An Analysis of Backward and Forward Linkages of Pharmaceutical Sector in India Based on an Input-Output Model

.

ABSTRACT

Aims: The paper study about the inter-linkages between pharmaceutical sector and other sectors of Indian economy. The paper also measures the effects of growth in pharmaceutical sector on other sector's growth.
Study design: The study is mainly a static analysis based on secondary data concentrated in studying the production structure of Indian pharmaceutical sector.
Duration of Study: The time taken for the research to be completed is for a period of four months.
Methodology: We have used the latest input-output table available for the period of 2015-16 to conduct the analysis. First, we converted the input-output table from 131 sectors structure to a 60 sectors structure by aggregation of most related sectors. Then, technical coefficient matrix and Leontief inverse matrix for the 60 sectors included in the table has been calculated to analyze the forward and backward linkages of the industry. In addition to that we have calculated output multiplier of pharmaceutical industry to know the effects of changes in the growth of pharmaceutical sectors on all other sectors of the economy.
Results: The input-output analysis reveals that both forward linked indicator and backward linked indicator are greater than one. The forward linked indicator is of value 1.12 and backward linked indicator is of value 1.50. These results indicated that pharmaceutical sector is strongly inter-linked both backwardly and forwardly with other industries in the Indian economy. The value of output multiplier of the industry is 2.34; it indicates positive contribution of the pharmaceutical sectors both directly and indirectly to the Indian economy.
Conclusion: The study finds that pharmaceutical industry is a key industry in stimulating the production activities of other industries. Thus with proper planning and execution of pharmaceutical industry it can help in promoting other sectors growth.

Keywords: Backward linkages, forward linkages, input-output analysis, India, inter-linkages, output multiplier, pharmaceutical sector.

1. INTRODUCTION

India holds an important position in the global pharmaceuticals sector. The country ranks third globally for pharmaceutical production by volume and 14th by value. India's pharmaceutical industry domestically owns 3000 drug companies and 10,500 manufacturing unit. In addition, India ranks 12th in terms of export of pharmaceutical products worldwide. The paper tries to examine the role played by the Indian pharmaceutical sector in India and its interaction with other sectors of the economy using input- output (I-O) analysis. Backward and forward linkages of the pharmaceutical sector in the national economy are calculated to

know the extent of impact of the pharmaceutical industry on other sectors of the economy and to know the extent of influence experienced by the pharmaceutical industries from the other sectors of the economy. In other words, the study of backward and forward linkages will show the interdependencies between the pharmaceutical sector and other sectors in the economy. Based on the I-O model, we also calculated the output multiplier of the pharmaceutical industry to know what role does this industry play for the growth of other industries in the national economy.

In 1936, Wassily Leontief[1] presented the Input-output model, which is a useful technique for analyzing the structure of an economy and for production planning. The Leontief model has been widely in use to estimate backward and forward linkages between industries and useful multipliers so to determine the 'key industries' of an economy and to know what role a specific industry play in the national economy.

