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# Viewing economy as a network: An exploration through input-output model

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# Abstract

National Innovation System is a departure from viewing entrepreneurship as individual-agent based phenomenon. Viewing economy as a network system gives a perspective to make interventions for innovation at systemic level. In this paper, by identifying the network properties of the Indian economy, using input-output data sets, we provide evidence for co-movement of economic growth, employment and betweenness of the sectors in input-output network of Indian economy. We argue that by structurally repositioning the sectors of economy (by generating new ties or strengthening existing but weak ties), it is possible to create opportunities for innovation, which will have multiplier effects through chains of economy. By examining the structure of the networked Indian economic system, we identify integration of services particularly that of transportation services to be the primary challenge for growth and innovation.


**Key Words: Input-output network, economic growth, innovation**

**JEL Codes: R15, O53, P41, D57**

**Introduction**

An integrating feature of neoclassical literature on economic growth is the tendency to factor out the growth, and seek sources of economic growth (Solow, 1956). It is important to note the notion of decomposing growth has immense impact on macro economic governance. For instance, wider prevalence of growth accounting, especially related concepts such as total factor productivity, bears testimony to this. Although, the growth accounting assumes the main stream status in growth literature and economic policies, there are alternative scientific lineages, not just focusing on decomposing the sources of growth, but more inquisitive about processes that shape growth, such as entrepreneurship. For instance, evolutionary economics (Schumpeter, 1934, Nelson and Winter, 1982), instead of factoring out economic growth historically, articulate perspectives giving pivotal role to entrepreneurship, innovation and evolution. A salient aspect of evolutionary view is the metaphors used are based on phenomena such as interdependence, evolution, adaptation, strategy and innovation.

The relationship between entrepreneurship and economic growth is complex. Often, entrepreneurship is seen as a micro phenomenon, where an individual or group of individual takes lead bringing a particular effect in one of the sectors of economy. However, economy in itself is an inter-dependent complex macro system. The effect of entrepreneurship on this macro system has its limits, especially in setting system wide sustainable inclusive economic growth. The natural question arises as to if the effect has to be systemic, what sort of entrepreneurial activity is required? Taking this inquiry forward, we present a systemic view of Indian economy through input-output analysis, using national data set. Adopting the theories of economic sociology and network approach, we identify key nodes and ties in the Indian economy where entrepreneurial activities could make systemic changes.

An interesting stylized fact, during last two decades (since 1980), emerging in Indian economy is jobless growth[1]. Quite interestingly, for primary and secondary sectors during 1980-2005, employment over a period of time resembles inverted U shape, clearly indicating deceleration of employment generation as economic activity goes up (Datta *et al*, 2007). Further, employment elasticity, often cited measure of employment absorption in GDP, has been steadily declining during this period. On the one hand, employment generation is on decline, on the other hand there is little convincing evidence that supports increase in the quality of labour. Moreover, proportion of labour force with vocational training is dismal and much lesser than growing economies like Korea. A recent view gaining popularity among entrepreneurs is that labour force does not necessarily mean employable manpower, thus, a significant proportion of labour force remain unemployed.

It is doubtful if Indian policy makers and planners have developed a strategic approach to enhance the employability of labour force, instead the concern has been about status of employment as a measure of welfare. The moment economic growth is linked to employability; the understanding of economy can not escape interdependence and complexity. This constrains conventional "vector-based" research design addressing the economic growth and employment.

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[1] In contemporary times, although Indian economy is frequently cited as a case of fast economic growth, data on employment rather give a dismal picture; Jobless growth seems to be a reality in India. However, the phenomenon has no significant presence in tertiary sector, especially in emerging sectors such as Information Technology Enabled Services (ITES), retail, and financial services.

In this paper, taking cues from inter-sectoral interdependence in Indian economy, we examine a possible link among betweenness[2], employment and economic growth. This paper is organized in three sections. Section I identifies the gaps in the existing growth literature, by exploring mainstream perspectives and alternatives. We argue, falling in line with recent perspectives in evolutionary economics and economic sociology, that network metaphor of economic system has the potential for generating explanations linking growth, employment and innovation, by understanding the structural aspects of the economy. Section II describes the input-output model, network measures, and data used in this study. Section III is a discussion based on the network analysis of Indian Economy.

## Section I

### Growth and innovation possibilities in network

We address an important issue: Given the complex - interdependent – transactions, to what extent decomposing growth into aggregate units, such as labour and capital, represent reality? A tractable answer is by aggregating data, be it time series, cross section, panel, meet the requirements of frames such as axiomatic, algebraic and so on.[3] However, innocence couched in this approach, with overconfidence in theory, may hardly throw any insights on ever evolving complex transactions in an economy. For instance, tractable models such as Cobb-Douglas form the base for most of neoclassical growth empiricism, producing estimates by regressing output vector on input vectors.

[2] Betweenness is a network measure to understand whether the other sectors of the economy are centred around a particular sector. Higher the degree of betweeness implies that sector has strategic significance. This measure is explained in detail in section II.

[3] It is worth quoting Mirowski (1991) reflecting on the limitation of the quantification in the economics (p 155): "Quantification is itself not an invariant in human history, even within the more limited subset of market organized structures. Prices in modern markets obviously conform to specific algebraic structures. Prices in modern markets obviously conform to specific algebraic structures, but they are not the a priori products of nature or of the individual mind (through projection of completeness, reflexivity, transitivity, and so on upon preference structures); rather, they are provisional invariances imposed upon the motley variety of human perception by various conventions and social structures… If this be the case, then the argument becomes stronger that the mathematization of economic discourse should not be traced to natural quantification of commodities, but rather should be explained empirically by changing social perceptions of the symmetries and invariances read into market activities through the instrumentality of social institutions."

Over a period of time, spanning over five decades since 1950, 'growth empirics' grew in volume mainly focusing on data organization, robustness and so on, while, not much attention was given to represent the processes such as evolution, agents of change, and strategies to adapt. Although, the neo-classical models, as discussed above, vary in modeling approaches, share an integrating aspect. These models show how economies grow over time through dynamic processes, with some complex characteristics. For example, Solow's (Solow, 1956) growth process is represented first order difference equation. Quite interestingly, taking cues from, May (1976), even simple models, like first order difference equation, can be the source for complexity. Post-Solow growth theories (especially endogenous growth schools such as Luckas, Romer among others)[4] were more concerned about sources of economic growth, hovering around more accurate de-composition of economic growth, using vector-based empirics. However, it is important to note that endogenous growth models, especially Romer, have made a significant departure from decomposing the 'growth notion' (Romer, 1990). Romer brought the issue of non-convexity – value being higher than the marginal product – as a challenge to the growth empirics. Following this, a new scholastic tradition of technology spill-over school became more prevalent in the growth literature.

There is an important missing link in Romer's lineage. Although, Romer views knowledge as an important source of growth, since it generates spill-over resulting in increasing returns, he does not explore the process of knowledge activity. Viewing knowledge as a process entails inter-dependent complex processes, more as a network. A recent development in the field of economics of innovation is the explicit acknowledgement of the role of networks in economic system, particularly in knowledge activity (Cowan and Jonard, 2001). As viewed by Cowan and Jonard knowledge activity is an interactive process within a network, rather than an outcome. Given this perspective, accepting knowledge as a source of growth, as explicated previously by endogenous school, is tantamount to propose networks play a significant role in economic growth. Upholding the importance of network in explaining economic growth, there is a need for exploring alternative way of viewing economy, as a network, as a set of interactions.

