Productivity and technical change in Indian economy

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1. Introduction

This paper makes an attempt to analyze the structural changes in Indian economy as evident from input-output tables. Input-output tables provide details of the use of the output of one industry/ sector by all the other industries/sectors and the use of the outputs of all the individual industries/sectors as inputs by each industry/sector for its production. The data on input is in terms of factor costs and cannot indicate quantity of respective inputs. The Input-Output table also provides technology matrix where each column represents different amounts of the various commodities, shown in the rows, required to produce one unit of the commodity represented by the column. Input-output methodology has wider applications in diverse field of economies. In this paper, we have made an application of input-output technology to understand the following issues:

- Identifying the components of total productivity growths of Indian economy during the period 1998-99 to 2006-07
- Linkage of productivity growth and technical change in Indian economy over the period under observation
- Technical change in Indian economy vis-à-vis other selected economies
- Import intensities of Indian economies

The plan of the paper is as follows. The next section identifies the components of productivity changes in Indian economy in recent years. Following section analyses technical change as witnessed in Indian economy over the period 1998-99 to 2006-07. The structural changes in Indian economy with regard to energy intensities is discussed in section 4. In section 5, we compared the technical coefficient of India's input-output table with that of other countries to highlight the strength and weaknesses India's production processes. The following section analyses the import intensities of India's production processes. Finally, we summarize our findings in the concluding section.

2. Sectoral Productivity Changes in India

Productivity is probably one of the most important measures to judge the performance of an economy. The first theoretically founded research on productivity dates back to Solow (1956, 1957) in which he uses a neoclassical formulation to understand sources of productivity growth. Following Solow, others have alternative methodologies to estimate productivity growth. Among them, Leontief works' on structural change using input–output tables and subsequently use of the

input-output methodology to estimate productivity growth can be mentioned. In the input-output literature the rate of technological changes for each activity (or each sector) is defined as difference between the growth rate of gross output and the weighted average growth rate of the various inputs of the activity. This measure is called the growth rate of total factor production (TFP). TFP measure in the input-output framework works under two assumptions: first the market for output and factors are is perfect competition and the second production function is constant returns to scale. By the first assumption, the factors inputs are priced according to their marginal productivities. On the other hand, the second assumption implies that the output has a well-defined growth rate. The input growth rate must be some weighted average of the labor growth and capital growth rates in which both are considered as value shares in national income (Ten Raa 2004).

In the input-output methodology, gross output is defined as the sum of intermediate inputs, and the value added from each industry.

$$X_{j,t} = \sum_i X_{ij,t} + L_{j,t} + K_{j,t}$$

Following Kuroda & Nomura 2004), the rate of TFP growth for sector j can be formulated as:

$$\left(\frac{\dot{T}_j}{T_j}\right)_t = \left(\frac{\dot{X}_j}{X_j}\right) - \sum_i \frac{X_{ij,t}}{X_{j,t}}\left(\frac{\dot{X}_{ij}}{X_{ij}}\right)_t - \frac{L_{j,t}}{X_{j,t}}\left(\frac{\dot{L}_j}{L_j}\right) - \frac{K_{j,t}}{X_{j,t}}\left(\frac{\dot{K}_j}{K_j}\right)_t \qquad (1)$$

where, X_j denote the gross output of sector *j*. likewise X_{ij}, L_j, and K_j denote for sector *j,* respectively, the intermediate input *i*, the input of labour, and input of capital. In equation (1) the weights of each input in the monetary term, which are defined by the nominal cost shares of the components in intermediate, labour and capital inputs sum to unity. This equation shows that the sectoral growth rate of total factor productivity (TFP) is defined by the weighted average of the growth rates of partial productivities of all the inputs.

The Data and analysis of Results

We have used for our analysis 1998-99 and 2006-07 input-output tables for India.[2] The tables have different sectoral classification. However, we have aggregated the tables into 27 main sectors for our analysis. It must be mentioned that the input-output tables are published in current prices. So, for our analysis, we have converted the 2006-07 input-output table at 2006-07 prices to 1998-99 prices.

[2] The sources of the input-output tables are Central Statistical Organization of Government of India.

The results of our analysis are shown in Table 1. During this period, most of the sectors have registered positive output growth, barring wood and allied and real estate and business services sector. What is evident is that most of the manufacturing and services sectors have registered double digit per annum growth during this period. Most of these sectors exhibit large intermediate input factor productivity growth during the years under observations. Notable among them are electrical machinery (41%), coke, refined petroleum etc (26%), radio, television and communication equipments (43%), machinery and equipments (19%), construction (17%), and hotels and restaurants (17%).

