16	1.203	20	1.069	20
31.	Repair & installation of machinery & equipment	1.065	27	0.819	44	1.520	13	1.245	13
32.	Construction	1.148	24	1.051	24	0.197	48	0.668	48
33.	Electricity	0.018	54	0.648	54	1.816	8	1.398	6
34.	Gas	1.824	4	1.308	3	1.136	21	1.031	22
35.	Water supply	1.106	25	1.0289	27	2.200	5	1.390	7
36.	Trade	0.532	45	0.819	45	0.970	25	0.969	26
37.	Hotels & restaurants	1.168	21	1.078	20	1.032	23	1.019	24
38.	Railway transport	0.679	39	0.877	39	0.836	27	0.937	27
39.	Land transport	1.047	28	1.038	26	0.819	28	0.910	29
40.	Air transport	1.540	9	1.168	12	2.292	3	1.488	3

41.	Supportive & Auxiliary transport activities	0.670	40	0.884	37	1.056	22	1.025	23
42.	Storage & warehousing	1.150	22	1.038	25	2.315	2	1.356	8
43.	Communication services	1.795	5	1.302	5	1.541	12	1.244	14
44.	Financial, legal & insurance services	0.596	43	0.843	42	1.459	15	1.209	15
45.	Ownership of dwellings	0.094	53	0.676	53	0	53	0.596	53
46.	Education	0.611	42	0.850	40	0.041	50	0.610	50
47.	Health	2.103	1	1.202	10	0.009	51	0.599	51
48.	Computer related services	1.195	20	1.058	23	0.093	49	0.631	49
49.	Business services	0.735	36	1.015	29	1.66	9	1.306	10
50.	Real estate services	0.288	50	0.737	49	2.232	4	1.415	5
51.	Renting of machinery & equipment	0.690	38	0.879	38	2.322	1	1.740	1
52.	Community, social & personal services	0.712	37	0.887	36	0.001	52	0.596	52
53	Other services	0.815	32	0.925	33	0.210	47	0.675	47
54.	Public administration & defence	0.616	41	0.848	41	0	53	0.596	53