Efficiency of India s Intermediate Goods Industries in the Liberalized Regime

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This study analyses the technical scale, cost and allocative efficiencies of select Indian intermediary goods industries such as manufacture of chemical and chemical products, paper and paper products, leather and leather products and non-metallic mineral products in the liberalized regime between 1991-92 and 2005-06. The efficiency scores were obtained by applying Data Envelopment Approach (DEA). It was found that for the entire period, technical, scale, cost and allocative efficient Decision Making Units were more under variable returns to scale (VRS) than under constant returns to scale (CRS) production technology.

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Intermediate Goods

Manufacturing is an organized activity devoted to the transformation of raw materials into marketable goods. In technical parlance, marketable goods are known as economic goods; they cannot be obtained without paying a price. This is in contrast to free goods, which are available at no cost. The manufacturing system usually employs a series of value adding processes to convert raw materials into more useful forms and eventually into finished products. The outputs from one manufacturing system may be utilized as the inputs to another. A manufacturing system is, therefore, a typical input-output system, which produces outputs (economic goods) through activities that transform the inputs (raw materials). In an industrialized country, the manufacturing industries are the backbone of the national economy because it is mainly through their activities that the real wealth is created.

A crucial characteristic of the production process in the industrialized countries is that many goods are produced in one industry and used as input in other industries, in both home country and the trade partner countries. The goods are called intermediate goods and, are produced goods which, through the production processes, are transformed into goods of a greater value, whether another intermediate good or the final good.

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Because of high degree of specialization in production processes, and the optimal use of the production factors in the single split processes, it is important that intermediate goods, to a great extent, fulfill the connected specific needs of factors. In every link of the production processes there is precisely defined need for intermediate goods according to, certain kind of specification. The production technology for the group of intermediate goods being considered is taken to be non-combinable. This means that the single producer of the final good cannot obtain characteristics in proportions not represented among the available intermediate goods by buying more of such goods and using them in combination consequently.

The production of a specific variety of the final good requires one specific variety of intermediary goods, the ideal intermediate goods. Therefore, the number of ideal intermediate good varieties is identical with the produced number of final goods varieties. Among the intermediary goods industries, the following industries were selected based on their significant contributions to the economy.

Chemical Industry

The chemical industry is an important constituent of the Indian economy with an estimated turnover at around US$ 35 billion, constituting 1.5 per cent of the global chemical industry estimated at US$ 2,400 billion. The total investment in the sector is nearly US$ 60 billion and the employment is about one million. The industry accounts for 13-14 percent of the total exports and 8 -9 percent of the total imports into the country. Gujarat dominates with 51 percent of the total share of major chemicals produced in the country (Eleventh Five Year Plan 2007-12).

Increased competition resulting from globalization is driving the chemical industry towards consolidation, cost reduction, location of manufacturing bases close to raw materials, cheaper energy sources, lower tax regimes, increased use of information technology (IT), and intensification of R&D activities. At the same time, the industry is responding to the increased environment consciousness worldwide. Over the last decade, the Indian chemical industry has evolved from being a chemical producer to becoming an innovative industry. With increasing investments in R&D, the industry is registering significant growth in the knowledge sector comprising speciality chemicals, and pharmaceuticals. Broadly, the share of basic, knowledge, and speciality chemicals is 57 per cent, 18 per cent, and 25 per cent, respectively.

Leather Industry

The importance of the Indian leather industry is derived from the fact that it is labour-intensive and contributes substantially to exports. Artisans, micro enterprises, and SSIs account for 60-65 percent of the total production. The manufacturing activity provides full-time employment to 1 million persons and activities connected with the recovery of hides from carcasses provides part-time employment to another 0.8 million. The turnover of the industry was Rs 25,000 crore in 2004-05, out of which Rs 10,800 crore (43 per cent) was exported. Exports have risen in recent years from US$ 1.9 billion in 2006-07. The composition of exports of leather and leather goods has been moving increasingly towards leather footwear, but the share (32 per cent in 2006-07) still falls far short of the 65 per cent share of footwear in the world export of leather and leather products. The Inter-Ministerial Group constituted to evolve a comprehensive strategy for the development of the leather sector has assessed that India has the potential to expand exports from the level of US$ 2.7 billion in 2005-06 to US$ 7 billion in 2011-12.

