Dynamics of Inter-industrial Linkages in the Economy of Uttar Pradesh

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The paper analyzes the dynamics of inter-industrial linkages for the economy of Uttar Pradesh within the Input-Output framework. It applies the Graph-theoretic approach for the categorization of industrial sectors and sectoral groupings, i.e., cluster analysis. This approach helps in classifying each industry into one of the five categories, namely, the 'transmitter', 'receiver', 'carriers', 'ordinary', and 'isolate' sectors. In this way, six prominent industrial groups have been identified for the state economy. The significant inter-industrial dependency within a specific industrial group implies that it would be difficult to develop a single industry of the group in isolation. The group as a whole should be developed in order to yield maximum gains from the technological links of the sectors in the context of the overall regional development.

Introduction

The purpose of the present paper is to analyze the structural properties of the economy of Uttar Pradesh (UP), India, using Input-Output approach. This state is a geographically large state having highest state-wise population in India. In this paper, the possibility of analyzing inter-sectoral through Graph Theory approach is explored. The applications of this approach into the fields of engineering and computer science are very well known (see, Deo, 1987). But this approach is not very common in the regional economic analysis. However, Lever (1975) used this approach to find the degree of integration in sub-regional economic structure. Following this, Campbell (1975) and Lever (1979) have shown that input-output matrices can be converted into directed graphs for analyzing the structure of an economy.

We are using a disaggregated (64x64) input-output matrix for the UP, which a latest revised version of Input-Output, table. The inter-sectoral linkages derived from 64x64 I-O matrix directed graphs were constructed which shows the flows between linked sectors in the state economy. An adjacency matrix is derived from the I-O matrix. Each sector in this

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matrix is represented as a node (vertex) in the directed graph. The flow of goods or services from sector i to sector j is indicated by and arc (edge) joining the two nodes in the direction $i \rightarrow j$.

Characteristic Features of the Economy of Uttar Pradesh

Using the directed graph analysis, Srivastav (1985) depicts the following main features of the state economy:

- UP has mainly a rural-based, agricultural-based economy in which the agricultural sector has less inter-sectoral dependency than the industrial sector.
- Most of the industries in the state are agro-based industries. The sectoral groups will substantiate this fact later, that the most of the industries in the state are drawing inputs from agriculture and allied activities.
- The capital and intermediate goods industries in UPare still in developing phase. Most of these products are either not being produced within the state or their production is very much inadequate to satisfy the inter-sectoral needs of the state.

Applications of Directed Graph Approach in Inter-sectoral Analysis

There are two specific uses of the directed graphs applying inter-sectoral linkages: (1) Categorization of sectors; and (2) Sectoral groupings, i.e., cluster analysis.

Categorization of Sectors

This refers to the categorization of the sector of an economy, according to their capacity to generate backward linkage impacts. It is supposed that the expansion of any sector transmits impacts through a backward linkage chain to those sectors which supply inputs to the expanding sector. It is possible to get some insight into the functional role of vertices derived from an adjacency matrix. For this purpose, the row sum and the column sum of the adjacency matrix are defined as 'positive degree (δ^+)' and 'negative degree (δ^-)' respectively. The positive degree (δ^+) means the number of arcs directed away from the nodes, i.e., number of lines originating from the sector to other sectors in the present context, whereas the negative degree (δ^-) means the number of arcs directed towards the node i.e., the number of lines terminating at the sector.

Each node in a directed graph may be examined in terms of its positive and negative degrees. These measures are utilized in the classification of each node (each economic sector of the Input-Output matrix in the present context) into one of the five categories, namely, 'transmitter', 'receiver', 'carriers', 'ordinary', and 'isolate' points.

Transmitters are the points, which have finite positive degree and zero negative degree, i.e., all the arcs adjacent to the points are outgoing arcs. Therefore, the transmitter sectors are making payments in rupees to the input supplier sectors and this sector is not supplying significant amount of inputs to other sectors of the economy. Thus, the expansion of a transmitter sector will place increased demands, through the backward linkage chain on all input supplying sectors.