Note that barring four sectors namely food products etc, wood products etc, radio, television, etc, and real estate & other services etc, most of the sectors registered capital productivity gain during this period. The sectors with large productivity gains are coke, refined petroleum etc, post & telecommunications, wholesale & retail trade, transport & storage, and machinery & equipment. Note that we have not been able to register significant capital productivity gains in the labour intensive sectors like food products, textile products etc, even though India has comparative advantage in these sectors being a labour rich economy.

By contrast, labour productivity is negative in as many as 15 of our sectors. As Table 1 shows, there is falling labour productivity in many of the labour intensive sectors like agriculture and allied, mining and quarrying, food products, wood products, pulp and paper. This is surprising since India being labour rich country has comparative advantage in labour intensive goods. We find that significant labour productivity gains are registered in the following sectors: other services (5%), post and communications (7%), transport and storage (6%), finance and insurance (2%). By and large, we find that labour productivity growths in manufacturing sectors are generally less than 1% per annum during this period.

With regard to total factor productivity growth, we find the highest growth is registered in the sector electrical machinery etc (4%) followed by radio, television and communication equipments (4%), mining and quarrying (4%), coke, petroleum etc (3%), machinery and equipment (2%). There are only three sectors which show negative total factor productivity growth. Notable among them are agriculture, research and development.

Table 1 Components of Productivity Growths per annum for the period 1998-99 to 2006-07

Sl. No	Sector	Growth in per cent per annum for the period 1998-99 to 2006-07				
		Output	Intermediate Input Factor Productivity	Labour Productivity	Capital Productivity	Total Factor Productivity
1	Agriculture, hunting, forestry & fishing	5.38	2.67	-0.22	3.04	-0.11
2	Mining & quarrying	5.92	0.00	-2.23	4.32	3.84
3	Food products, beverages & tobacco	4.42	4.89	-0.30	-0.29	0.12
4	Textiles, textile products, leather & footwear	7.22	6.71	-0.12	0.38	0.25
5	Wood & products of wood & cork	-4.43	-1.38	-1.48	-1.49	-0.07
6	Pulp, paper, paper products, printing & publishing	6.69	5.41	-0.44	1.44	0.29
7	Coke, refined petroleum products & nuclear fuel	43.23	25.67	0.07	14.57	2.91
8	Chemicals & chemical products	10.91	8.36	0.19	1.87	0.48
9	Rubber & plastics products	15.31	13.08	-0.35	2.02	0.57
10	Other non-metallic mineral products	12.51	8.02	-0.45	4.27	0.66
11	Basic metals	17.87	13.74	-0.44	3.71	0.87
12	Fabricated metal products except machinery & equipment	15.22	11.46	-0.34	3.28	0.83
13	Machinery & equipment	27.91	19.99	0.66	5.05	2.21
14	Electrical machinery & apparatus	49.33	41.43	0.58	3.40	3.92
15	Radio, television & communication equipment	45.38	43.24	-0.36	-1.07	3.57
16	manufacturing of Transport equipments	18.58	14.50	-0.18	2.69	1.57
17	Other manufacturing	6.60	4.82	-1.35	2.71	0.43
18	Electricity, gas & water supply	4.57	3.79	0.30	0.39	0.09
19	Construction	18.84	16.59	-1.50	2.93	0.82
20	Wholesale & retail trade	10.33	1.55	1.40	7.17	0.21
21	Hotels & restaurants	23.50	17.23	1.41	4.43	0.43
22	Transport & storage	23.97	9.05	6.09	6.81	2.01
23	Post & telecommunications	30.23	6.56	6.60	16.80	0.28
24	Finance & insurance	11.70	2.47	1.90	7.16	0.16
25	Research & development	4.67	0.47	0.45	3.79	-0.03
26	Real estate & other business activities	-7.46	-0.30	-6.88	-2.58	2.30
27	Other services	11.35	-1.13	4.54	7.33	0.61

3. Technical Changes in Indian economy

In the earlier section, we have seen that India has achieved significant intermediate input factor productivity growth in recent years. Naturally question arises what are the sources of its gain. In this section, we have attempted to answer the same.

The input-output table provides technology matrix where each column represents different amounts of the various commodities, shown in the rows, required to produce one unit of the commodity represented by the column. A change in the elements of a column vector of the

technology matrix over an interval of time represents technological changes in the production of the commodity. Technological changes in the input-consuming commodity production allow changes in inputs and technological changes in some or all of the input commodities allow substitution or other kinds of changes in the input-vector constituents or in their relative weights. Further, a technological change brings about changes in relative prices and thus we might argue that innovation is about bringing about changes in relative prices which reflect the bargaining strength of respective producers as captured by the changes in the column vectors of the input-output matrix in the post-innovation phase.