There have been quite a few studies on inter-linkages between sectors of an economy along with comparisons of two or more economy in terms of structural changes in production sectors using input-output framework. Some of the literatures are mentioned below that have used input-output model to study the economic impacts of industries. Rumiana Gorska [1] compares the production structure of polish economy with some selected European countries by analyzing the backward and forward linkages between the countries using the input-output model. The analysis reveals that the production structure varies with respect to different countries. The study identified some of the key industries of the polish economy as well as important forward and backward linkage industries in that economy. The study through using Multiplier Product Matrix (MPM) found that the production structure or the economic landscape of Polish economy is identical with some of the European countries. Ilhan and Yaman [2] had a comparative study on the performance of the construction sector in Turkish economy and selected European Union countries based on input-output analysis for two periods, 1998 and 2002. The study used the input-output table to obtain some of the indicators for comparative analysis such as share of the construction sector in Gross National Product (GNP) and National Income (NI), direct and total forward and backward linkage indicators of the construction sector and direct and total construction input from the manufacturing and service sectors indicating the technologies used in output production of construction sector. Ashyrov et al. [3] used the input-output model to study the production structure of blue industries in economies of Finland and Estonia for the period 1995 to 2011. Their analysis involved 34 industries out of which some of the sectors are considered as maritime industries in the study. Their findings shows that maritime industries are weakly linked with other industries in both the economies. When comparing both the countries, they found that fluctuation in inter- industry linkages are less in Finland than in Estonia over the years. The output and employment multiplier of the blue industries estimated from the input-output model reveals that blue industries plays an important role in increasing output and employment in both the countries. Nojszewska [4] studied about the impact of pharmaceutical companies upon the economy such as on net value added, employment, income effect on employees of suppliers and consumers and on public finance. These effects of pharmaceutical companies are studied through a case study of the Sanofi company in Poland in which they have found that pharmaceutical companies has positive impact on the economy and public finance through improving public health. Antaloczy et al. [5] conducted a value-chain analysis of the pharmaceutical industry in Hungary. From input-output table data they found that the industry is weak in forward and backward linkages and the industry is mainly contributing from the indirect value addition. While by conducting interviews they came to know that Hungary's pharmaceutical productions are mostly substantial generic production that is limiting the industry's contribution on the economy. Muratoglu [7] using panel data analysis for the period 2000-2014 found that pharmaceutical

[1] Wassily W. Leontief [6], *The Structure of American Economy 1919-1939*, 2nd ed., Oxford University Press, Fair Lawn, N.J., 1951.

exports positively affects growth in countries with specialization on pharmaceutical products. Zuhdi [8] utilizes the input-output model to study the characteristics of industries in Japan using data for the period 2005 to 2011. They found that industries namely manufacturing, transport and postal services have high economic impact on other sectors and also these sectors get high influences from the external sectors. Moreover, the characteristics of the industries have remained same over the analysis periods. In case of India, a study has been done for the years 1989-90 to 1998-1999 by Munjal [9] where the structural changes of Indian industries over time has been investigated using the input-output model. Bhattacharya et al. [10] uses input-output model to measure total factor productivity growth (TFPG) of different sectors of the Indian economy and find association between TFPG and output as well as employment linked sectors. Their findings show that not all high linked sectors are positively productive and thus require special attention in those sectors to improve their productivity so that they can generate high output or employment through linkage effects. Boudhar et al. [11] uses input-output framework to analyze the relationship between economic sectors and water use in morocco as well as the intersectoral water use relationship. Their result shows that agriculture, hunting and forestry have high direct water use. On the other hand, secondary and tertiary sectors have high intersectoral water use relationship. Bocoum [12] used input-output framework to study the economic significance of mineral and energy sectors for various economies at different stages of economic development. They have measured the multipliers and linkages of the sectors using static input-output model. The result suggested that mineral and energy sectors had a significant role in economic development. Kim et al. [13] investigated the structures and growth patterns of pulp and paper industries of Korea using input-output table for the year 1995, 2005 and 2007. They have studied the production inducement effects, import inducement effects and forward linkage effects of the industries. Ojaleye and Narayanan [14] uses input-output framework for Nigerian economy to study about the production structure and key sectors of the economy. Kecek et al. [15] studied about the significance of the Croatian transport sectors using input-output analysis. They have measured type I and type II output, gross value added and employment multipliers for the years 2010 and 2015. Gersak and Muhaj [16] examined the structure of the Slovenian economy pre- and post-crisis of 2008 using input-output model. They observed change in the structural pattern through shift from services industries to manufacturing during the crisis. They also identified that except for the construction sector most of the key economic sectors preserved their status during the crisis. Kim et al. [17] uses input-output analysis to examine the industrial linkages effects of logistic industries. The study identified that the logistic sectors are interdependent on each other and form a service ecosystem. Bartokova [18] applied input-output model to compare the technical, allocation and import coefficients as well as output, input and import multipliers for two sectors namely agriculture and food production in V4 countries for the period 2000-2014. They also studied the two sectors stability, development similarity and strength of forward and backward linkages.