Paper Industry

Paper industry is one of the 35 high-priority industries in India and is presently growing at 6.3 per cent per annum. The turnover is nearly Rs 17,000 crore per annum and its contribution to the national exchequer is around Rs 2,500 crore. The industry employs 0.3 million people directly and is estimated to employ 1 million people indirectly. The per capita consumption of paper in India is 7.2 kg, which is far lower than that in other emerging economies, for example it is 45 kg in China, 15-20 kg in other East Asian countries, and much higher level that exists in the US and Europe. The consumption of paper is likely to increase manifold with the rise in literacy.

At the end of the Tenth Five Year Plan there were about 666 industrial units with the total installed capacity of 8.50 million tons of paper and paperboard. However, 98 units with a capacity of 1.1 million tons have been closed due to environmental problems. The industry produces 5.80 million tons of paper and paperboard. It has made significant progress after independence with government support and fiscal incentives. The country is almost self-sufficient in most varieties of paper and paperboard, and imports are taking place only of certain speciality items such as coated paper, cheque paper, etc. However, the industry has failed to keep pace with the technological advances and is beset with major difficulties such as high production cost, pollution problems, and finished paper quality not conforming to international standards.

Mining Sector

Accelerated growth rate of the Indian economy needs rapid development of the mining sector, on which most of the basic industries depend. The efforts for locating minerals over the last 55 years have enhanced reserves of various minerals. The mining sector was opened to FDI in 1993 and 100 per cent

FDI has been allowed since 2000. During the Eleventh Five Year Plan however, the actual flows for prospecting have been minimal in the absence of policies conducive to FDI. Attracting FDI for exploration and prospecting will require a revision of the current non-investor-friendly mining regime and adoption of a multi-disciplinary approach, embracing the legal framework, technology, sustainability, infrastructure, and procedural streamlining.

There is an increasing recognition of the necessity to assess the efficiency of performance of the manufacturing sector. Efficiency is a very important factor for productivity growth especially in developing economies, where resources are scarce and opportunities for developing and adopting better technology have lately started dwindling. Past studies showed that productivity can be raised by improving efficiency, which usually is neglected, without increasing the resource base or without developing new technologies.

The Data

The data for the current study was collected from secondary sources like the economic survey and the annual survey of the industries (various issues). The reference period chosen for the study is from 1991-92 to 2005-06.

DEA Model

There are basically two approaches for estimation of efficiency, viz., the Stochastic Frontier Approach (SFA) and the Data Envelopment Approach (DEA). While the stochastic frontier approach (econometric approach) estimates the efficiency of the firms by estimating the production function, the DEA technique involves the use of mathematical programming to estimate the efficiency of the firms / industry. DEA is a non-parametric, deterministic methodology for determining relatively efficient production frontier, based on the empirical data on chosen inputs and outputs of a number of entities called Decision Making Units (DMUs). From the set of available data, DEA identifies reference points (relatively efficient DMUs) that define efficient frontier (as the best practice production technology) and evaluate the inefficiency of other interior points (relatively inefficient DMUs) that are below the frontier.

The DEA provides a measure of efficiency that allows intra-firm comparison, as the efficiency measure is a pure number. The main advantage of DEA is that unlike SFA, it does not require the *a priori* assumption about the analytical form of the production function. Instead, it constructs the best practice production solely on the basis of observed data and therefore the possibility of misspecification of the production technology is minimized. In the case of SFA, the parameter estimates are sensitive to the choice of the probability distribution specified for the disturbance term.

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There are two approaches to estimating the efficiency of a firm by DEA viz., the output-oriented efficiency and the input-oriented efficiency. In the output oriented approach, efficiency is determined by maximum output that can be produced from an input bundle. In the input-based measure, the technical efficiency of a firm is evaluated by the extent to which all inputs could be proportionally reduced without a reduction in the output. Among a number of DEA models, the two most frequently used ones (input oriented) the CCR model (Charnes, Cooper & Rhodes Model) and BCC model (Banker, Charnes & Cooper Model) have been used in the study. The DEA model has been used to estimate the technical, scale, cost and allocative efficiency of the industries under study.

I. Technical Efficiency

(i) CCR Model: Charnes, Cooper and Rhodes (1978) introduced a measure of efficiency for each DMU that is obtained as a maximum of ratio of weighted outputs to weighted inputs. The weights for the ratio are determined by a restriction that the similar ratios for every DMU have to be less than or equal to unity, thus reducing multiple inputs and outputs to single "virtual" output without requiring pre-assigned weights.