Receivers, on the other hand, are the points, which have finite negative degree and zero positive degree—all adjacent arcs are incoming. Such sectors are input suppliers to one or more sectors in an economy, but they themselves don't use input from the economy. Receivers may therefore, be affected by increased demands placed on them by expanding other linked sectors but will not pass along any backward linked impacts to other sectors. Carriers are intermediate sectors in character. They have one positive and one negative degree. Whereas, ordinary points have finite positive and negative degrees and such points receive and pass along a greater of backward linked impacts than the carriers. In last 'isolate points' have zero positive and zero negative degrees such sectors cannot receive or transmit any inter industry impacts in the economy.

The directed graph of UP economy obtained from its adjacency matrix has been utilized to calculate the positive and negative degrees for each of 64 economic sectors. These sectors have been categorized on the basis of the above classification. This shows that UP's economy has 17 transmitters, six receivers, two carriers, one isolate point, and 38 sectors as ordinary points.

Out of the 17 transmitters, the main transmitter sectors for the economy of UP are construction, dairy products, gur and khandsari, tea and coffee processing, beverages industries, soaps and glycerin, trade and commerce, and services. On the basis of structural characteristics of the transmitters, these sectors deserve a special attention in a development plan for the state economy because expansion of these sectors would be passing growth impulses through backward linkage chain to those sectors which supply inputs to them. This way the development of transmitter sectors will accelerate the growth of other sectors in the economy.

On the other hand, oils, agricultural byproducts , tobacco, fruit, vegetable, and spices are among the sectors which depict the characteristics of receivers. If such sectors are to be developed then more inputs will be available for them and their growth will be accelerated further. Potassic fertilizer is a typical sector in the state economy, which is isolated in character. This sector has zero positive degree because it is used insignificantly as an input in other sectors and it has zero negative degree because it is not being produced in the state.

Rest of the sectors of the state economy displays the characteristics of 'carriers' and 'ordinary points'. These sectors are intermediate in nature, as they have more or less balanced transmission and absorption effects. Such sectors generate both backward and forward growth linkage effects in the economy of the state.

The linkage effects of different sectors in backward and forward direction derived from directed graphs are important in the context of the identification of the priority sectors. Whether more weight should be given to the backward or forward linkage effect of a sector is an open question in the context of unbalanced growth strategy.

Sectoral Grouping: Cluster Analysis

Another use of the directed graph analysis in studying the inter-sectoral relationship in the context of regional planning is concerned with the identification of groups of the

economic sectors in the form of clusters. The procedure adopted for the formation of certain grouping of the sectors is as follows:

As mentioned earlier, the column total of the adjacency matrix (negative degrees) is defined as the intensity of the sectoral backward linkage. All the sectors were then arranged in the descending order of backward linkages. The key sectors are defined as those sectors which are having higher ranking in the order of sectoral backward linkages because these sectors are having high degree of linkage with other sectors. So any increase in the level of production of such sector transmits growth impulse to many other interconnected sectors and this way key sectors play an important role in regional economic development.

Some of the sectors, which are having top ranking, identified on the basis of backward linkages for UP's economy, are Wrapping, packing-filling and plastic materials (wpfm) (rank I); Non-electrical equipments (rank II); Metal products and Miscellaneous food preservation (rank III); Transport equipments (rank IV); Non-metallic products; and, Sugar, Cotton textiles and Miscellaneous chemicals (rank V). Three sets of sectors were identified on the basis of structural similarities. Adding three other sectors constitute six nuclei key sectors, which could be used as the starting point for the sectoral groupings. These six nuclei sectors are (1) Sugar and miscellaneous food preservation; (2) Miscellaneous chemicals; (3) Wrapping, packing-filling and plastic materials; (4) Metal and non-metal; (5) Electrical equipments; and, (6) Transport equipments.