On this note from the study of the extant literatures we came to acquaint ourselves that there has been very limited study on the characteristics and economic significance of pharmaceutical industries especially for India. There has been no study till date on the input-output analysis of pharmaceutical industry for India and therefore this study is an attempt to contribute on this ground. The broad objective of the paper is to study the forward and backward linkages of the pharmaceutical sectors along with the other main sectors of the Indian economy. Besides, the output and input multipliers of the sectors are also analyzed in the paper. Through this study we can know the strength of different sectors of the economy in terms of boosting other sectors growth and thus will contribute to policy making by prioritizing the growth of the highly linked sectors that will help to improve the state's competitiveness.

2. MATERIAL AND METHODS

The input-output table data for the analysis are taken from “Input Output Transactions Table: India 2015-16” constructed by Chadha et al. [19]. The table is in form of commodity*commodity (C*C) matrix comprising of 131 sectors. For our analysis, we have converted the 131 sector structure to 60 sector structure by aggregation of most related sectors. We have considered drugs and medicine (manufacture of pharmaceutical; medicinal chemicals and botanical products as represented in SUT table 2015-16[20]), no. 74 of I-0 table as the pharmaceutical industry for our analysis. In UN’s International Standard Industrial Classification of All Economic Activities (ISIC) Rev. 4, class 21 defines the pharmaceutical industry as “Manufacture of basic pharmaceutical products and pharmaceutical preparations” which includes basic pharmaceutical products, pharmaceutical preparations, medicinal chemicals and botanical products.

Input-output (I-O) framework is an economic model that represents the inter-linkages of economic activities of different sectors of an economy. The values of the I-O table as used by us are in basic prices in which the row represents the output of the commodity used either for intermediate consumption or for final consumption. The column of the I-O table represents the goods and services used as input for production of the commodity.

In Leontief input-output model, the total output of an industry is equal to the sum of intermediate consumption and final demand of goods and services by household and government.

In matrix notation it can be stated as,

$X = AX + D$

Where,

X is the column vector of sectoral outputs,

A is the square matrix of technical coefficients. Technical coefficient is the input requirement for producing a given amount of goods and services. It is the ratio of intermediate consumption by a sector from a particular sector to total output of that sector. ‘A’ is also known as Input Coefficient Matrix,

D is the column vector of sectoral final demands.

After rearrangements, the Leontief model is represented as follows:

$(I-A)\ X = D$, where matrix I-A is Leontief matrix.

Pre-multiplying both sides by $(I-A)^{-1}$, we get

$X = (I-A)^{-1}D$, where $(I-A)^{-1}$ is Leontief inverse matrix. From vertical summation of coefficients in the Leontief inverse matrix we can derive the output multiplier. The multiplier tells us that for a dollar worth of change in final demand of a sector how much changes in activities occur in all other sectors in the table. The summation of row of Leontief inverse matrix gives us the input multiplier. The input multiplier tells us that for a dollar worth of changes in all other industries how much changes in activities occur for the industry in that row.

To calculate the relative strength of an industry and the inter-industry linkages, forward and backward linkages are estimated from the I-O table. A forward linkage of an industry shows how the final demand changes of all other industries in an economy affects the changes in output of that industry. A backward linkage of an industry shows how final demand changes in that industry affects the output changes in all other industries in that economy. The formula we have used for calculating forward linkages (FL) and backward linkages (BL) are as follows:

$FL = [(1/n)*\text{ input multiplier}] / [(1/n^2)*\text{ total input multiplier}]$ and

$BL = [(1/n) * \text{output multiplier}] / [(1/n^2) * \text{total output multiplier}]$

Where,

FL is forward linkage indicator of an industry,

BL is backward linkage indicator of an industry,

Input multiplier is the row summation of elements of $(I-A)^{-1}$ matrix,

Total input multiplier is the summation of values of input multipliers of all sectors,

Output multiplier is the column summation of elements of $(I-A)^{-1}$ matrix,
Total output multiplier is the summation of values of output multipliers of all sectors,
N is the number of sectors taken for the I-O analysis.
The inter-industry linkages help in identifying the key industries that are crucial for economic development of an economy. If both the forward and backward linkage indicators are greater than one, then we can consider that the corresponding industry is a key industry in leading an economy. Backward linkages say, for pharmaceutical industry would imply that production activities in pharmaceutical industry are linked with greater use of other industries production as input in the pharmaceutical industry. Forward linkage in that case would imply that pharmaceutical industry's production will be available in the form of input for other sectors production.