The efficiency measure is then a function of weights of the "virtual" input-output combination. Formally, the efficiency measure for the DMU can be calculated by solving the following mathematical programming problem:

$$\max h_0(u,v) = \frac{\sum_{r=1}^{S} u_r Y_{ro}}{\sum_{i=1}^{S} v_i x_{io}} \quad \ldots\ldots\ldots\ldots(1)$$

subject to

$$\frac{\sum_{r=1}^{S} u_r Y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1, j = 1, 2..., j_o, ..., n......(2)$$

u_r □ 0, r = 1,2,....,s .... (3)

v_i □ 0, j = 1,2,....,m .... (4)

where x_{ij} is the observed amount of input of the ith type of the DMU (xij> 0, i = 1,2,......n, j = 1,2,.....n) and yrj = the observed amount of output of the rth type for the jth DMU (Yrj > 0, r = 1,2,.....s, j = 1,2,...n).

The variables u_r and v_i are the weights to be determined by the above programming problem. However, this problem has infinite number of solutions since if (u*, v*) is optimal then for each positive scalar á (áu*, áv*) is also optimal. Following the above one can select a representative solution (u,v) for which

$$\sum_{i=1}^{m} v_i x_{io} = 1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

to obtain a linear programming problem that is equivalent to the linear fractional programming problem

(1) - (4). Thus, denominator in the above efficiency measure h_0 is set to equal one and the transformed linear problem for DMU can be written:

$$\max\ z_0 = \sum_{r=1}^{S} u_r Y_{ro} \text{ ....} \quad (6)$$

subject to

$$\sum_{r=1}^{S} u_r Y_{rj} - \sum_{r=1}^{m} v_i x_{ij} \leq 0,\ j = 1,2,...,n ...(7)$$

$$\sum_{r=1}^{m} v_i x_{io} = 1 \text{ ....} (8)$$

$u_r \geq 0$, r = 1,2,...., s.................. (9)

$v_i \geq 0$, i = 1,2,...., m................. (10)

For the above linear programming problem, the dual can be written (for the given DMU) as:

min z_0 = Èo.......................... (11)

subject to

$$\sum_{j=1}^{n} \lambda Y_{rj} \geq Y_{ro},\ r = 1,2,....,s\ \sum_{j=1}^{n} \lambda_r Y_{rj}$$

$\geq y_{ro}$, r = 1,2,...,s................... (12)

$$\text{È}ox_{io} - \sum_{j=1}^{n} \lambda_j x_{ij} \geq 0, i = 1,2,...,m ...(13)$$

$\lambda_j \geq 0$, j = 1,2,...,n.............(14)

Both the above linear problems yield the optimal solution È*, which is the efficiency score (so-called technical efficiency or CCR efficiency) for the particular DMU and repeating them for each DMUj , j = 1,2,....n efficiency scores for all of them are obtained. The value of È is always less than or equal to unity (since when tested, each particular DMU is constrained by its own virtual input-output combination too). DMUs for which È*❑1 are relatively inefficient and those for which È*❑=1 are relatively efficient, having their virtual input-output combination points lying on the frontier. The frontier itself consists of linear facets spanned by efficient units of the data and the resulting frontier production function (obtained with the implicit constant returns to scale assumption) has no unknown parameters.

ii. *BCC Model*: Since there are no constraints for the weights ëj, other than the positivity conditions in the problem (11) - (14), it implies constant returns to scale. For allowing variable returns to scale, it is necessary to add the convexity condition for the weights ëj, i.e. to include in the model (11) - (14) the constraint:

$$\sum_{j=1}^{n} \lambda_j = 1 \text{ ....} \quad (15)$$

The resulting DEA model that exhibits variable returns to scale is called BCC model, after Banker, Charnes and Cooper (1984). The input-oriented BCC model for the DMU0 can be written formally as:

min z_0 = Èo.......................... (16)

subject to

$$\sum_{j=1}^{n} \lambda_r Y_{rj} \geq Y_{ro} r = 1, 2, ..., s \text{ .... (17)}$$

$$\text{ÈoX}_{10} - \sum_{j=1}^{n} \lambda_j x_{ij} \geq 0, i = 1, 2, ..., m \text{ .. (18)}$$

$$\sum_{j=1}^{n} \lambda_j = 1 \text{ .... (19)}$$

ë$_j$ ❑ 0, j = 1,2,...,n............... (20)

$$\sum_{i=1}^{n} z_i = 1$$

Running the above model for each DMU, the BCC efficiency scores are obtained (with similar interpretation of its values as in the CCR model). These scores are also called "pure technical efficiency scores", since they are obtained from the model that allows variable returns to scale and hence eliminates the "scale part" of the efficiency from the analysis. Generally, for each DMU the CCR efficiency score will not exceed the BCC efficiency score, what is intuitively clear since in the BCC model each DMU is analysed "locally" (i.e. compared to the subset of DMUs that operate in the same region of returns to scale) rather than "globally".