[4] This is not meant for discounting the new insights these scholars brought to the growth literature. In fact, the identification of knowledge as a source of growth was really path breaking.

There is scope for drawing parallel between network metaphors applied to knowledge activity (as Cowan has done) and seeing the whole economy as a network. In this paper, we, using input-output model, examine network form of Indian economy, mainly to investigate change born out of transactions of raw material in economy. Economic growth takes place as an outcome of interactions within a network, more importantly dynamic processes such as innovation.

**Networks of innovations for economic growth**

Innovation, has been gaining scholarly attention, involving experts from a variety of disciplines such as neo-classical economists, evolutionary economics, strategic management, organization science and so on. The perspective born out of these scholarly lineages have two major impacts. First, they helped to contribute insights about local and economy wide innovation policies. For instance, the concept of National Innovation System (OECD 1997) is an off-shoot of this. Second, different schools, using a variety of approaches, identified agents of innovation. Of these, Schumpeter's identification of sources of innovation is an illustrious example.

A supposedly received view, integrating most of the innovation literature, treats the innovation process stemming from initiatives by agents like entrepreneur or institutions like venture capital market or interaction of both, but not as a phenomenon born out of interactive processes in an economic system as whole. A probable reason for inadequacy of an economic system approach for innovation is lack of data base. So, an important question remains: can innovation be viewed as economic system-wide process? We argue in this paper that, to get cues of an economic system-wide innovation, it is important to see economic system as a network of interaction between sectors. Interestingly, Leontif's input-output model, representing the transaction between the connected sectors in an economy, aptly exhibits a form of network with interactions and chains.

Inability to understand the interactions in the network system could heavily retard the possibility to innovate. The pattern of interactions points out the structure or shape of system, within which individual actors interact. The entrepreneurial success will, to great extent, depend on the possibility to alter the interactions between sectors, and to establish new links (or ties) with other wise isolated or weakly connected sector.

National Innovative System, for setting the economic growth, needs to consider the form of interdependence in an economy represented by interactions between sectors, more explicit in transactions between them. This enables the system, by unraveling the shape and structure of economy, to adapt to complexity emerging from changes be it endogenous or exogenous. Exchanges in an economy, involving flow of information, technology transfer, price determination and transaction of raw material between sectors, firms, intermediation by institutions and initiatives by individuals are important for this kind of analysis. In this paper, we are primarily examining the empirical situation of the flow of raw material between sectors. It goes without saying that other aspects listed above, which may be embedded with the raw material supply, deserves to be studied in their own right. Quite importantly, as identified by Schumpeter (1934) sources of raw material are one of the sources of innovation, which entrepreneurs explore for setting ventures and make profit.

Network of economic systems could be defined as an arrangement of different sectors of economy through linkages or various ties. The ties between two sector indicates the exchange between them. Uzzi (1997) distinguished two types of exchange: arms length and embedded. In the context of networked economic system, the arms length tie could be identified through thin line or small volume of transaction, which may be sporadic in nature. On the other hand, the transaction between two sectors in an embedded tie would be significantly high volume. However, the strength or usefulness of a tie can not be estimated merely from the high volume of the tie. As Granovetter (1973) has shown, in a dense structure, much of the information circulating may be redundant, and a weak tie may be useful for bringing innovation through key information or raw material as in our case. Thus, strategic location of the economic sectors[5] may be crucial for the stability of the system as well as economic growth.

[5] One school of thought from the innovation literature that comes closer to this sort of analysis is Michael Porter's (1990) cluster theory of innovation systems. Three key factors for the innovation capacity is 1) infrastructure including financial, human and policy resources, 2) cluster specific aspects such as demand and competitiveness and 3) linkage qualities, both formal and informal networks (Porter and Stern, 2001). Interestingly, from network literature, Burt (1992) has suggested the

## Section II
## Methodology

In this section, we will discuss the input-output model and its theoretical basis, the network measures used in this paper and the data we have used in this paper to analyse input-output transaction in the economy.

### IO Model: An Overview

An IO model describes the interdependence between sectors in an economy. In other words, it simply shows the transaction between sectors. The scope of transaction mainly covers three purposes namely (i) sell or buy inputs (ii) sell or buy goods for final consumption, and (iii) sell or buy goods for future use. Here, input implies raw material being used for producing another goods or services, known as intermediate consumption while final goods and goods for future use refer to final consumption and capital formation (i.e. investment), respectively. Interestingly, an output may be transacted for all three purposes. In other words, output of sector *i* may be demanded for intermediate uses by *i* itself and the sector called j, and whatever remains be sold as final good or investment.[6] Terming IO as a 'system of interdependent processes forming a network', Leontief (1974, p 823) describes what an IO is

> The world economy, like the economy of a single country, can be visualized as a system of interdependent processes. Each process, be it the manufacture of steel, the education of youth, or the running of a family household, generates certain outputs and absorbs a specific combination of inputs. Direct interdependence between two processes arises whenever the output of one becomes an input of the other: coal, the output of the coal mining industry, is an input of an electric power generating sector. The chemical industry uses coal not only directly as a raw material but also indirectly in the form of electric power. A network of such links constitutes a system of elements which depends upon each other directly, indirectly, or both.

Quite clearly, Leontief says that interdependence is a core feature of any economy, and therefore, Leontief points out, is that links between sectors can form a network.

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importance of selectively (getting rid of the redundant ties) maintaining those ties that bridge the 'structural holes' for a more efficient system.

[6] It is important to note that the nature of use partly indicates the nature of an economic system. For instance, those economies, just with intermediate consumption, are called closed economies while economies with all three types of consumption are identified as open. However, it will be difficult to find the cases matching the limits of the extent of openness. In reality, economies show varying degrees of openness; it can be low or medium or high.

Taking cues from Leontif's description of IO, we show a simple IO model (Table 1). In the model, given in table 1, there are two sectors in an economy namely Agriculture (A) and Industry (I)[7].

**Table 1: A simple IO model**

| | Agriculture | Industry | Final Demand + Capital Formation | Output |
|---|---|---|---|---|
| Closed System | | | | |
| Agriculture | *a* | *b* | *zero* | ***A*** |
| Industry | *c* | *d* | *zero* | ***I*** |
| Value Added | *Zero* | *Zero* | | |

a = Units of output from Agriculture to itself,
b = Units of output from agriculture to Industry,
c = Units of output from industry to Agriculture,
d = Units of output from industry to itself,
A = Total Output from Agriculture,
I = Total Output from Industry,

Table 1 can be converted into matrix form by using the following ratios. These ratios are known as technology coefficients.

$$a_{11} = \frac{a}{A},\ a_{12} = \frac{b}{I},\ a_{21} = \frac{c}{A},\ a_{22} = \frac{d}{I}$$

Using these ratios we can say how much input is required for producing 1 unit of output in each sector. For instance, one unit of A requires $a_{11}$ and $a_{21}$ units of A and I, respectively.[8] In this paper, we use technology coefficients for making the network representing transaction of raw material between sectors.