A large number of descriptions of innovation remain limited to novelty within a firm or at the most within a sector or within a competition milieu. A firm or a sector is embedded within a larger matrix of input-output and therefore, changes within the former are bound to be translated to changes within the input-output matrix. In the inter-sector framework, innovation in one sector would thus entitle that sector to cheaper capital, cheaper better resources, larger market and most importantly better or monopoly price entitling that innovator to the innovator's profit. Innovation is thus the dynamic engine operating a shift in the economic structure. In a system of input-output matrices across time, this structural shift can be captured to indicate whether the economy as a whole has innovated or failed to do so. Although there are alternative definitions of innovation, we would simply describe the shifts in the inputs as descriptors of corresponding changes in both technology and relative prices.

In this section we have analyzed some sectors of the Indian economy by observing changes in a few select important inputs, such as energy, feedstock including agricultural inputs, machine tools and other machineries. The analysis is done first by analyzing the technical changes of India’s input-output table over time. In the following section, we follow the analysis by comparing the same vis-à-vis other selected countries.

We have used three input-output tables of India published by Central Statistical Organization (government of India). The input-output tables are following years, 1998-99, 2003-04, and 2006-07. As the sectors of these three input-output tables are different, we have aggregated the three input-output tables into common 21 sectors for comparison purposes.

The data in Table 2 indicate that input cost on agriculture allied activities in food products, beverages sector has progressively fallen over the years. By contrast, input value per unit value of output has consistently increased in following sectors: food products, beverages and tobacco, fuel related sector (Sl. No. 7), machinery, transport and storage and wholesale and retail trade. The rise in share of cost on machinery is expected as food products sector is increasingly being capitalized in view of the modernization of the sector. The surge in fuel price is on the

expected line in view of the global surge in oil price and so in the transport and storage. However, the surge in input cost on wholesale and retail trade does not augur well. It probably suggests the absence of competitive forces in this sector.

By and large, similar trend is observed in textile, textile products, and leather and footwear sector. A rise in per unit input cost on transport and storage, wholesale and retail trade, fuel related sector, machinery and on textile, textile related activities. The modernization of the textile sector implies that per unit input cost on machinery and transport equipment has trebled up between the years 199899 and 2006-07. During this period, input cost on electricity etc has declined by more than fifty percent. This probably suggests that the industry could save on electricity bill by upgrading the plants.

With regard to pulp, paper, paper products etc sector, input value per unit value of output has declined in few of the sectors like electricity, wholesale and retail trade. There has not been appreciable change in most of the sectors. The major rise in input cost per unit of output has occurred for fuel sector and transport related sector.

Table 2 suggests that input cost on chemicals and chemical products for per unit value of output of coke, refined petroleum products has risen for the period under observation. By and large, the sector has to decrease in most of the other sectors. However, the sector has not machinery during these years, as the input cost on same indicates no perceptible change.

With regard to chemical and chemical products sector, there has not been any significant change between the 2003-04 and 2006-07. The point to note is that input value per unit value of output in this sector has increased for construction activities since 1998-99.

Table 2 suggests that input cost on fuel etc, chemicals etc, rubber and plastic products, has increased substantially in respect of rubber and plastic products sector. In this sector, there has marginal rise in input cost on all categories of capital goods. On the other hand, this sector has been able to reduce input cost on other services, and wholesale and retail trade.

With regard to basic metals sector, input cost per unit of output has increased in respect of mining and quarrying from 0.09 in 1998-99 to 0.12 in 2003-04, to 0.118 in 2006-07. The other component of rise in input cost is electricity etc. There has not been any major change in other components of input cost. Also, there has been marginal increase in input cost of machinery indicating investment in new technology in this sector.

With regard to other manufacturing sector, we find increased input cost on machinery items. There has been marginal saving in respect of expenditure of electricity etc. However, input cost on other services per unit value of output in this sector has increased between the years 2003-04 to 2006-07. The sector has also been able to economize cost on chemical related item.

Between the years 2003-04 and 2006-07, there is no significant change in input cost on various components per unit output of machinery and equipment sector. There is marginal rise in input cost on electrical machinery as well as on construction per unit of output. On the other hand, we find from data in Table 2 that input cost on account of machinery and equipment as well as wholesale and retail trade has declined.

The input cost structure per unit output of electrical machinery etc sector suggests that this sector has been able to cut down progressively (almost by 50%) its cost on electricity etc between the years 1998-99 to 2006-07. This sector seems to be in a spate of technological upgradation: input cost on machinery and equipment has increased from 0.007 in 1998-99 to 0.046 in 2006-07 while the same on electrical machinery has risen from 0.075 in 1998-99 to 0.122 in 2003-04.