II. Scale Efficiency

Following the scale properties of the above two models, (Cooper et al. 2000) the scale efficiency is defined as follows. For a particular DMU, the scale efficiency is defined as the ratio of its overall technical efficiency score (measured by the CCR model) and pure technical efficiency score (measured by the BCC model).

III. Cost Efficiency

The standard measure of cost efficiency is obtained via a two stage process: i) estimate the minimum price-adjusted resource usage given technological constraints, and (ii) compare this minimum to actual, observed costs. Cost efficiency can be measured if input prices are available in addition to output and input data. Let x =(x_1, ...x_k) åR+k denotes a vector of inputs and y = (y1, ...Ym) åR+m denote vector of outputs. Formally, the cost efficiency model can be specified as :

$$\text{Min z,x } \sum_{j=1}^{m} w_{jo} x_j \text{ .... (21)}$$

s.t. z.Y ❑ y_0

z.x $\leq$x0

zi ❑ 0

where Y is an n x m matrix of observed outputs for n industries and x is an n x k matrix of inputs for each industry. z is a l x n vector of intensity variables and w = (w1,...wk) åR+^{k} denoted input prices. The constraints of the model (21) define the input requirement set given by:

$$L(y) = (x.\ z.\ y \square\ y_0,\ z\ x_d\text{''}\ x,\ z\ i \square o,\ \sum_{i=1}^{n} z_i = 1) \quad \text{.........................} \quad (22)$$

The input requirement set specifies a convex technology with Variable Returns to Scale (VRS), which is imposed by the constraint $\sum_{i=1}^{n} z_i = 1$. Leaving the constraint out of the model changes the technology to Constant Returns to Scale (CRS).

IV. Allocative Efficiency

Allocative efficiency is defined as a ratio of cost efficiency score to technical efficiency score. This efficiency score was estimated for the present study both under CRS production and VRS production technologies.

Results & Discussion

Technical Efficiency: The results regarding technical efficiency scores of the selected intermediary goods industries are presented in Table 1.

Under Constant Returns to Scale (CRS) production technology, technical efficiencies during the period 1991-92 to 2005-06 were 0.834, 0.677, 0.820 and 0.815 respectively for industries manufacturing Chemical & Chemical Products, Paper & Paper Products, Leather & Leather Products and Non-Metallic Mineral Products. This implies that the industries needed only 83.4 percent, 67.7 per cent, 82.0 per cent, and 81.5 percent of the inputs currently being used. In terms of average inefficiency they would have need 19.9 per cent, 47.7 per cent 21.9 per cent and 22.6 per cent more inputs to produce the same output, which implies waste of resources to the extent mentioned above.

Under VRS production technology, the number of efficient DMUs exceeded the number of efficient DMUs under CRS production technology.

Under VRS production technology, the number of efficient DMUs exceeded the number of efficient DMUs under CRS production technology. Under VRS production technology, higher average efficiency was always recorded. It may be due to the reason that DMUs that were efficient under Constant Returns of Scale (CRS) were accompanied by new efficient DMUs that could operate under increasing or decreasing returns to scale. Higher degree of average technology inefficiency, particularly under CRS production technology, can be attributable to the fact that the industries may not be using the most efficient technology available to transform the inputs into outputs. Due to differences in products produced, the industries were likely to have different best practice frontiers; relatively small regional spheres of operation of the industries may have resulted in inefficiencies; and structured problems regarding staff efficiency and operating efficiency may have prevented the firms from improving their efficiency levels. It can be concluded