**Network measures[9]**

We use the following network measures to examine different structural aspects IO network such as interconnectedness, nature of relation between two sectors, coherence of the structure and the pattern of exclusion of sectors from the economy.

[7] Basically, IO models are of two types: closed & open. The closed system consists of transaction of raw material between sectors in the economy, excluding sources of factors of production and final demand. Whereas, open system contains transactions involving raw material, value added by factors of production, and final demand. Paul et al (2007) provide a comparison of closed and open IO systems.

[8] Value of technological coefficients ($a_{ij}$) varies from zero to one.

[9] Network measures explained in this section are widely accepted (e.g. Wasserman and Faust, 1994).

**Connections between sectors**

Distinction of directed and non-directed nature of the ties/lines that connect two sectors is one of the most important measure of understanding network. When there is a symmetrical relation between two nodes,[10] the pertinent question is whether a relation exists or not. In the case of asymmetrical relations, the direction (from which sector to which sector, and whether reciprocity exists) becomes important. In the case of input-output data set, it is obvious that direction is crucial, and therefore the relationship between two sectors is asymmetric. As a result, merely counting the degree of connections (with how many other sectors one sector is connected) does not inform sufficiently. Therefore, we examine as to how many sectors one particular sector is giving out raw materials (out-degree), and from how many sectors one particular sector receives raw material (in-degree). It is also likely that a sector provides raw materials for the same sector. As a result, unlike the social network data, which does not emphasise self-relation (or self-loop), in input-output analysis self-relation is an important measure.

**Strength of the tie**

In the input-output analysis, the volume of input and output is important, and this is operationalised as strength of the tie/link in this study. Therefore, each of the lines are valued in this network. However, as we will see, there are only two sectors which do not have any connections with other sector, and thus presents a very complex system pausing challenges to understand the patterns. It is important to distinguish a thin line from a thick line while understanding the structure of a network. Therefore, we have binarized the volume of flow with three cut-off measures. These are explained in detail in next section where we describe the data. However, binarized information has its own severe limitations, and therefore we have used the volume of transactions wherever relevant, for example while computing betweenness.

**Density**

'Density' is a measure used to understand the cohesiveness of a group of nodes. The density of a network is calculated as the proportion of actual lines to that of the maximum possible lines. Maximum possible lines for a directed graph, with self-loop is

[10] 'Node' represents a sector and therefore both are interchangeably used in this paper.

calculated using the formula $n(n-1) + n$, where $n$ is the number of nodes. These measures are easily calculated using software, and we have taken the aid of Ucinet.

**Centralization index**

The concept of 'centrality' is a critique of the concept of degree. It signifies that it is not enough merely to look at the number of contacts an actor has, but the positioning of the actors in the network must also be considered. Using this measure, we examine how far a set of nodes (in our case the sectors that supply raw materials in the economy) has a centralized structure. Density as a measure is examining the cohesion among the relational pattern within the nodes of graph, but does not say anything as to whether this cohesion is organized around particular nodes. Centralization index measures this. Therefore, by calculating the node centralities, we need to arrive at a centralization index for the whole graph. Centralization, "is the ratio of the actual sum of differences to the maximum possible sum of differences" (Scott, 1991: 93).[11] Centralization index of a graph is calculated from the centralization properties of individual nodes. We have used the measure of betweenness to calculate centralization property of each node. Bonacich (1972, 1987), the proponent of the measure of betweenness, made a distinction between 'actors who are connected to each other already' and 'actors who function as connections of unconnected actors'. Bonacich argued that being connected to already connected actors makes an actor central, but not powerful. This concept is important because an actor placed at strategic points is able to function as a broker and gatekeeper (Scott, 1991).

**Inclusiveness**

Some of the sectors getting isolated from the interaction (of raw material exchange in the case of this paper) is an important feature. For instance, exclusion of the sector of education and research may have important implications for innovation. Inclusiveness as a measure of network, examines how far economy is integrated and able to hold together the sectors with links. The calculation for inclusiveness is done by dividing the connected number of nodes by total number of nodes. The measure of inclusiveness varies between 1 and 0, where 1 is perfect inclusiveness. Though self-loop

[11] There are at least three ways of measuring centralization. We adopted Freeman betweenness approach, which is sensitive to 'chaining' effects of the nodes (Freeman, 1979). We have carried out this estimation without binarizing the data.

is an important measure in our paper, while calculating inclusiveness, we have not taken self-loop into consideration, because connection with other sector is the focus while calculating inclusiveness.

**Source of Data and Scheme of Analysis**

The first IO system in India was published by the Central Statistical Organization (CSO) in 1978 which accounted input-output flow for the year 1968-69. The IO system was jointly made by the CSO and the Planning Commission. Following this, the Reports for the reference years 1978-79, 1983-84, 1989-90, 1993-94, and 1997-98 were published in 1989, 1990, 1997, 2000, and 2002, respectively. The Indian IO system consists of 115 sectors. During 1978-2002, barring marginal changes, sector definitions remained same. The first 32 sectors represent primary production, the next 66 sectors represent manufacturing industries and the remaining 17 sectors deal with the tertiary activities (i.e. services). In the primary production, 17 categories belong to agriculture, 3 to animal husbandry and 1 each to forestry and fishing and the remaining 10 to mining. For manufacturing industries, dis-aggregation is based on 4-digit level of National Industrial Classification (NIC), 1998. Tertiary activities consists of services such as construction, electricity, gas, water supply, railway transport, other transport, storage and warehousing, communication, trade, hotels & restaurants, banking, insurance, ownership of dwellings, education, medical and health and other services. All transport activities other than railways are clubbed under a single sector namely other transport[12].

The network, considered in this study, has 115 nodes (i.e. sectors). For the analytical convenience, we set three cut-off values, mainly for reducing the sparsity of the network. Any cell in the network, which is less than the cut-off value, is treated as zero or otherwise one. Three cut-off values are as follows: 1%, 5% and 10%. For instance, suppose the technological coefficient, for the transaction, from sector i to j is 0.08 (i.e. 8 %), this means the coefficient is treated as zero (tie between i and j non existent) when the cut-ff value is 10 % while the same will be given a value of one when the cut-off value is 5% or 1% (tie between i and j existent). As explained earlier, where

[12]The model, methodology and data are given in the website of Ministry of Statistics and Programme implementation, Government of India. The content can be downloaded free of cost from http://mospi.nic.in/cso_rept_pubn.htm.

we described about the strength of ties, we have used weight of the ties while computing certain measures like betweenness. For each of these cut-off values, different graph is drawn. The conversion of IO into graph is done with the help of the software 'Ucinet 6'.

To illustrate this point, we present the network of the sector of electricity (Figure 1). Though the sector provides (indicated with the direction of the line) raw material to 104 sectors, only 6 of the ties have 10% and above weight, including the sector of electricity it self, which can be seen as a loop in the diagram (for the sector of Organic heavy chemicals too there is a loop). In similar way, though 50 sectors provide raw materials to electricity only the sector of Coal and lignite satisfied 10% cut off.

