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Assessing comparative efficiency of the state-owned mixed and private sectors in Indian industry*

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Abstract. This paper evaluates performance differences between government owned, mixed sector and private sector enterprises in India for the period 1973–1974 to 1988–1989. The results establish that enterprises owned by the central government and state governments are less efficient than mixed or private sector enterprises, while mixed sector enterprises are less efficient than those in the private sector. The results contradict extant evidence finding no performance differences between government-owned and private firms in India. There have, however, been inter-temporal efficiency gains for the sector as a whole, perhaps resulting from reforms undertaken towards improving government-owned enterprises' performance.

1. Introduction

Considerable disquiet about the performance of the government-owned sector of Indian industry has been expressed by writers who have been senior policy-makers (Bhoothalingam, 1993; Jalan, 1991; Marathe, 1989) and academics (Bardhan, 1984; Bhagwati, 1993). Yet, extant comparative evidence (Bhaya, 1990; Jha and Sahni, 1992; Ramaswamy and Renforth, 1994) points to no significant differences in the performance of private versus state-owned firms. What is the true picture? If the Indian government-owned sector is as efficient as the private sector, then the large amount of effort being currently devoted to privatization and reforms is of no avail, since the efficiency gains are unlikely to be material.[1] Conversely, the authors expressing disquiet may have substantive reasons for doing so, and contemporary empirical research could be flawed. The resolution of such a conundrum, then, has to be based on evidence, and this paper reports the results of a study evaluating comparative efficiency patterns among segments of Indian industry owned by different categories of investors.[2]

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Comparative efficiency assessment is also important for another reason. Research shows that the evolution of modern industry, the capabilities developed within industry, and the efficiency with which these capabilities have been utilized have been a major force in shaping the growth and economic strength of modern nations (Chandler, 1993). The state-owned sector accounts for a substantial part of employment and capital investment in many developed as well as developing nations. Therefore, understanding whether the state-owned sector performs better or worse than private enterprises is relevant in shedding light on whether national progress is being propelled forward, at least sustained at a certain level, or impeded.[3]

The Indian experience with the state-owned sector provides a rich backdrop for assessing comparative efficiency. In terms of magnitude, the state-owned sector constitutes a large proportion of industrial activity, and for the first four decades since independence the Indian economy has seen an ever-increasing role played by state-owned enterprises. Jalan (1991) notes that the total investments in Indian central government-owned enterprises were Rs. 182,000 crores (Rs. 34 = $1; 100 crores = 1 billion) in 1990, made up as fixed capital: Rs. 82,000 crores, working capital: Rs. 76,000 crores, sundry investments: Rs. 11,000 crores and the deficit financed by the owners: the government of India: Rs. 13,000 crores. These figures excluded the assets of enterprises in the banking and insurance sectors, as well as those of departmental undertakings such as railways, posts and a large portion of the telecommunications network.

Table 1 gives an indication of the increasing role of the state-owned sector in India's industrial economy. It shows the composition of employment, productive capital (including fixed and working capital) and value added between the state-owned sector (owned by the central government and the governments of different states), the mixed sector and the private sector for six recent time-periods: 1973–1974, 1976–1977, 1979–1980, 1982–1983, 1985–1986 and 1988–1989.

With respect to employment, the share of the state-owned and the mixed sectors has risen, in total, from 27 percent in 1973–1974 to 37 percent in 1988–1989. With respect to productive capital invested, the share of the state-owned and mixed sectors was over half, at 58 percent, in 1973–1974. By 1979–1980, this share had risen to 68 percent. Though fluctuations have occurred, in 1988–1989 the share remained at 66 percent, implying that two-thirds of the capital invested in Indian industry is owned by the state-owned and mixed sectors.[4]

The paper evolves as follows. In Section 2 theory and evidence with respect to performance assessment are discussed. Thereafter, in Section 3 the empirical analyses are described. Data and estimation issues connected with the

Table 1. Composition of employment and capital in the Indian industrial sector: Trends over time

Year	Sectoral composition of employment		Sectoral composition of capital employed	
	Private	State	Private	State
1973–1974	0.73	0.27	0.42	0.58
1976–1977	0.70	0.30	0.36	0.64
1979–1980	0.68	0.32	0.32	0.68
1982–1983	0.66	0.34	0.32	0.68
1985–1986	0.63	0.37	0.37	0.63
1988–1989	0.61	0.39	0.34	0.66

paper are discussed. The analysis is based on a comparison of efficiency patterns for sixteen time-periods between 1973–1974 and 1988–1989, which is the last year for which data have been released by the Central Statistical Organization of the Government of India, for four sectors of Indian industry in respect of which data have been reported by ownership type. These are: the central government-owned sector; the state government-owned sector; the mixed sector; and the private sector.[5] Section 4 discusses the results that are obtained from the empirical analyses, and Section 5 concludes the paper.