Table 1: Technical Efficiency (TE) Estimates

Industry	Chemical and Chemical Products		Paper and Paper Products		Leather and Leather Products		Non-Metallic Mineral Products	
DMU	CRS	VRS	CRS	VRS	CRS	VRS	CRS	VRS
1991-92	0.793	1.000	0.968	1.000	0.863	1.000	1.000	1.000
1992-93	0.942	1.000	0.934	0.968	0.735	0.998	0.738	0.988
1993-94	0.982	1.000	1.000	1.000	1.000	1.000	0.747	1.000
1994-95	0.886	0.949	0.815	0.997	0.693	0.855	0.792	0.999
1995-96	0.886	0.910	1.000	1.000	0.712	0.863	1.000	1.000
1996-97	0.840	0.868	0.905	1.000	0.731	0.876	0.709	0.970
1997-98	0.677	0.822	0.793	0.951	0.957	1.000	0.775	1.000
1998-99	0.725	0.907	0.598	0.704	0.946	0.759	0.750	0.966
1999-00	0.681	0.893	0.393	0.396	0.770	0.814	0.731	0.958
2000-01	0.763	1.000	0.427	0.427	0.766	0.810	0.728	0.865
2001-02	0.689	0.882	0.432	0.433	0.832	0.906	0.752	0.960
2002-03	0.870	0.939	0.411	0.415	0.783	0.882	0.708	0.762
2003-04	0.876	0.983	0.478	0.483	0.902	0.964	0.795	1.000
2004-05	1.000	1.000	0.475	0.480	0.807	0.886	1.000	1.000
2005-06	1.000	1.000	0.524	0.536	1.000	1.000	1.000	1.000
Average Technical Efficiency (1991-92 to 2005-06)	0.834	0.944	0.677	0.719	0.820	0.907	0.815	0.965
Average Technical Inefficiency 1991-92 to 2005-06	0.199	0.059	0.477	0.390	0.219	0.102	0.226	0.036
No. of Technical Inefficient DMUs (1991-92 to 2005-06)	2	6	2	4	2	4	4	7

Note: Calculations based on ASI data. CRS- Constant Returns to Scale. VRS- Variable Returns to scale that though the efficiency of the firms varied considerably on account of the various reasons mentioned, all the firms were estimated to be on the frontiers at least once. In other words, both under CRS and VRS technologies, the efficiency scores or levels during the entire period, are indicative of the fact that the efficiency of firms was not strongly influenced by the size of production.

Scale Efficiency: The scale efficiency scores of all the industries selected, for the present study are presented in Table 2.

DEA results applied to know the scale efficiency of industries for the entire period revealed that the industries were not operating at an optimum scale.

DEA results applied to know the scale efficiency of industries for the entire period revealed that the industries were not operating at an optimum scale. The average scale efficiency of manufacturing Paper and Paper Products was maximum (97.9 percent), followed by Leather and Leather Products (92.4 percent), Chemical and Chemical Products (92.1 per cent) and Non-Metallic Mineral Products (84.4 per cent). In terms of average inefficiency, production could increase to the extent of 2.1 per cent, 8.2 per cent and 18.4 per cent respectively in the above industries, by taking advantage of their scale characteristics. DEA allows assessment of whether a firm lies in the range of increasing, constant or decreasing returns to scale. In other words, it reveals the scale characteristics of DMUs. Market efficiency can be increased if more DMUs attain constant returns to scale, because fewer resources are wasted. The measurement of economies of scale, therefore, helps assess, at the same time whether higher market concentration should be encouraged to improve efficiency. A DMU may be scale inefficient, if it experiences decreasing returns to scale or if it has not taken full advantages of increasing returns to scale. Indeed most of the inefficient DMUs presented increasing returns to scale characteristics which indicates that industries can increase the scale to effectively improve that efficiency. It is clear that inefficiency can be due to the existence of either increasing or decreasing returns to scale.

Cost Efficiency: Table 3 gives details regarding cost efficiency scores of selected industries for the reference period under study.