3. RESULTS AND DISCUSSION

In this part of our research paper, we analyze the results of the calculated inter-linkages of pharmaceutical industry with the other industries and total output multiplier (both direct and indirect) of the pharmaceutical industry using I-O table of 2015-16. We have also considered other industries of the economy for input-output analysis so to make a comparison of the relative strength of the pharmaceutical industry against other industries in the economy. Figure 1 displays the forward and backward linkages of the main sectors of the economy through four quadrants. The X-axis depicts the backward linkages and the y-axis depicts the forward linkages. Each sector belongs to a particular quadrant. Quadrant I is a place where the value of both forward and backward linkages are greater than one. In other words, any sector belongs to quadrant I is a key sector as the sector is most influenced by other sectors and at the same time influences other sectors. In quadrant III the opposite case happens as both forward and backward linkages are less than one. Quadrant II is a place where the value of forward linkage is greater than one whereas the value of backward linkage is less than one. The sectors that belongs to this quadrant weakly influences other sectors but gets highly influenced by other sectors activity. In other words, the sectors in this quadrant are sensitive to the development of other sectors. The opposite happens in case of quadrant IV. Based on the facts from figure 1, pharmaceutical sector and information and communication sector are placed in quadrant I. These two sectors are the key sectors of Indian economy as these sectors highly influences production activities of other sectors and also gets influenced by the external sectors. The least important sectors are agriculture, forestry, fishing and mining as they are weakly interlinked with the external aspects of the economy.

3.1 Output multipliers and backward linkages

With the use of I-O table we have calculated output multiplier of pharmaceutical industry that depicts the effect of change in final demand in pharmaceutical sectors on all other activities. It measures the total effect of a monetary unit change in final demand for the goods and services of pharmaceutical sectors on output of all other sectors. The total output multiplier of the pharmaceutical sector is 2.34 (table 2) which implies that a one unit change in final demand for goods and services of pharmaceutical sector induces 1.34 unit changes in all other sectors. That means the industry highly stimulates production activities in all other related sectors. The total output multiplier captures both the direct and indirect effects[2] of an industry on all other sectors. Table 2 reports that public administration has the lowest output multiplier among all the sectors of the economy with value of 1.48. Whereas manufacturing sector has the highest output multiplier with value of 2.38.

[2] Direct effect points to the industry that we are interested in and the indirect effect points to the industrial linkages evident in the region.

The backward linkages of pharmaceutical industry with other industries indicates to what extend pharmaceutical industry stimulates the production activities of other sectors. From our analysis, we find that backward linkage of pharmaceutical industry is 1.12 which is greater than one. It indicates that pharmaceutical industry is a key industry of the national economy where the growth of this industry can help in boosting other sectors growth. The pharmaceutical industry can cause other industries to increase their production by demanding more input goods from them. The analysis reveals that pharmaceutical industry is strongly backward linked with itself that means pharmaceutical industry uses large amount of inputs from the industry itself. The major backward linked industries (measured in terms of values greater than the average value) with the pharmaceutical sector are crude petroleum, manufacture of chemical and chemical products, land transport and trade (reported in table 1). Based on the facts from table 2, we see that public administration has weak backward linkages with other sectors with value of 0.71 whereas manufacturing has the highest backward linkages with value of 1.14.

3.2 Input multipliers and forward linkages

The input multiplier measures the total effect of a monetary unit change in final demand for the goods and services of all other sectors of an economy on output of a particular sector, say, on pharmaceutical sector. The total input multiplier of the pharmaceutical sector is 0.47 (table 2) which implies that a one unit change in final demand for goods and services of all others sectors induces 0.47 unit changes in pharmaceutical sectors. The input multiplier for agriculture, forestry, fishing and mining are the lowest with value of 0.07 and 0.08 respectively. Real estate, public administration and services have the highest input multipliers with value of 1.07, 1 and 1.006 respectively.