By and large, a similar trend is observed in case of manufacturing of transport equipments. Over the years, there has been a cut down in input cost on electricity etc concomitant with rising expenditure on different categories of machinery.

Table 2 Technical Changes in Indian Economy, 1998-99 to 2006-07

Sl. No.	Input Use per Unit of Output	Food products, beverages & tobacco			Textiles, textile products, leather & footwear			Pulp, paper, paper products, printing & publishing			Coke, refined petroleum products & nuclear fuel		
		1998-99	2003-04	2006-07	1998-99	2003-04	2006-07	1998-99	2003-04	2006-07	1998-99	2003-04	2006-07
1	Agriculture, hunting, forestry & fishing	0.411	0.372	0.347	0.120	0.097	0.091	0.033	0.051	0.047	0.001	0.000	0.000
2	Mining & quarrying	0.005	0.001	0.001	0.004	0.002	0.001	0.032	0.012	0.011	0.611	0.611	0.646
3	Food products, beverages & tobacco	0.092	0.117	0.125	0.001	0.000	0.001	0.001	0.002	0.002	0.000	0.000	0.000
4	Textiles, textile products, leather & footwear	0.004	0.003	0.003	0.187	0.203	0.204	0.011	0.004	0.004	0.000	0.000	0.000
5	Wood & products of wood & cork	0.006	0.006	0.005	0.002	0.003	0.003	0.020	0.014	0.016	0.001	0.000	0.000
6	Pulp, paper, paper products, printing etc	0.011	0.014	0.013	0.004	0.006	0.006	0.239	0.266	0.259	0.000	0.000	0.000
7	Coke, refined petroleum products & nuclear fuel	0.007	0.011	0.012	0.004	0.015	0.016	0.004	0.016	0.017	0.011	0.037	0.035
8	Chemicals & chemical products	0.024	0.023	0.026	0.071	0.068	0.070	0.073	0.075	0.075	0.015	0.013	0.018
9	Rubber & plastics products	0.006	0.011	0.011	0.005	0.010	0.011	0.002	0.011	0.011	0.000	0.001	0.001
10	Other non-metallic mineral products	0.005	0.002	0.000	0.001	0.000	0.000	0.003	0.001	0.001	0.000	0.000	0.000
11	Basic metals	0.003	0.000	0.000	0.003	0.001	0.001	0.011	0.003	0.004	0.001	0.000	0.000
12	Fabricated metal products except machinery & equipment	0.005	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.003	0.000	0.000
13	Machinery & equipment	0.004	0.008	0.008	0.006	0.019	0.020	0.003	0.003	0.003	0.001	0.001	0.001
14	Electrical machinery & apparatus	0.001	0.000	0.000	0.002	0.001	0.001	0.002	0.004	0.004	0.001	0.000	0.000
15	Manufacturing of Transport equipments	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16	Other Manufacturing	0.001	0.001	0.000	0.004	0.004	0.006	0.006	0.004	0.006	0.001	0.000	0.001
17	Electricity, gas & water supply	0.011	0.016	0.008	0.070	0.038	0.029	0.047	0.034	0.027	0.026	0.015	0.012
18	Construction	0.003	0.009	0.010	0.002	0.012	0.015	0.002	0.011	0.011	0.001	0.001	0.007
19	Wholesale & retail trade	0.088	0.129	0.135	0.091	0.094	0.102	0.060	0.051	0.053	0.046	0.011	0.010
20	Transport & storage	0.046	0.051	0.055	0.063	0.077	0.082	0.054	0.070	0.073	0.036	0.021	0.023
21	Other services	0.066	0.042	0.039	0.068	0.068	0.069	0.054	0.038	0.038	0.047	0.028	0.024