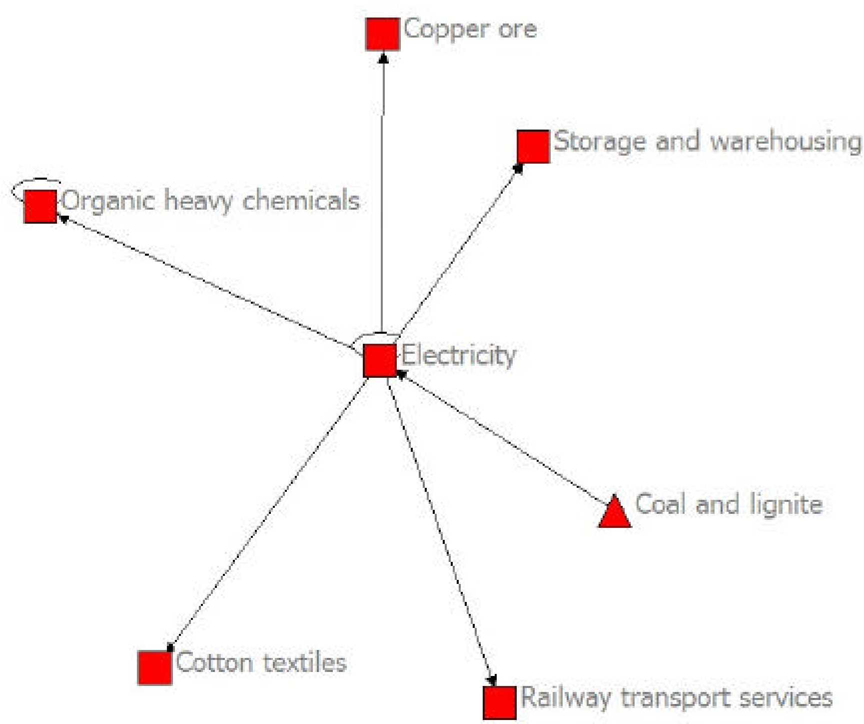


**Figure 1**: An illustration of input-output network of electricity sector satisfying 10% cut-off for 1998-99.

## Section III
## Identifying key sectors and clusters of sectors for growth in the networked economy

It is important to get a summary of structural aspects of IO network, such as nature of inter-connectedness, degree of cohesiveness, key positioning of the sectors and degree of concentration of economy around some key sectors. Table 2 gives basic network measures for IO network of 1993-94 and 1998-99, namely, number of nodes, number of connected nodes, inclusiveness, maximum possible lines, number of lines present, number of nodes with in-degree and out-degree, density and centralization index. From the table it is apparent that the network measures, except centralization index, for 1993-94 and 1998-99 irrespective of weights show high degree of stability, with near stagnation or slight drifting. However, centralization index show a markedly different behaviour. The index, independent of cut-off weights, show significant decline between the years 1993-94 and 1998-99. In fact, centralization index is an aggregate measure representing the positioning of the nodes of a system. In other words, a higher centralization index would indicate a system in which nodes are structured around one particular node or cluster of nodes, while a lower value mean a structure with scattered nodes. Therefore, it is plausible that during the period of analysis structure of economy became more decentralized, perhaps impacted by economic reforms.

Centralization index is computed using the betweenness score for each of the node. Therefore, to understand which sectors of economy have experienced lowered central position, we need to examine the betweenness scores of each sector. This is presented in Appendix 1 along with the measure of in-degree and out-degree for each sector. Quite convincingly, as given in Table 3, tertiary sector registers highest degree of betweenness irrespective of weights and years, followed by secondary sector. The sector of ‘Other Transport Services’ records the highest betweenness score (743.27), indicating the significance of infrastructure in triggering of economic growth.

Further, this finding may have important cues for shaping innovation policy for attaining higher economic growth. Perhaps, in a National Innovation System, a consciousness of hierarchy of economic activities based on betweenness, thus acknowledging the structural importance of some sectors, could have manifold results positively impacting the whole network. Given this view, it is important to compare the

**Table 2: Summary of network measures**

| | 10% | | 5% | | 1% | |
|---|---|---|---|---|---|---|
| | 1993-94 | 1998-99 | 1993-94 | 1998-99 | 1993-94 | 1998-99 |
| Number of nodes | 115 | 115 | 115 | 115 | 115 | 115 |
| Number of connected nodes | 80 | 85 | 107 | 107 | 114 | 114 |
| Inclusiveness (measured without loop) | .70 | .74 | .93 | .93 | .99 | .99 |
| Maximum possible lines | 13225 | 13225 | 13225 | 13225 | 13225 | 13225 |
| Number of Lines present | 107 | 107 | 299 | 290 | 1039 | 1053 |
| Number of nodes with indegree (with loop) | 75 | 79 | 99 | 98 | 114 | 114 |
| Number of nodes with indegree (without loop) | 61 | 69 | 96 | 99 | 114 | 101 |
| Number of nodes with outdegree (with loop) | 49 | 43 | 71 | 70 | 104 | 100 |
| Number of nodes with outdegree (without loop) | 35 | 37 | 54 | 56 | 88 | 88 |
| Density | Matrix average = 0.0081 Standard deviation = 0.0896 | matrix average = 0.0081 Standard deviation = 0.0896 | matrix average = 0.0226 Standard deviation = 0.1487 | matrix average = 0.0219 Standard deviation = 0.1464 | matrix average = 0.0786 Standard deviation = 0.2691 | matrix average = 0.0796 Standard deviation = 0.2707 |
| Network centralization index | 0.19% | 0.11% | 6.0% | 1.03% | 30.03% | 18.65% |

*Source: Computed by authors*

volume of investment towards innovation such as creating universities, research funds, which degree of betweenness prevalent in key sectors in the economy. Here, we explore a hypothetical case. A government creates a University specializing in technology aiming to produce human capital required for relevant sectors. Over a period of time, instead of catering to these sectors, the graduates pursue the professions for which the skills they learn do not have direct relevance. Here, government investment is unlikely to foster the betweenness of the education system with the relevant sectors. This lack of consciousness of the structural positioning of sectors of economy in which investments are made, could be the reason for retarded innovation, and poor growth.

To understand the structural positions of different economic sectors in India, we present the network of input-output transactions in Indian economy, based on input-output tables for 1998-99.[13] Here, we impose a constraint: for a node to be the part of network needs to have the value of 10% and above. This is mainly for pragmatic reasons of highlighting the high volume transactions. We also have avoided isolated sectors (which have no connections with other sectors) since these sectors contribute very little to the structural aspects of the networked economy.

This network is presented with three coloured partitions of the economy. GREEN indicates the primary sector (agriculture), RED indicated industry and BLUE indicates service sector. We present the network of the 85 nodes, which are connected to at least one other sector. Therefore, 30 isolated nodes are excluded from the network diagram. When we examine the network we come across with a major cluster and a small cluster and three dyadic ties (Forestry and logging wood and wood products; Construction Water supply ; Paper and paper products Printing and Publishing). The small cluster is around Tea, Jute, other transport services and petroleum products. These dyads and small cluster could be seen in the right hand bottom corner of the network diagram.