The forward linkage of pharmaceutical industry with other industries indicates that pharmaceutical industry is stimulated by other industries activities. It measures the sensitivity of the pharmaceutical industry's activity to other industries fluctuation. The value of forward linkage of pharmaceutical industry is 1.50 which is greater than one. It indicates that pharmaceutical industry is sensitive to the activities or growth of other industries. It also implies that growth or increase in production in pharmaceutical industries relies on other industries growth. The economic fluctuation in the nation will have impact on the production activities of the pharmaceutical sector since the industry has strong forward linkage with other industries. The forward linkage of the pharmaceutical sector is not extended to many sectors rather the industry supply its production to only a limited sectors. The important forward linked industries or the industries that are heavily dependent on pharmaceutical industry for input supplies are pharmaceutical industry itself and medical & health sector. The important forward linked industries are reported in table 1. Since both the linkage effects are greater than one it means pharmaceutical sector is a key sector in the development process. The development of pharmaceutical sector will induce the development of all other linked industries; also the development of forward linked industries will help pharmaceutical sectors to grow. Among all the sectors of Indian economy real estate, public administration and services have high forward linkages with value of 3.41, 3.18 and 3.21 respectively. On the other hand, agriculture, fishing and forestry and mining have the lowest forward linkages with value of 0.23 and 0.25 respectively.