Table 2 Technical Changes in Indian Economy, 1998-99 to 2006-07

Sl No.	Input Use per Unit of Output	Chemicals and chemical products			Rubber and plastics products			Basic metals			Other Manufacturing		
		1998-99	2003-04	2006-07	1998-99	2003-04	2006-07	1998-99	2003-04	2006-07	1998-99	2003-04	2006-07
1	Agriculture, hunting, forestry & fishing	0.044	0.033	0.023	0.050	0.052	0.051	0.000	0.000	0.000	0.009	0.002	0.004
2	Mining & quarrying	0.050	0.017	0.017	0.011	0.007	0.008	0.090	0.120	0.118	0.077	0.068	0.074
3	Food products, beverages,	0.003	0.011	0.013	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
4	Textiles, textile products, leather & footwear	0.010	0.006	0.006	0.041	0.018	0.017	0.003	0.001	0.000	0.013	0.003	0.004
5	Wood & products of wood &	0.004	0.008	0.006	0.004	0.003	0.003	0.002	0.001	0.001	0.009	0.004	0.006
6	Pulp, paper, paper products,	0.023	0.007	0.007	0.008	0.008	0.008	0.001	0.001	0.001	0.005	0.005	0.007
7	Coke, refined petroleum products & nuclear fuel	0.007	0.045	0.047	0.003	0.017	0.019	0.035	0.026	0.027	0.011	0.018	0.024
8	Chemicals & chemical products	0.284	0.321	0.337	0.275	0.290	0.300	0.013	0.014	0.015	0.041	0.016	0.026
9	Rubber & plastics products	0.010	0.015	0.015	0.041	0.098	0.109	0.001	0.003	0.003	0.013	0.016	0.023
10	Other non-metallic mineral	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.005	0.008
11	Basic metals	0.006	0.006	0.006	0.013	0.021	0.022	0.263	0.239	0.262	0.294	0.021	0.032
12	Fabricated metal products except machinery & equipment	0.004	0.001	0.001	0.004	0.006	0.007	0.036	0.022	0.029	0.005	0.006	0.012
13	Machinery & equipment	0.003	0.006	0.006	0.002	0.010	0.011	0.003	0.007	0.009	0.003	0.008	0.016
14	Electrical machinery & apparatus	0.001	0.002	0.002	0.001	0.005	0.006	0.001	0.004	0.007	0.004	0.015	0.025
15	Manufacturing of Transport equipments	0.000	0.000	0.000	0.000	0.004	0.006	0.001	0.004	0.002	0.001	0.001	0.001
16	Other Manufacturing	0.008	0.005	0.007	0.006	0.003	0.005	0.005	0.002	0.002	0.011	0.171	0.192
17	Electricity, gas & water supply	0.048	0.047	0.040	0.049	0.032	0.025	0.049	0.069	0.060	0.037	0.032	0.030
18	Construction	0.002	0.005	0.008	0.002	0.003	0.004	0.001	0.002	0.005	0.002	0.005	0.007
19	Wholesale & retail trade	0.064	0.062	0.059	0.072	0.057	0.056	0.080	0.095	0.084	0.057	0.034	0.038
20	Transport & storage	0.042	0.047	0.045	0.045	0.045	0.043	0.057	0.062	0.062	0.043	0.061	0.061
21	Other services	0.049	0.037	0.036	0.063	0.043	0.043	0.059	0.033	0.035	0.048	0.066	0.080

Table 2 Technical Changes in Indian Economy, 1998-99 to 2006-07

Sl. No.	Input Use per Unit of Output	Machinery & Equipment			Electrical Machinery & Apparatus			Manufacturing of Transport equipments		
		1998-99	2003-04	2006-07	1998-99	2003-04	2006-07	1998-99	2003-04	2006-07
1	Agriculture, hunting, forestry & fishing	0.000	0.001	0.001	0.000	0.001	0.001	0.000	0.000	0.000
2	Mining & quarrying	0.004	0.006	0.007	0.004	0.006	0.006	0.001	0.003	0.007
3	Food products, beverages &	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	Textiles, textile products, leather & footwear	0.005	0.003	0.002	0.003	0.005	0.005	0.002	0.002	0.005
5	Wood & products of wood &	0.010	0.006	0.006	0.011	0.004	0.004	0.008	0.002	0.002
6	Pulp, paper, paper products,	0.003	0.004	0.004	0.005	0.006	0.006	0.003	0.002	0.002
7	Coke, refined petroleum products & nuclear fuel	0.011	0.009	0.010	0.009	0.013	0.011	0.010	0.007	0.010
8	Chemicals & chemical products	0.018	0.015	0.016	0.040	0.040	0.040	0.033	0.022	0.024
9	Rubber & plastics products	0.010	0.012	0.012	0.023	0.018	0.018	0.026	0.020	0.023
10	Other non-metallic mineral	0.002	0.002	0.003	0.004	0.006	0.006	0.002	0.002	0.002
11	Basic metals	0.243	0.236	0.247	0.279	0.229	0.239	0.183	0.105	0.117
12	Fabricated metal products except machinery & equipment	0.014	0.038	0.043	0.005	0.046	0.052	0.012	0.012	0.014
13	Machinery & equipment	0.112	0.093	0.098	0.007	0.036	0.046	0.013	0.074	0.092
14	Electrical machinery &	0.011	0.039	0.043	0.080	0.127	0.149	0.013	0.035	0.045
15	Manufacturing of Transport	0.001	0.005	0.005	0.001	0.001	0.002	0.080	0.101	0.105
16	Other Manufacturing	0.015	0.010	0.014	0.024	0.012	0.016	0.033	0.007	0.020
17	Electricity, gas & water supply	0.037	0.025	0.015	0.034	0.023	0.014	0.055	0.031	0.027
18	Construction	0.003	0.021	0.024	0.002	0.012	0.015	0.002	0.004	0.010
19	Wholesale & retail trade	0.053	0.036	0.031	0.053	0.038	0.035	0.054	0.042	0.043
20	Transport & storage	0.027	0.031	0.025	0.022	0.036	0.033	0.026	0.029	0.029
21	Other services	0.095	0.087	0.086	0.085	0.087	0.086	0.119	0.116	0.128