[13] We generated network graph for 1993-94 and 1998-99 input-output tables published by the Department of Statistics and Programme Implementation, the Government of India. While comparing both the graphs, we found not much structural dissimilarity. For this reason, our discussion is based on 1998-99 data set, since it is more contemporary.

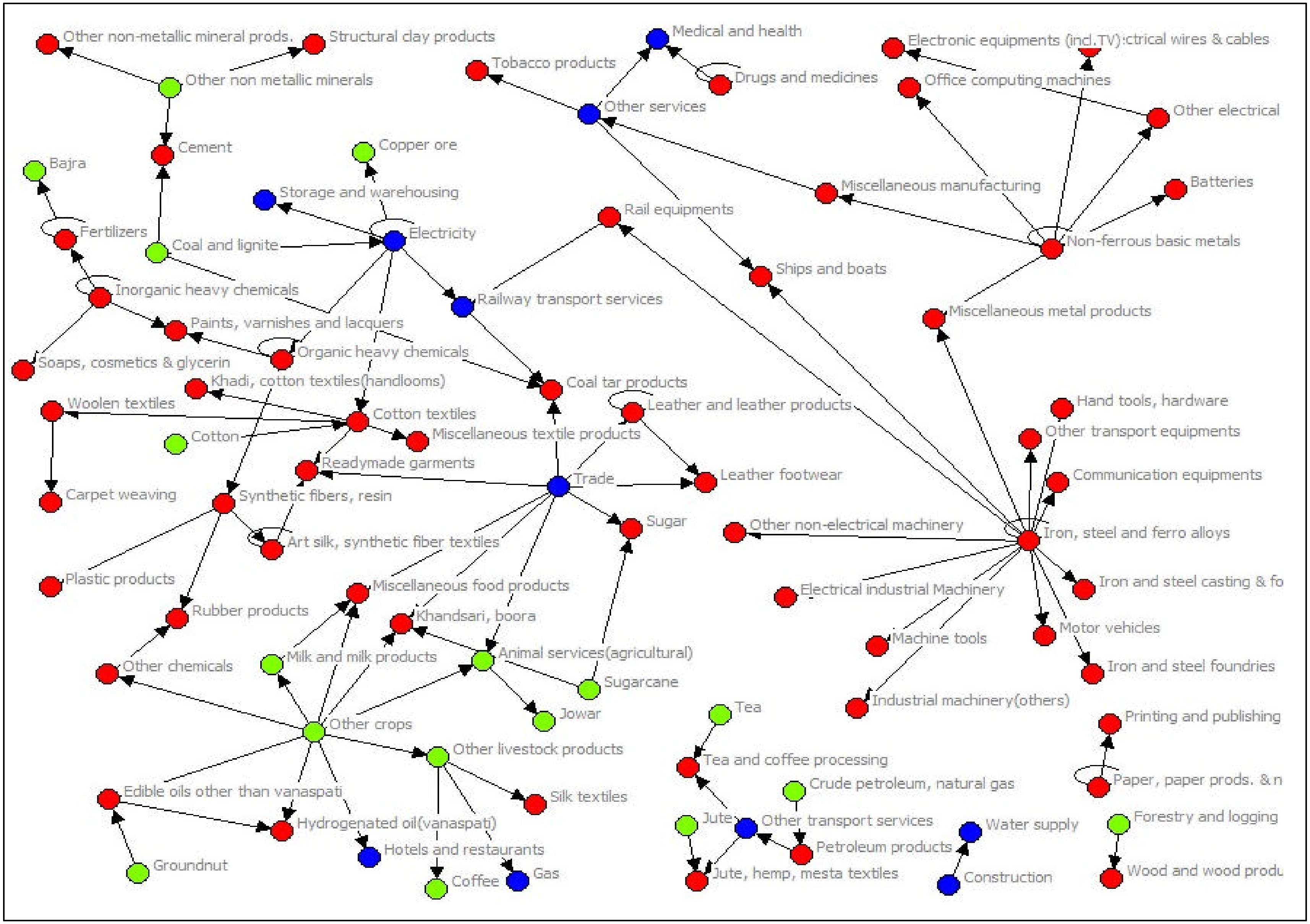


**Figure 2: Network of connected sectors in 1998-99 at 10% level**

It is interesting to examine the properties of major cluster in detail. We can observe five major nodes around which the whole economy is structured. These are 1) Iron, steel and ferro alloys, 2) non-ferrous basic metals, 3) trade, 4) other crops,[14] and 5) electricity. Though these sectors hold central positions and greater adjacency/neighbourhood, it is not clear whether these are the sector that hold the economy together. Burt's (1992) structural hole theory tells that one needs to look at the bridgers to understand as to who provides 'gel' to connect sectors. It can be observed that 'Railway transport services' and 'Rail equipments' does this role to connect the nodes, which are structurally separated. It is also interesting that 'Other transport services', which ranks highest in the betweeness score for the valued ties (see Appendix 1), features only as the structural hole bridger in the small cluster, other wise unconnected with the major cluster. This indicates that there is a need for more integrated transport system and infrastructure for the growth of the economy.

One important consideration while making decisions on generating ties between two sectors, it is important to consider which sector is able to generate chain effects. In this graph, in most of the cases, the out-degrees from one sector into another sector do not create a chain effect of the similar volume. The supply could be in smaller volume and to different sectors. There are nine sectors which creates these chain effects in small way. **Miscellaneous manufacturing** (with one in-degree) which provides raw material to 'other services' has three out-degrees. **Electricity** (with one in-degree) which has five out-degrees out of which three sectors create a chain effect of generating their own out-degree. In a similar way though the sector of **'Iron, steel and ferro alloys'** (with no in-degrees) supplies raw material to 13 sectors, except the sector of rail equipments, no other sector supplies raw material to other sectors in similar volume. Interesting is the case of **Cotton textile** (with two in-degrees), which has an out-degree to the sector of woolen textile supplies raw material to the sector of carpet weaving. Similarly, **Non-ferrous basic metals** (with no in-degrees) has five out-degrees, and out of which three sectors create chain effect. **Trade** (with no in-degree) has eight out-degrees, but except for the sector of leather and leather products, which supplies to leather foot ware, none of

[14] The sector such as 'other crops' indicate aggregation of many subsectors, and it is not particularly informative. This indicates, more disaggregated data is required to make important policy decisions.

them creates chain effect. Sector of **'other crops'** (with no in-degree), supply raw material to nine sectors in high volume. Four sectors of them produce a chain effect. The sector of **Synthetic fiber and resin** (with one in-degree) supplies raw material to three sectors, out of which one of them (Art silk, synthetic fiber textile) creates a chain effect. **Inorganic heavy chemical** (with no in-degree) has three out-degrees, and one of them creates chain-effect.

So far we have been examining the shape of structure of Indian economy, identifying the clusters, and sectors those generate chain effects. This has helped us to identify possible zones of innovation, where the change would have systemic effects. How could this be used to plan a growth model pioneered by innovation? We take up this issue next.

**Exploring new explanation?**

It is important to seek if the network measures provide explanations for contemporary phenomenon such as jobless growth. Interestingly, the comparison between average betweenness,[15] GDP growth rate and employment elasticity[16] generate an important explanation, though these are sectoral aggregates. It is apparent from table 3 that all three measures move in same direction. The tertiary sector registers highest in all three measures while primary sector has the lowest. An important cue emerging, here, is high degree of betweenness of a sector moves along with growth, and absorbs more people into the growth by generating jobs.