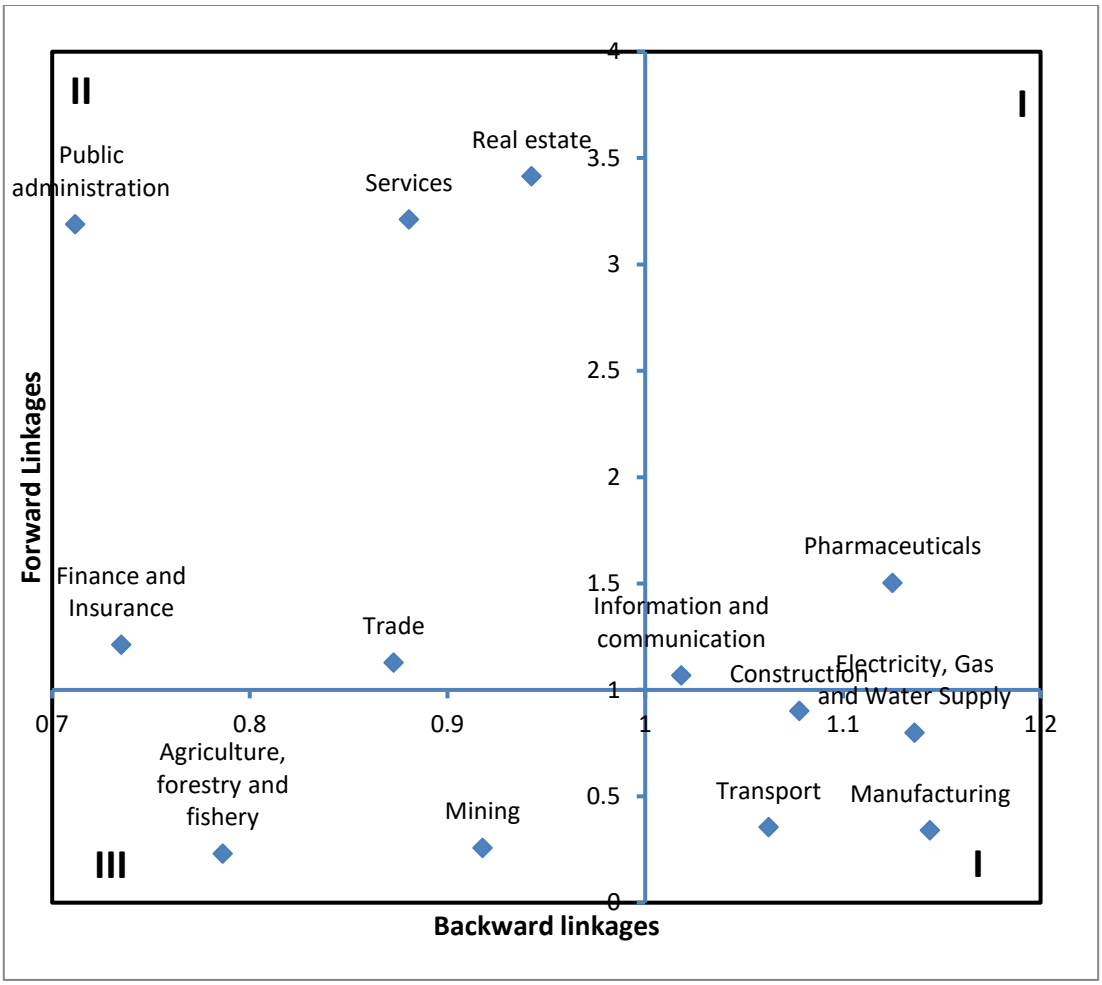

Figure 1. Quadrant view of backward and forward linkages of the sectors of Indian economy. *Source: Author's Calculation.*

Table 1. Forward and backward linkages of pharmaceutical industry in India.

Backward Linked Industries	
Crude petroleum	0.07
Manufacture of chemical and chemical products	0.59
Manufacture of Pharmaceuticals, medicinal chemicals and botanical products	1.17
Land transport	0.04
Trade	0.06

Total backward linkage	1.12
Forward Linked Industries	
Manufacture of Pharmaceuticals, medicinal chemicals and botanical products	1.71
Medical & health	0.46
Total forward linkage	1.50

Note: In the table above only the industries with values greater than the average are reported. *Source: Author's Calculation.*

Table 2. Forward linkages, backward linkages, input multiplier and output multiplier of the major sectors of Indian Economy.

Sectors	**Backward linkages**	**Forward linkages**	**Output multiplier**	**Input multiplier**
Agriculture, forestry and fishery	0.786353	0.23059	1.63789	0.07229
Mining	0.917731	0.257646	1.911537	0.080772
Manufacturing	1.144127	0.340581	2.381449	0.121957
Construction	1.078012	0.900925	2.245387	0.28244
Electricity, Gas and Water Supply	1.13626	0.799616	2.36671	0.394756
Trade	0.872807	1.129045	1.817965	0.353955
Finance and insurance	0.734973	1.21255	1.530873	0.380134
Real estate	0.942617	3.41503	1.963372	1.070612
Transport	1.062441	0.355507	2.212953	0.111451
Information and communication	1.018375	1.068703	2.121168	0.335038
Public administration	0.711619	3.189793	1.482227	1
Services	0.88052	3.211778	1.834032	1.006892
Pharmaceutical Products	1.125144	1.503065	2.343558	0.471211

Source: Author's Calculation.

4. CONCLUSION

The pharmaceutical sector is a key sector in the development process of the national economy. The study uses input-output analysis to identify the economic contribution of the pharmaceutical sector in India. From our analysis we found that pharmaceutical sector is strongly backward and forward linked with other sectors of the economy. The important industries with whom pharmaceutical industries are most backwardly linked are crude petroleum, manufacture of chemical and chemical products, land transport and trade. Pharmaceutical industry is also strongly dependent on its own industry for direct input requirements. Therefore, the industry plays an important role in stimulating other sectors production by means of creating input demand from them. Pharmaceutical industry supplies it outputs to mainly medical and health sector and to its own industry's production units. The analysis of output multiplier of pharmaceutical industry also provides us with qualitative information that can be used for decision in policy making relating to industrial sectors. A one unit increase in final demand in pharmaceutical industry leads to 1.34 unit growth in output of other industries particularly in crude petroleum, manufacture of chemical and chemical products, land transport and trade. While taking into consideration the input-output analysis of the main sectors of the economy we find that manufacturing sector is the most backward linked sector with output multiplier of 2.38. That is, manufacturing sector has the capacity to stimulate other sectors production activities in the economy to a great extend. The highly forward linked sectors are real estate, public administration and service sector with input multiplier of 1.07, 1 and 1.006 respectively. The information and communication sectors and pharmaceutical sectors have both forward and backward linkage effects greater than one and therefore these two sectors are the key sectors of the economy. The input-output analysis provides us with valuable information regarding study of role of an industry in economic development process. This study is entirely a new initiative in using the input-output method to determine the role played by the pharmaceutical sector in India. However, a more inclusive study can be undertaken in future research in regard to analyzing employment multiplier and import dependencies of the pharmaceutical sector using this method.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