4. Energy Intensities of Indian Economy: Structural Changes, 2003-04 to 2006-07

In the last section, we have seen some evidences that Indian economy has become energy efficient over the years. However, we have not quantified the change. In this section, we attempt to do the same using input-output modeling framework.

Let, A_{0304} and A_{0607} be India's input-output coefficient table (technology matrix) for the years 2003-04 and 2006-7. Let I be the identity matrix of the same order. Let TFU_{0607} and TIU_{0607} be the total final use and intermediate use vectors respectively for the economy in the year 2006-07. Then actual intermediate use in 2006-07 to produce the observed output is given by the equation (2):

$$TIU_{0607} = (I - A_{0607})^{-1} TFU_{0607} \qquad (2)$$

If there has not been technical change over the years, one can use technical coefficient matrix of 2003-04 to estimate the likely demand of intermediate good to produce the observed output of 2006-07 by the equation as given below:

$$\overline{TIU_{0607}} = (I - A_{0304})^{-1} TFU_{0607} \qquad (3)$$

where $\overline{TIU_{0607}}$ is the estimated demand of intermediate good using 2003-04 technology matrix. Subtracting TIU_{0607} from $\overline{TIU_{0607}}$, one can estimate the saving on account of any intermediate use. If in the above two input-output tables, there are n types of energy sources (commercial as well as primary), then energy saving on account of ith type of energy =

$$\overline{TIU_{i\,0607}} - TIU_{i\,0607} \qquad (4)$$

So, total energy saving in the economy is given as follows:

$$\sum_0^n \overline{TIU_{i\,0607}} - \sum_0^n TIU_{i\,0607} \qquad (5)$$

For the analysis, we have considered the following forms of primary and commercial energy namely, coal, petroleum, natural gas, biomass and electricity. The source of our input-output tables Pal, Pohit and Roy (2010), which are modification of India's input-output table with more disaggregated energy sector. The analysis of the results is shown in Table 3. As this table shows, energy intensities of Indian economy have declined by more than 14% between the years 2003-04 and 2006-07. This is significantly big change for growing economy. Note that, this is true irrespective of the type of energy except petroleum. The biggest gain in the energy efficiency has been in the area of electricity followed by coal and biomass.

Table 3 Changes in Energy Intensities (Rs Lakhs), 2003-04 to 2006-07

Energy type	Actual Energy Mix (2006-07)	Share	Estimated Energy Mix (2006-07)	Share	Percentage Change in Intermediate Use
Coal	5724427	11.31	6709595	11.60	14.68
Petroleum	26608415	52.58	26585664	45.94	-0.09
Biomass	1230412	2.43	1515345	2.62	18.80
Natural Gas	1572761	3.11	1741909	3.01	9.71
Electricity	15468393	30.57	21312446	36.83	27.42
Total	50604408		57864959		14.35

Source: Authors' estimates

5. Inter-country Analysis of Input-Output Coefficient

Input-Output Table of a country represents the input mix of producing a commodity in value term. If a firm used better technology, it would probably use less input to produce per unit of output. Of course there is a caveat. Since IO coefficients are calculated in value term, a significantly high input price may show increased input cost even when input use (in quantity) may decline due to use of better technology. However, such outlier is generally believed to be rare. If there are two input-output tables, one which uses less input to produce per unit of output would imply more efficient use of resources. In other words, the same technology mix would be more productive. Productivity improvement usually comes from innovation. So, inter-country comparison of IO tables, viz. India versus others may give idea whether India is resourcing to innovating technology to improve productivity in production process. Our focus of analysis is manufacturing sector. The countries of comparison are China and Brazil, the two of the BRIC countries, which are generally compared with India in discussion. The time-frame of India's IO table is 2006-07 discussed earlier while the same for China are Brazil are of 2006, downloaded from OCED websites. The comparison is restricted to 7 major manufacturing sectors, namely, (a) food products, beverages, and tobacco, (b) textile, leather, and their products, (c) chemicals and chemical products, (d) other manufacturing, (e) machinery and equipments (f) electrical machinery and (g) manufacturing of transport equipments. The relevant data id complied is Table 4.