**Table 3: Average betweenness, GDP growth and employment elasticity**

| | Average Between ness (1993-94 IO Network) | Average Between ness (1998-99 IO Network) | GDP Growth rate (1990-91 to 1999-2000)* | Employment elasticity for (1990-91 to 1999-2000)* |
|---|---|---|---|---|
| Primary sector | 23.38 | 26.61 | 3.18 | 0.23 |
| Secondary sector | 88.23 | 85.10 | 6.21 | 0.29 |
| Tertiary sector | 126.11 | 153.88 | 7.71 | 0.41 |

Computed by authors; *Source: Datta et al (2007)

[15] This is calculated based on Appendix 1 for grouping of primary, secondary and tertiary sectors.
[16] Employment elasticity indicates the proportionate change in employment divided by proportionate change in GDP. This is one of the widely accepted measures to understand employment absorption.

Certainly, building a robust explanation from these cues need further disaagregation. However, we initiate a discussion, taking lead from the phenomenon we observed and the network we generated from the data, on the possibility of linking the question of economic growth with patterns in the network, especially identifying structural aspects like sectors, clusters, chains for setting a system innovation policy.

To make this point more clear, it is good to go back to the network structures we have seen earlier. Though the sector of 'Other transport service' is the highest in the betweeneness score in the valued ties, it has importance only in a cluster when the ties are examined at 10% level. It is the Railway transport service, which plays central role at 10% level. This indicates the importance of integration of transportation services in India for better economic growth. In the similar way, the sector of education and research is almost isolated from other sectors. A National Innovation System will need to find means to establish connect those sectors, which may bring multiplier effects in the chains of economy.

## Conclusion

In this paper, we have argued network measures of an economic system as important explanatory category for propelling growth, and to serve as a beacon for policy guidelines in the context of complex systems. We have shown that input-output transactions of raw materials within the system generate a process of structure of transactions, through which some sectors assume strategically significant positions. Therefore, centrality measurements, particularly betweenness is an important guiding light to understand the pecking order of an innovation system aimed at growth.

Systemic innovation needs to identify the structural interconnectedness of an economy to generate the maximum change possible through entrepreneurial activity. We have shown that in the present growth pattern of India, service sector, particularly transportation system is of critical importance. Innovation in this sector through integration of services could have important implications for generating employment in unconnected sectors of economy.

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## References

Bonacich, P. (1972). Factoring and weighting approaches to status scores and clique identification. *Journal of Mathematical Sociology, 2*, 113-120.

Bonacich, P. (1987). Power and centrality: A family of measures. *American Journal of Sociology, 92*, 1170-1182.

Burt, R. S. (1992). *Structural holes: The social structure of competition*. Cambridge: Harvard University Press.

Central Statistical Organization (1997), *Input-Output Tables for Indian Economy 1993-94*, Ministry of Planning, New Delhi.

Central Statistical Organization (2003), *Input-Output Tables for Indian Economy 1998-99*, Ministry of Planning, New Delhi.

Cowan, Robin and Nicolas Jonard (2001) "Knowledge Creation, Knowledge Diffusion and Network Structure" in *Economies with Heterogeneous Interacting Agents*, A. Kirman and J-B. Zimmermann (eds.) Springer.

Datta, R. C. *et al* (2007) Indian labour market in transition: Setting the tone for employability. ATLMRI Discussion Paper 1/2007. Mumbai: Tata Institute of Social Sciences.

Freeman, L. C. (1979) "Centrality in social networks: Conceptual clarification", *Social Networks*. Vol. 1.

Granovetter, M. (1973) "The strength of weak ties" *American Journal of Sociology* 78 (May) pp. 1360-80.

Leontief, Wassily (1974), Structure of the World Economy, *The American Economic Review*, 64:6, p 823-34

May, R. M. (1976) "Simple mathematical models with very complicated dynamics" *Nature* Vol. 261 (June) pp. 459-63)

Mirowski, P. (1991) “The When, the How and the Why of Mathematical Expression in the History of Economic Analysis”, *Journal of Economic Perspectives*, Vol. 5, 145-157

Nelson, Richard R and Sidney Winter (1982), *An Evolutionary Theory of Economic Change*, Cambridge MA, Harvard University Press.

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD) (1997), National Innovation Systems, OECD Publications, Paris.

Paul, B. G. D., Ramachandran, V. & Areejit, S. (2007) India’s Input Output System: an Enquiry, Paper presented for 43rd Annual Conference of the Indian Econometric Society, January 2007.

Porter, M. (1990) The competitive advantage of nations. New York: Basic Books.

Porter, M. & Stern, S. (2001) “National innovative capacity” Harvard: Institute for Strategy and Competitiveness.

Romer P. M. (1990), “Endogenous Technological Change”, *Journal of Political Economy*, pp. s 71-102 vol 98, number 5.

Schumpeter, J.A. (1934). *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle.* Cambridge: Harvard University Press. Reprinted 1983, Transaction, Inc.

Scott, J. (1991). *Social network analysis: A handbook*. London: Sage publications.

Solow, R. (1956) “A Contribution to the Theory of Economic Growth”, *Quarterly Journal of Economics* 70 (1), 65-94

Uzzi, B. (1997). Social structure and competition in interfirm networks: The paradox of embeddedness. *Administrative science quarterly, 42*(1), 35-67.

Wasserman, S. and Faust, K. (1994) *Social network analysis: Methods and applications.* Cambridge: Cambridge University Press.

**Appendix**

This table provides three centrality measures for the sectors of the raw material supply of Indian economy. The sectors are ordered here in descending order of the betweenness value for 1998-99.