Under Constant Returns to Scale (CRS) technology, industries manufacturing Chemicals and Chemical Products, Paper and Paper Products, Leather and Leather Products and Non-Metallic Mineral Products were efficient to the extent of 73.9 percent, 52 .9 per cent, 65.3 per cent and 79 per cent respectively. Under Variable Returns to Scale (VRS) production technology the same industries were more efficient to the extent of 87.2 per cent, 58.9 per cent, and 77.8 percent and 83.8 percent respectively. The

Table 2: Scale Efficiency (SE) Estimation

Industry	Chemical and Chemical Products	RTS	Paper and Paper Products	RTS	Leather and Leather Products	RTS	Non-Metallic Mineral Products	RTS
1991-92	0.793	IRS	0.968	IRS	0.899	IRS	1.000	CRS
1992-93	0.942	IRS	0.944	IRS	0.910	IRS	0.806	IRS
1993-94	0.982	IRS	1.000	CRS	1.000	CRS	0.795	IRS
1994-95	0.922	IRS	0.933	IRS	0.934	IRS	0.823	IRS
1995-96	0.953	IRS	1.000	CRS	0.859	IRS	1.000	CRS
1996-97	0.939	IRS	1.000	CRS	0.861	IRS	0.722	IRS
1997-98	0.974	IRS	1.000	CRS	1.000	CRS	0.777	IRS
1998-99	0.900	IRS	1.000	CRS	1.000	CRS	0.762	IRS
1999-00	0.899	IRS	0.935	IRS	0.920	IRS	0.741	IRS
2000-01	0.780	IRS	0.978	IRS	0.950	IRS	0.824	IRS
2001-02	0.905	IRS	0.950	IRS	0.882	IRS	0.757	IRS
2002-03	0.923	IRS	0.990	IRS	0.824	IRS	0.852	IRS
2003-04	0.909	IRS	0.982	IRS	0.940	IRS	0.795	IRS
2004-05	1.000	CRS	1.000	CRS	0.882	IRS	1.000	CRS
2005-06	1.000	CRS	1.000	CRS	1.000	CRS	1.000	CRS
Average Scale Efficiency (1991-92 to 2005-06)	0.921	-	0.979	-	0.924	-	0.844	-
Average Scale Inefficiency (1991-92 to 2005-06)	0.085	-	0.021	-	0.082	-	0.184	-
No. of Scale Inefficient DMUs (1991-92 to 2005-06) to 2005-06)	2	-	7	-	4	-	4	-

Note: Calculations based on ASI data. RTS - Returns to Scale. IRS - Increasing Returns to Scale. DRS - Decreasing Returns to Scale. CRS - Constant Returns to Scale.

Table 3: Cost Efficiency (CE) Estimates

Industry	Chemical and Chemical Products		Paper and Paper Products		Leather and Leather Products		Non-Metallic Mineral Products	
DMU	CRS	VRS	CRS	VRS	CRS	VRS	CRS	VRS
1991-92	0.507	1.000	0.735	1.000	0.724	1.000	0.907	1.000
1992-93	0.651	0.997	0.752	0.692	0.689	0.904	0.678	0.935
1993-94	0.739	1.000	0.898	1.000	1.000	1.000	0.703	0.833
1994-95	0.726	0.923	0.678	0.722	0.634	0.695	0.759	0.820
1995-96	0.794	0.900	1.000	1.000	0.596	0.630	0.970	1.000
1996-97	0.722	0.833	0.708	0.732	0.583	0.601	0.697	0.731
1997-98	0.639	0.729	0.613	0.649	0.782	0.862	0.765	0.791
1998-99	0.711	0.783	0.589	0.619	0.636	0.715	0.744	0.764
1999-00	0.680	0.743	0.305	0.358	0.581	0.694	0.727	0.745
2000-01	0.700	0.757	0.323	0.360	0.566	0.692	0.725	0.737
2001-02	0.656	0.707	0.234	0.264	0.588	0.725	0.725	0.726
2002-03	0.801	0.840	0.250	0.268	0.550	0.643	0.700	0.712
2003-04	0.844	0.870	0.266	0.285	0.642	0.809	0.766	0.778
2004-05	1.000	1.000	0.267	0.285	0.560	0.699	0.996	0.998
2005-06	0.910	1.000	0.321	0.325	0.671	1.000	1.000	1.000
Average Cost Efficiency (1991-92 to 2005-06)	0.739	0.872	0.529	0.589	0.653	0.778	0.790	0.838
Average Cost Inefficiency (1991-92 to 2005-06)	0.353	0.146	0.890	0.697	0.531	0.285	0.265	0.193
No. of Cost Inefficient DMUs (1991-92 to 2005-06)	1	4	1	3	1	3	1	3

Note: Calculations based on ASI data. CRS - Constant Returns to Scale. VRS - Variable Returns to Scale.

cost efficient DMU's were more under VRS production technology. The average cost inefficiency was more under CRS production technology than under VRS production technology.