The next step towards sectoral grouping is to derive the distance matrix from the adjacency matrix and directed graphs. A distance matrix indicates by an appropriate entry in each cell, d_{ij} the number of steps along a sequences of arcs providing the shortest directed path from i to j, if such a directed path exists; j is 'reachable' from i, if it does not exists, then j is said to 'unreachable from i, the entry d_{ij} will be ∞ in this case. The distance between two nodes of a directed graph is the length of the shortest path joining them. The distance matrix derived from the adjacency matrix for the state economy is a symmetric matrix of the order of 64x64. It is used for further sectoral groupings for the six nuclei key sectors. The sectors were identified for each of the key sector, which is directly or indirectly connected, and with the number of steps these are reachable to the specific key sector. This is displayed in the form of vector diagram, which shows the intensity, and direction of the inter-sectoral linkages with the key sectors. In this way, the directed graph for each key sector is obtained in the form of group of sectors called cluster of sectors around the specific key sector[1].

This type of grouping of sectors is useful for two reasons. Firstly, a group of sectors consists of mutually 'reachable' points. Therefore, it shows cluster of industries closely linked together. A change in output of any one sector within the group will be influencing every other sector of the group. This characteristic of the mutually interdependent sectors, shown by group, may allow the group as a whole to be taken as a composite unit for planning purposes. Secondly, this sectoral grouping simplifies the inter-sectoral relationships confined to within a group, rather than more complex set of relationships between all the sectors of the economy.

[1] (The group-wise directed graphs are not being reported here because of their large sizes. However, these graphs are available with the author on request.)

The sectoral groups derived from the input-output table for the state economy of UP are being described below:

Sectoral Group A: Sugar and Miscellaneous Food Preservation

There is one transmitter in this group, the Beverages industry, which takes inputs from a Sugar and Miscellaneous Food Preservation. Beverages industry has a strategic importance because large share of its output is used as final demand (92.72%) and a sizable proportion of the total output (10.5%) is exported. On the other hand, the proportion of value added to total output of this sector is 0.42 ,which is quite high, compared to other sectors. Hence, this sector is both income and export oriented. The major input supplier to the beverages sector is sugar, which is itself a major product of the state. The expansion of sugar industry has the backward linkage effect on sugar cane, services, and other textiles sectors. The other textiles sector includes bleaching and jute textiles. Sugar cane has its feedback effect on production of nitrogenous fertilizer.

The second sector, which supplies inputs to the beverages industry, is miscellaneous food preservation industry, which is itself directly linked with vanaspati, oils, forestry, wpfm and grain mill products and indirectly linked with cereals, pulses, canning preservation, glass and glass products and fruit, vegetable and spices sectors. The expansion of this group of industries may lead to increase in wage earnings and additional employment opportunities in these sectors.

Sectoral Group B: Miscellaneous Chemicals

There are two transmitters in this group, namely, dairy products, and drug and pharmaceuticals. Dairy products take input from animal husbandry, wpf materials and miscellaneous chemicals. Miscellaneous chemicals in turn take inputs from wpf materials, miscellaneous food preservation, wooden products and forestry. Miscellaneous chemicals also supply inputs to nitrogenous fertilizer, dairy products and drug and pharmaceuticals sectors. This inter-sectoral dependence reflects a strong link mutual complimentarity between industry and agriculture sector in the state economy. In this context, dairy products as a transmitter sector have a strategic importance in the development plan of the state economy.

Sectoral Group C: Wrapping, Packing-Filling and Plastic Materials (wpf Materials)

Wpf materials sector has the highest number of inter-sectoral linkages. It is connected with as many as 15 sectors. This sector supplies inputs to a large number of sectors like, construction, dairy products, tea and coffee processing, beverages industries, cigar and cigarettes, and miscellaneous chemical industries along with other sectors. This sector takes inputs mainly from the sectors like wooden products, animal husbandry, oil seeds, miscellaneous chemicals, and power. Due to high forward and backward links of this sector, its development would pass the growth impulse to large number of linked sectors.