The first observation is that in all these seven sectors, per unit cost on electricity, gas and water supply is highest in India in comparison to China and Brazil. Incidentally in most of these sectors, per unit cost of same in China is lowest. If these costs can be reduced, India

manufacturing would be more competitive in the global arena. Since this holds across diverse sectors, the cause is probably inefficiency in the electricity, gas and water supply sector. Thus, innovation is needed in this cost to make this sector more efficient.

The second observation is that per unit cost on fuel (represented by coke, refined petroleum products, etc) is generally higher in India than in China or Brazil. Incidentally, China also depends on imported fuel like that of India. So, it probably suggests that India's fuel sector is inefficient as compared to China. Innovation is needed to reduce cost of fuel.

The third observation is that transport and storage cost is on the higher side relative to China or Brazil. Transport and storage sector in India is still at the nascent stage of development. Only in recent times, investment has been taking place to develop efficient transports and storage system in India. It is interesting to know that China is way ahead in reducing per unit cost in this sector through innovation. This is an important factor why China is export power-house in today's world.

The fourth observation is that per unit cost on whole and retail trade for food products, beverages and tobacco cost stands at 0.13 whereas the same in Brazil and China are respectively 0.06 and 0.03 only. This is not a good sign. This probably indicates either absence of competitive forces in whole and retail trade sector or the sector is highly inefficient.

Table 4 Technical Coefficient of India's Input-Output: A cross-country comparison

	Sectors	Food products, beverages & tobacco			Textiles, textile products, leather & footwear			Chemicals & chemical products			Other manufacturing		
		India	Brazil	China	India	Brazil	China	India	Brazil	China	India	Brazil	China
1	Agriculture, hunting, forestry & fishing	0.37	0.35	0.34	0.10	0.03	0.11	0.03	0.01	0.04	0.00	0.00	0.05
2	Mining & quarrying	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.05	0.07	0.00	0.01
3	Food products, beverages & tobacco	0.12	0.16	0.15	0.00	0.03	0.02	0.01	0.01	0.01	0.00	0.00	0.00
4	Textiles, textile products, leather & footwear	0.00	0.00	0.00	0.20	0.26	0.33	0.01	0.00	0.01	0.00	0.02	0.03
5	wood, paper & their products	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.09	0.03
6	Coke, refined petroleum products & nuclear fuel	0.01	0.01	0.00	0.02	0.01	0.00	0.04	0.07	0.04	0.02	0.01	0.01
7	Chemicals, rubber & their products	0.03	0.02	0.03	0.08	0.05	0.08	0.34	0.20	0.33	0.03	0.09	0.09
8	Other non-metallic mineral products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00
9	Metals & metal products	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.02	0.02	0.03	0.07	0.09
10	Machinery & equipment	0.01	0.01	0.00	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
11	Electrical machinery & apparatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.07
12	manufacturing of Transport equipments	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	Other manufacturing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.02	0.03
14	Electricity, gas & water supply	0.02	0.02	0.01	0.04	0.03	0.02	0.05	0.04	0.06	0.03	0.02	0.01
15	Wholesale & retail trade; repairs	0.13	0.06	0.03	0.09	0.07	0.03	0.06	0.05	0.03	0.03	0.05	0.03
16	Transport & storage	0.05	0.05	0.03	0.08	0.02	0.02	0.05	0.03	0.03	0.06	0.02	0.02
17	Other services	0.05	0.04	0.04	0.08	0.04	0.06	0.04	0.08	0.05	0.07	0.03	0.05

Source: The input-output tables are drawn from OECD website

Table 4 Technical Coefficient of India's Input-Output: A cross-country comparison