AUTHORS' CONTRIBUTIONS

This work has been carried out in collaboration among all authors. All authors read and approved the final manuscript.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

REFERENCES

1. Gorska R. Backward and forward linkages based on an input-output analysis-comparative study of Poland and selected European countries. Applied Econometrics Papers. 2015; 30-50.

2. Ilhan B, Yaman H. A comparative input-output analysis of the construction sector in Turkey and EU countries. Engineering Construction & Architectural Management. 2011;18(3):248-265.

3. Ashyrov G, Paas T, Tverdostup M. The Input-Output Analysis of Blue Industries: Comparative Study of Estonia and Finland. SSRN Electronic Journal. 2018.

4. Nojszewska E. Impact of pharmaceutical companies upon the economy and public finance in Poland: The Sanofi case study. Journal of Management and Financial Sciences. 2018;11(34):113-123.

5. Antaloczy K, Gaspar T, Sass M. The Specialties of the Pharmaceutical Value Chains in Hungary. Acta Oeconomica. 2019;69(S2):41-72.

6. Leontief W.W. The structure of American Economy 1919-1939. 2nd ed. Fair Lawn, N.J.: Oxford University Press; 1951.

7. Muratoglu G. Does Pharmaceutical Industry Boost Economic Growth? A Competitiveness-Related Approach. Journal of Yasar University. 2017;12(48):296-314.

8. Zuhdi U. An analysis of the characteristics of Japanese industrial sectors from 2005 through 2011. IOP Conf. Series: Earth and Environmental Science. 2017.

9. Munjal P. Structural Changes in Indian Economy: An Input-Output Analysis. Indian Economic Review. 2007;42(1):77-95.

10. Bhattacharya T, Rajeev M, Bairagya I. Are high-linked sectors more productive in India? An analysis under an input-output framework. Indian Economic Review. 2019; 53(4). https://doi.org/10.1007/s41775-019-00035-8

11. Boudhar A, Boudhar S, Ibourk A. An input-output framework for analyzing relationships between economic sectors and water use and intersectoral water relationships in Morocco. Journal of Economic Structures. 2017; 6(9).

12. Bocoum B. The Mineral and Energy Sectors and stages of Economic Development: A Comparative Input-Output Analysis. Asian Development Bank, Economic Research Papers No 59.

13. Kim C. H, Moon J. M, Kim E. G, Ahn B. I. Input-output analysis for pulp, paper and paper product industries. Palpu Chongi Gisul/Journal of Korea Technical Association of the Pulp and Paper Industry. 2010; 42(4):45-55.

14. Ojaleye D, Narayanan B. Identification of Key Sectors in a Lower Middle-Income Country- Evidence of Backward and Forward Linkages from Input-Output Analysis. SSRN Paper. 2021.

15. Kecek D, Brlek P, Buntak K. Economic effects of transport sectors on Croatian economy: an input-output approach. Economic Research- Ekonomska Istrazivanja. DOI: 10.1080/1331677X.2021.1931908

16. Gersak U, Muhaj D. Inter-sectoral Production Linkages in Solvenia: An Input-Output Analysis. Bank of Slovenia. 2016.

17. Kim Y, Lee S, Trimi S. Industrial linkage and spillover effects of the logistics service industry: an input-output analysis. Service Business. 2021; 15:231-252.

18. Bartokova L. Input-Output Analysis of Agriculture and Food Sectors in V4 Countries. Journal of Environmental Management and Tourism. 2018;8[5]:1009-1019.

19. Chadha R, Saluja M, Sivamani G. Input Output Transactions Table: India 2015-16. Brookings India. 2020.

20. Ministry of Statistics and Programme Implementation (MoSPI), Government of India. 2015-16. Available: https://mospi.gov.in.

333

334
335