Sectoral Group D: Cotton and Other Textiles

Cotton textile is one of the major industrial products of the state. A major proportion of the output of this sector is used by the households for final consumption. This sector takes inputs from fibers, cotton and cottonseeds, other textiles, miscellaneous chemicals and

wpf materials sectors. Other textiles sector shows links with woolen textiles, fisheries and miscellaneous chemicals and cotton textiles sectors. The animal husbandry sector supplies inputs to woolen textiles.

Expansion of cotton textile sector has its backward growth impulses directly on miscellaneous chemicals, other textiles, fibers, cotton and cottonseeds, and wpf material sector. Growth impulses will further affect the regional expansion of those sectors, which are indirectly linked with cotton textile sectors like woolen textiles, animal husbandry and fisheries, and byproducts of agriculture. This sector is highly labor-intensive sector; so, development of this sector will create additional employment opportunities.

Sectoral Group E: Metal, Non-metal and Electrical Equipments

This group of sectors is slightly more complex than the earlier ones since it contains a cluster of both intermediate and capital goods industries. There are three key sectors in this cluster as it is mentioned in the title of the group. These sectors have significantly high inter-industrial linkages. Metallic products take inputs from non-ferrous metals and in turn supply inputs to construction, paints and varnishes, dairy products, and iron and steel. Non-ferrous metals take inputs from the sector of mining, petroleum products and coal and coke and supply inputs to the sectors of metal products and non-metallic products. Similarly, non-electrical equipment sector takes input from iron & steel and non-ferrous metals and supplies inputs to printing and publishing.

Metallic and non-metallic products are the major industrial products of the state economy. A significantly large proportion of total output of these sectors is being produced in the unorganized sector of the economy, which is more labor intensive by nature. Thus, the encouragement for the development of the transmitter sectors will apparently increase the employment potential and spread of the entrepreneurship in small scale and unorganized sectors of the economy.

Sectoral Group F: Transport Equipments

This sector derives its main inputs from iron and steel, electrical equipments, rubber products, petroleum products, and power sector. Output of this sector mainly goes to the sectors like railway transport and motor and other transports. Rubber product sector takes inputs from power, other agricultural products, wpf materials, synthetic rubber, miscellaneous chemicals, and service sector. Synthetic rubber, in turn, takes inputs from petroleum products, miscellaneous chemicals, coal and coke and beverages industry. Electrical equipments sector, which is an important sector in the group, takes inputs from the sectors like iron and steel, metallic products, non-ferrous metals and services. It provides inputs to transport equipments sector.

The transport equipment sector has inter-sectoral links with almost all the sectors in the group. It is a crucial sector for the infrastructural sector like transport facilities in the state economy. But this sector is not fully developed in the state. One of the possible explanations for the underdevelopment of this sector could be that the required inputs are not adequately produced in the state.

Conclusion

It has been conceptualized in this paper that the directed graph theory approach applied to inter-sectoral flows reveals certain structural features of the economy, which would otherwise be difficult to identify and analyze by using simple input-output linkages analysis. The directed graph for the 64 disaggregated economic sectors of the state economy are derived from the adjacency and distance matrices used for sectoral groupings around the six nucleus sectors.

The inter-sectoral dependency within the group implies that it would be difficult to develop a single sector of the group in isolation. The group as a whole should be developed in order to have maximum gains from the technological links of the sectors in the context of overall regional development. The directed graph approach used in this paper has a number of limitations. Firstly, a considerable amount of information content of the input-output table is lost in the derivation of the binary adjacency matrix. Secondly, inter-group relationships have not been discussed in this approach. Thirdly, this approach does not measure feedback effects quantitatively. This approach is static in nature and based on direct impact only, the indirect and induced inter-sectoral effects cannot be measured using this approach.

Reference # 21J-2006-05-01-01

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