	Sectors	Machinery & equipment			Electrical machinery & apparatus			Manufacturing of Transport equipments		
		India	Brazil	China	India	Brazil	China	India	Brazil	China
1	Agriculture, hunting, forestry & fishing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	Mining & quarrying	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.01
3	Food products, beverages & tobacco	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	Textiles, textile products, leather & footwear	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01
5	wood, paper & their products	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.00
6	Coke, refined petroleum products & nuclear fuel	0.01	0.01	0.01	0.01	0.03	0.01	0.01	0.01	0.01
7	Chemicals, rubber & their products	0.03	0.05	0.06	0.06	0.06	0.10	0.04	0.07	0.07
8	Other non-metallic mineral products	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.00
9	Metals & metal products	0.27	0.27	0.23	0.28	0.09	0.11	0.12	0.13	0.13
10	Machinery & equipment	0.09	0.03	0.12	0.04	0.01	0.02	0.07	0.02	0.06
11	Electrical machinery & apparatus	0.04	0.03	0.05	0.13	0.11	0.25	0.04	0.02	0.02
12	manufacturing of Transport equipments	0.00	0.01	0.01	0.00	0.01	0.00	0.10	0.22	0.26
13	Other manufacturing	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.00	0.00
14	Electricity, gas & water supply	0.02	0.02	0.03	0.02	0.02	0.01	0.03	0.02	0.02
15	Wholesale & retail trade; repairs	0.04	0.04	0.03	0.04	0.05	0.03	0.04	0.07	0.03
16	Transport & storage	0.03	0.03	0.03	0.04	0.03	0.02	0.03	0.03	0.02
17	Other services	0.11	0.07	0.06	0.10	0.08	0.06	0.12	0.07	0.06

Source: The input-output tables are drawn from OECD website

6. Import contents of Exports

Input-output tables, along with the production and flow of different commodities across all the commodities, also provide data on imports of different commodities. From these, it is possible to compute import content of exports across type of goods. It is of our interest to analyse how imports contents of India's exports has changed over time, and how does it fare relative to other countries. The comparison is done relative to the following countries namely USA, Germany and China. The relevant data are shown in Table 5.

The data in Table indicates that import contents of India's exports have gone up in recent years. However, this is true for all countries and across different categories of manufacturing or services sectors. This probably reflects the integration of Indian economy with the world. Note that import content of India's exports is lower that of China. Even in category of high/medium technologies manufactures, it is lower than that of Germany. This is surprising. Unless India invests in new technologies, it can got sustain its export's growth over time.

Table 5 Import content of Exports

Category	USA		Germany		China		India	
	Early 2000s	Mid 2000s	Early 2000s	Mid 2000s	Early 2000s	Mid 2000s	Early 2000s	Mid 2000s
Manufactures (ISIC 15-37)	0.157	0.179	0.290	0.309	0.214	0.283	0.167	0.190
Services (ISIC 45-99)	0.039	0.046	0.109	0.114	0.097	0.135	0.071	0.064
High/Medium Technologies Manufactures (ISIC 24,29-33,35)	0.152	0.164	0.276	0.278	0.273	0.348	0.190	0.222
Low/Medium Technologies Manufactures (ISIC 15-23,36-37)	0.165	0.200	0.303	0.332	0.172	0.206	0.159	0.173

Source: The input-output tables are drawn from OECD website

7. Concluding Remarks

This paper makes a modest attempt to apply input-output methodology to understand the structural changes in Indian economy in recent years. Our observations cover the period 1998-99 to 2006-07, the latest year for which India's input-output table is published. The following observations can be made from our analysis:

- Most of these manufacturing as well as services sectors exhibit large intermediate input factor productivity growth during the years under observations. Notable among them are electrical machinery, coke, refined petroleum etc, radio, television and communication equipments, machinery and equipments, construction, and hotels and restaurants.

- Barring few sectors, most of these sectors registered capital productivity gain during this period.
- India has not been able to register significant capital productivity gains in the labour intensive sectors like food products, textile products etc, even though India has comparative advantage in these sectors being a labour rich economy.
- We find that there is falling labour productivity in many of the labour intensive sectors like agriculture and allied, mining and quarrying, food products, wood products, pulp and paper.
- We find that the highest total factor productivity growth is registered in the sector electrical machinery etc followed by radio, television and communication equipments, mining and quarrying, coke, petroleum etc, machinery and equipment.
- Our analysis of technical coefficient of India's input-output table suggests that input cost on agriculture allied activities in food products, beverages sector has progressively fallen over the years.
- We find that input costs on machinery related items in many of our sector are increasing which suggest that economy is on a path of modernisation. This has also helped in reducing energy cost on production.
- Energy intensities of the Indian economy have fallen significantly between the years 2003-04 and 2006-07, the period of our observation.
- A comparison of input-output tables of India with that of Brazil and China indicates that per unit cost on electricity, gas and water supply as well as fuel is highest in India in comparison to China and Brazil at our level of sectoral aggregation.
- The transport and storage cost in India is on the higher side relative to China or Brazil. The same is true for wholesale and retail trade sector. The absence of competitive forces as well as innovation in these sectors adds to higher cost in India.

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