| | Betweenness | | Out-degree | | | | In-degree | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1998-99 | 1993-94 | 1993-94 | | 1998-99 | | 1993-94 | | 1998-99 | |
| | | | N of out-degree | Rank | N of out-degree | Rank | N of in-degree | Rank | N of out-degree | Rank |
| Other transport services | 743.27 | 647.50 | 113 | 1 | 113 | 1 | 66 | 4 | 69 | 2 |
| Miscellaneous food products | 626.46 | 432.99 | 47 | 33 | 43 | 35 | 71 | 3 | 67 | 3 |
| Miscellaneous manufacturing | 475.02 | 583.11 | 101 | 7 | 102 | 6 | 76 | 1 | 81 | 1 |
| Railway transport services | 417.86 | 401.83 | 113 | 1 | 113 | 1 | 41 | 28 | 49 | 17 |
| Construction | 323.72 | 283.13 | 109 | 3 | 109 | 3 | 44 | 25 | 46 | 20 |
| Other non-metallic mineral prods. | 312.44 | 224.25 | 79 | 16 | 82 | 14 | 65 | 5 | 34 | 30 |
| Hotels and restaurants | 296.53 | 208.17 | 36 | 39 | 37 | 37 | 50 | 19 | 53 | 13 |
| Other chemicals | 280.76 | 476.03 | 86 | 12 | 87 | 13 | 75 | 2 | 62 | 6 |
| Other crops | 271.09 | 202.51 | 46 | 34 | 46 | 33 | 55 | 14 | 54 | 12 |
| Miscellaneous metal products | 265.46 | 219.67 | 102 | 6 | 103 | 5 | 62 | 8 | 61 | 7 |
| Non-ferrous basic metals | 252.41 | 229.31 | 68 | 24 | 67 | 23 | 57 | 12 | 57 | 9 |
| Miscellaneous textile products | 246.57 | 218.44 | 78 | 17 | 78 | 16 | 63 | 7 | 63 | 5 |
| Other livestock products | 196.51 | 171.73 | 53 | 29 | 50 | 30 | 20 | 41 | 23 | 40 |
| Trade | 192.64 | 154.20 | 113 | 1 | 113 | 1 | 38 | 29 | 45 | 21 |
| Other services | 178.64 | 156.25 | 103 | 5 | 104 | 4 | 44 | 25 | 43 | 23 |
| Other non-electrical machinery | 158.75 | 98.66 | 103 | 5 | 101 | 7 | 54 | 15 | 51 | 15 |
| Rubber products | 154.14 | 147.12 | 96 | 8 | 93 | 9 | 55 | 14 | 51 | 15 |
| Electricity | 153.75 | 66.43 | 103 | 5 | 104 | 4 | 46 | 23 | 50 | 16 |
| Organic heavy chemicals | 149.79 | 91.49 | 76 | 19 | 76 | 18 | 57 | 12 | 55 | 11 |
| Motor vehicles | 148.38 | 171.73 | 83 | 14 | 76 | 18 | 57 | 12 | 52 | 14 |
| Inorganic heavy chemicals | 144.11 | 66.43 | 79 | 16 | 79 | 15 | 57 | 12 | 56 | 10 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Paper, paper prods. & newsprint | 134.21 | 167.29 | 102 | 6 | 101 | 7 | 57 | 12 | 51 | 15 |
| Cotton textiles | 116.84 | 167.88 | 73 | 20 | 54 | 26 | 61 | 9 | 56 | 10 |
| Readymade garments | 104.88 | 66.29 | 27 | 44 | 44 | 34 | 58 | 11 | 49 | 17 |
| Paints, varnishes and lacquers | 104.58 | 80.03 | 76 | 19 | 73 | 20 | 58 | 11 | 54 | 12 |
| Batteries | 92.90 | 95.09 | 65 | 25 | 48 | 32 | 49 | 20 | 47 | 19 |
| Hand tools, hardware | 92.28 | 68.88 | 81 | 15 | 89 | 12 | 53 | 16 | 52 | 14 |
| Petroleum products | 90.46 | 149.78 | 105 | 4 | 104 | 4 | 47 | 22 | 40 | 26 |
| Wood and wood products | 89.62 | 83.17 | 88 | 11 | 82 | 14 | 55 | 14 | 56 | 10 |
| Fertilizers | 83.50 | 110.35 | 22 | 48 | 24 | 45 | 54 | 15 | 54 | 12 |
| Water supply | 82.42 | 43.88 | 95 | 9 | 100 | 8 | 43 | 26 | 43 | 23 |
| Communication | 80.44 | 78.36 | 103 | 5 | 103 | 5 | 30 | 34 | 30 | 34 |
| Forestry and logging | 78.16 | 100.43 | 69 | 23 | 49 | 31 | 44 | 25 | 48 | 18 |
| Iron and steel casting & forging | 76.80 | 14.32 | 30 | 42 | 31 | 40 | 49 | 20 | 49 | 17 |
| Banking | 73.76 | 69.48 | 110 | 2 | 111 | 2 | 35 | 31 | 38 | 28 |
| Other electrical Machinery | 73.13 | 98.66 | 70 | 22 | 62 | 24 | 49 | 20 | 47 | 19 |
| Electrical appliances | 73.09 | 113.28 | 85 | 13 | 91 | 11 | 52 | 17 | 47 | 19 |
| Plastic products | 70.85 | 77.03 | 77 | 18 | 78 | 16 | 56 | 13 | 49 | 17 |
| Bicycles, cycle-rickshaw | 63.03 | 32.16 | 50 | 31 | 53 | 27 | 48 | 21 | 45 | 21 |
| Insurance | 59.52 | 24.09 | 92 | 10 | 92 | 10 | 34 | 32 | 37 | 29 |
| Tractors and agri. implements | 57.11 | 60.57 | 35 | 40 | 19 | 49 | 53 | 16 | 52 | 14 |
| Jute, hemp, mesta textiles | 56.42 | 58.22 | 71 | 21 | 70 | 22 | 48 | 21 | 38 | 28 |
| Drugs and medicines | 56.15 | 66.62 | 22 | 48 | 23 | 46 | 64 | 6 | 58 | 8 |
| Printing and publishing | 54.93 | 124.98 | 86 | 12 | 77 | 17 | 51 | 18 | 43 | 23 |
| Pesticides | 52.13 | 73.08 | 26 | 45 | 30 | 41 | 43 | 26 | 42 | 24 |
| Art silk, synthetic fiber textiles | 49.96 | 19.49 | 23 | 47 | 21 | 48 | 49 | 20 | 47 | 19 |
| Edible oils other than vanaspati | 49.93 | 34.02 | 19 | 51 | 22 | 47 | 49 | 20 | 49 | 17 |
| Industrial machinery(others) | 48.53 | 33.23 | 78 | 17 | 74 | 19 | 55 | 14 | 49 | 17 |
| Furniture and fixtures-wooden | 48.05 | 101.57 | 76 | 19 | 72 | 21 | 52 | 17 | 43 | 23 |
| Other transport equipments | 45.50 | 61.74 | 51 | 30 | 51 | 29 | 51 | 18 | 45 | 21 |
| Iron and steel foundries | 44.12 | 67.08 | 73 | 20 | 72 | 21 | 51 | 18 | 45 | 21 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Wheat | 42.98 | 58.23 | 25 | 46 | 26 | 43 | 53 | 16 | 37 | 29 |
| Machine tools | 41.82 | 39.83 | 77 | 18 | 70 | 22 | 54 | 15 | 47 | 19 |