Allocative Efficiency: Allocative efficiency scores of the industries for the reference period is presented in Table 4.

Over the study period, the industries under CRS production technology had on an average, allocative efficiency level of 89.0 per cent, 75.0 per cent, 79.8 percent and 97.0 per cent for Chemical and Chemical Products, Paper and Paper Products, Leather and leather Products, and Non-metallic Mineral Products respectively implying that the industries were 11 per cent, 25 per cent, 20.2 percent and 3 per cent inefficient respectively. In the case of VRS production technology, an average allocative efficiency of 92.5 per cent, 78.7 per cent, 85.4 per cent and 86.9 per cent could be observed by industries manufacturing Chemical and Chemical Products, Paper and Paper Products, Leather and Leather Products and Non-Metallic Mineral Products respectively implying that the industries were on an average 7.5 per cent, 21.3 per cent, 14.6 per cent and 13.1 per cent inefficiency respectively in these industries. More efficient DMUs were observed under VRS production technology compared to CRS production technology. The average inefficiency scores were more for Paper and paper Products both under CRS and VRS Production technologies.

Conclusion

For the entire period, technical, scale, cost and allocative efficient DMUs were more under Variable Returns to Scale (VRS) production technology than under Constant Returns to Scale (CRS) production technology. Inefficiency could be due to the existence of either increasing or decreasing returns to scale. Technical efficiency was more in industries manucaturing Chemical and Chemical Products both under CRS and VRS production technologies. Technical inefficiency was more in industries manucaturing Paper and Paper Products under CRS and VRS production technologies. Cost efficiency both under CRS and VRS production technologies, was more in industries manufacturing Non-Metallic Mineral Products, while cost inefficiency was more in industries manufacturing Paper and Paper Products under CRS production technology. Industries manufacturing Paper and Paper Products were found to be cost inefficient, when compared to other industries under VRS production technology. Allocative efficiency under CRS and VRS technology was observed more in industries manufacturing Non-Metallic Mineral Products. On the contrary, high allocative inefficiency was observed in industries manufacturing Paper and Paper Products under CRS production technology, while Paper and Paper Products proved as an allocatively inefficient industry under VRS production technology when compared to the others.

Table 4: Allocative Efficiency (AE) Estimates

Industry	Chemical and Chemical Products		Paper and Paper Products		Leather and Leather Products		Non-Metallic Mineral Products	
DMU	CRS	VRS	CRS	VRS	CRS	VRS	CRS	VRS
1991-92	0.640	1.000	0.760	1.000	0.839	1.000	0.907	1.000
1992-93	0.691	0.997	0.804	0.993	0.937	0.906	0.910	0.945
1993-94	0.753	1.000	0.898	1.000	1.000	1.000	0.941	0.833
1994-95	0.819	0.973	0.832	0.725	0.914	0.813	0.958	0.821
1995-96	0.897	0.989	1.000	1.000	0.837	0.729	0.970	1.000
1996-97	0.898	0.960	0.783	0.732	0.797	0.687	0.983	0.754
1997-98	0.944	0.887	0.774	0.683	0.817	0.762	0.987	0.791
1998-99	0.980	0.863	0.985	0.880	0.852	0.942	0.991	0.791
1999-00	0.998	0.832	0.776	0.903	0.754	0.853	0.995	0.778
2000-01	0.928	0.755	0.756	0.844	0.740	0.855	0.996	0.852
2001-02	0.953	0.802	0.541	0.609	0.707	0.800	0.951	0.756
2002-03	0.993	0.892	0.607	0.645	0.703	0.729	0.989	0.934
2003-04	0.962	0.886	0.556	0.590	0.712	0.840	0.964	0.778
2004-05	1.000	1.000	0.563	0.595	0.694	0.789	0.996	0.998
2005-06	0.910	1.000	0.611	0.607	0.671	1.000	1.000	1.000
Average Allocative Efficiency (1991-92 to 2005-06)	0.890	0.925	0.750	0.787	0.798	0.854	0.970	0.869
Average Allocative Inefficiency (1991-92 to 2005-06)	0.123	0.081	0.333	0.270	0.253	0.170	0.030	0.150
No. of Allocative Inefficient DMUs (1991-92 to 2005-06)	1	4	1	3	1	3	1	3

Note: Calculations based on ASI data. CRS - Constant Returns to Scale. VRS - Variable Returns to Scale.

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