| Synthetic fibers, resin | 41.76 | 62.84 | 55 | 27 | 48 | 32 | 58 | 11 | 46 | 20 |
| Leather and leather products | 41.63 | 37.98 | 40 | 37 | 37 | 37 | 50 | 19 | 47 | 19 |
| Electronic equipments (incl.TV) | 41.40 | 85.82 | 71 | 21 | 52 | 28 | 49 | 20 | 49 | 17 |
| Paddy | 40.98 | 29.49 | 18 | 52 | 21 | 48 | 54 | 15 | 43 | 23 |
| Electrical industrial Machinery | 36.91 | 48.81 | 54 | 28 | 56 | 25 | 56 | 13 | 52 | 14 |
| Soaps, cosmetics & glycerin | 34.66 | 80.13 | 41 | 36 | 29 | 42 | 61 | 9 | 52 | 14 |
| Coal tar products | 32.08 | 21.36 | 62 | 26 | 53 | 27 | 52 | 17 | 46 | 20 |
| Industrial machinery(F & T) | 31.24 | 33.23 | 28 | 43 | 22 | 47 | 55 | 14 | 51 | 15 |
| Motor cycles and scooters | 30.76 | 29.03 | 45 | 35 | 52 | 28 | 52 | 17 | 45 | 21 |
| Structural clay products | 29.62 | 48.30 | 23 | 47 | 13 | 54 | 56 | 13 | 55 | 11 |
| Coal and lignite | 28.83 | 7411. | 73 | 20 | 74 | 19 | 32 | 33 | 38 | 28 |
| Pulses | 27.23 | 38.23 | 16 | 53 | 16 | 51 | 52 | 17 | 39 | 27 |
| Tea and coffee processing | 27.08 | 116.78 | 11 | 57 | 7 | 60 | 43 | 26 | 41 | 25 |
| Woolen textiles | 24.53 | 10.16 | 18 | 52 | 15 | 52 | 52 | 17 | 47 | 19 |
| Beverages | 23.52 | 13.70 | 11 | 57 | 10 | 57 | 54 | 15 | 53 | 13 |
| Iron, steel and ferro alloys | 23.49 | 42.23 | 48 | 32 | 37 | 37 | 51 | 18 | 49 | 17 |
| Milk and milk products | 22.90 | 25.17 | 12 | 56 | 12 | 55 | 19 | 42 | 20 | 43 |
| Office computing machines | 21.47 | 27.97 | 31 | 41 | 36 | 38 | 45 | 24 | 39 | 27 |
| Animal services(agricultural) | 21.25 | 14.91 | 13 | 55 | 13 | 54 | 11 | 44 | 13 | 44 |
| Cement | 17.42 | 16.27 | 12 | 56 | 14 | 53 | 42 | 27 | 42 | 24 |
| Other non metallic minerals | 16.52 | 5.53 | 36 | 39 | 38 | 36 | 21 | 40 | 34 | 30 |
| Gram | 15.40 | 12.08 | 12 | 56 | 12 | 55 | 28 | 36 | 38 | 28 |
| Khadi, cotton textiles(handlooms) | 15.23 | 7.51 | 9 | 59 | 8 | 59 | 59 | 10 | 52 | 14 |
| Jute | 14.99 | 4.98 | 5 | 63 | 7 | 60 | 12 | 43 | 28 | 36 |
| Communication equipments | 13.65 | 5.23 | 20 | 50 | 29 | 42 | 50 | 19 | 44 | 22 |
| Cotton | 10.86 | 11.54 | 12 | 56 | 13 | 54 | 28 | 36 | 22 | 41 |
| Crude petroleum, natural gas | 9.93 | 6.33 | 36 | 39 | 32 | 39 | 23 | 39 | 25 | 39 |
| Tobacco products | 9.15 | 19.98 | 3 | 56 | 5 | 62 | 57 | 12 | 49 | 17 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sugarcane | 8.54 | 4.56 | 5 | 63 | 8 | 59 | 28 | 36 | 31 | 33 |
| Bajra | 8.11 | 4.44 | 6 | 62 | 6 | 61 | 29 | 35 | 31 | 33 |
| Sugar | 7.75 | 21.29 | 13 | 55 | 9 | 58 | 44 | 25 | 29 | 35 |
| Medical and health | 7.37 | 5.11 | 5 | 63 | 4 | 63 | 48 | 21 | 46 | 20 |
| Groundnut | 7.17 | 5.64 | 10 | 58 | 9 | 58 | 28 | 36 | 29 | 35 |
| Electrical wires & cables | 6.69 | 11.04 | 53 | 29 | 25 | 44 | 49 | 20 | 43 | 23 |
| Maize | 6.29 | 8.30 | 9 | 59 | 8 | 59 | 28 | 36 | 31 | 33 |
| Khandsari, boora | 4.93 | 10.98 | 10 | 58 | 5 | 62 | 44 | 25 | 33 | 31 |
| Other metallic minerals | 4.65 | 6.78 | 39 | 38 | 18 | 50 | 27 | 37 | 32 | 32 |
| Silk textiles | 4.00 | 25.45 | 21 | 49 | 13 | 54 | 53 | 16 | 45 | 21 |
| Ships and boats | 3.47 | 4.03 | 5 | 63 | 5 | 62 | 50 | 19 | 45 | 21 |
| Fishing | 3.44 | 3.90 | 10 | 58 | 9 | 58 | 32 | 33 | 21 | 42 |
| Leather footwear | 3.30 | 1.12 | 7 | 61 | 10 | 57 | 50 | 19 | 50 | 16 |
| Storage and warehousing | 2.87 | 2.21 | 3 | 65 | 3 | 64 | 37 | 30 | 42 | 24 |
| Jowar | 2.79 | 255 | 4 | 64 | 4 | 63 | 29 | 35 | 31 | 33 |
| Tobacco | 2.69 | 6.09 | 6 | 62 | 5 | 62 | 24 | 38 | 31 | 33 |
| Lime stone | 2.51 | 0.72 | 8 | 60 | 14 | 53 | 21 | 40 | 28 | 36 |
| Hydrogenated oil(vanaspati) | 2.2 | 2.60 | 8 | 60 | 4 | 63 | 41 | 28 | 40 | 26 |
| Rubber | 2.09 | 2.94 | 7 | 61 | 6 | 61 | 9 | 46 | 8 | 46 |
| Iron ore | 1.96 | 0.73 | 5 | 63 | 12 | 55 | 23 | 39 | 28 | 36 |
| Gas | 1.95 | 1.57 | 6 | 62 | 7 | 60 | 10 | 45 | 10 | 45 |
| Carpet weaving | 1.61 | 5.22 | 14 | 54 | 11 | 56 | 51 | 18 | 41 | 25 |
| Rail equipments | 1.54 | 1.90 | 6 | 62 | 10 | 57 | 52 | 17 | 45 | 21 |
| Manganese ore | 1.33 | 2.87 | 5 | 63 | 5 | 62 | 23 | 39 | 27 | 37 |
| Education and research | 1.30 | 1.53 | 2 | 66 | 3 | 64 | 41 | 28 | 45 | 21 |
| Coffee | 1.00 | 0.47 | 3 | 65 | 2 | 65 | 10 | 45 | 10 | 45 |
| Watches and clocks | 0.72 | 0.67 | 7 | 61 | 8 | 59 | 43 | 26 | 46 | 20 |
| Tea | 0.61 | 0.63 | 4 | 64 | 2 | 65 | 8 | 47 | 7 | 47 |
| Bauxite | 0.42 | 0.18 | 3 | 65 | 3 | 64 | 20 | 41 | 26 | 38 |
| Copper ore | 0.24 | 0.06 | 1 | 67 | 2 | 65 | 28 | 36 | 33 | 31 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Mica | 0.06 | 0.02 | 2 | 66 | 1 | 66 | 9 | 46 | 21 | 42 |
| Ownership of dwellings | 0 | 0 | 0 | 68 | 0 | 67 | 1 | 48 | 1 | 49 |
| Coconut | 0 | 1.40 | 7 | 61 | 7 | 60 | 8 | 47 | 6 | 48 |
| Public administration | 0 | 0 | 0 | 68 | 0 | 67 | 0 | 49 | 0 | 50 |