2. Theory and evidence

2.1. *Theory*

Arguments advanced for the existence of performance differences between private and government-owned enterprises are as follows. To the extent that ownership composition varies, principal-agent issues arise (Putterman, 1993). Property-rights over the enjoyment and disposal of assets are attenuated in government-owned enterprises because a market for corporate control is absent. Capitalization of future consequences into current share prices is inhibited, leading to a reduction in owners' incentives to monitor managers, and the exit option that can be exercised where there is a market for corporate control is not viable. Consequently, there is a lack of capital market discipline to which state-owned enterprise agent-managers can be subjected to by owner-principals.

Next, an issue arises with respect to the fuzziness of owners' identity. With many owner-principals there are incentives to free-ride because any owner bearing the costs of monitoring has to share them with others (Ben-Ner et al., 1993). The ownership of state-owned enterprises is vested in individual government departments. Theoretically, therefore, this attribute ought to ensure superior performance, compared to the private sector, since ownership is not diffused among many owners but there is only one owner who can exercise strong control. However, the government department is, itself, an agency for citizens who are the de-jure owners of state-owned enterprises. This means that the control of government-owned enterprises, currently being undertaken by civil servants, is vested in persons who are themselves agents monitoring other agents, and have no incentives for carrying out their tasks.

The consequences can be as follows. As a collection of many principals, citizens face severe agency problems. Citizens in a democracy have neither the incentives, nor can they find it easy to control state-owned industrial enterprise managers. Individually they cannot arrange a private portfolio of state-funded enterprises, whereby the benefits of information acquired from having undertaken monitoring activities can be internalized. Then, the very diffuseness of public ownership implies that citizens acting individually have small probabilities in influencing outcomes or expressing voice. As a result, state-owned enterprises effectively become proprietary organizations owned de-facto by civil servants or politicians, while managers in such organizations know that they are free of both market discipline or sanctions from the ultimate principals.

In a related vein, Vickers and Yarrow (1988) argue that it is primarily variations in the nature of competitive regimes faced that determine performance differentials between privately and publicly-owned firms. There is some evidence which finds that public and private firms facing similar competitive environments do not display any efficiency differences (Caves and Christiansen, 1980), or that given sufficient competition between private and public producers, and no discriminating regulations, unit cost differences are insignificant (Borcherding et al., 1982). Nevertheless, in spite of similarities in competitive conditions, the composition of the specific institutional environments that private sector or public sector firms are faced with may affect performance.

For example, there is the reality of the political environment surrounding government-owned enterprises. While citizens may have little say in the functioning of government-owned firms, government decision-making is surrounded by a constellation of interests forming specialized coalitions interested in government-enterprise operations. These actors include politicians, unions, trade associations and consumer groups who can pressurize bureaucrats into directing government-owned bodies into acting in manners consistent with their own special interests. While the distributional consequences of such pulls and pressures may often be positive, their impact on efficiency is likely to be negative because such factors do tend to make the management process in government-owned enterprises complex and unfocussed.

2.2. *Evidence*

There is a large literature evaluating the relative performance of the public versus the private sector. Boardman and Vining (1989) evaluate fifty-four studies, of which six find the public sector to be more efficient, sixteen find no performance differences between the two sectors, while thirty-two find that the private sector is more efficient. Many of these studies have compared firms undertaking specific activities, such as running airlines, supplying water or supplying refuse collection services. However, comparatively few studies have compared efficiency patterns among different ownership segments of the industrial sector as a whole for a specific country.

There are some exceptions. Funkhouser and MacAvoy (1979) evaluate the performance of a number of Indonesian public and private firms, operating in different areas of the economy. Boardman and Vining (1989), in a comprehensive study, evaluate the performance of five-hundred of the world's largest corporations outside the United States for the year 1983. The companies they evaluate operate in the mining and manufacturing sectors, and belong to several nationalities. They find that, controlling for a variety of factors, mixed and state-owned enterprises perform worse than similar private enterprises. In terms of their key performance indicators, mixed enterprises are no different from state-owned enterprises, but relatively worse performers compared to the private sector firms.

With respect to India, three studies exist. These have used a variety of methodologies, data and performance benchmarks. Bhaya (1990) uses Annual Survey of Industries (ASI) data for the years 1981–1982 to 1985–1986. Calculating simple ratios of net value added to fixed capital, working capital and inventory, but ignoring human capital utilization, he believes it is safe to conclude that public sector management efficiency is in no way inferior to that of the private sector, but the sector does perform worse with respect to its return on investment.

Jha and Sahni (1992) use ASI data for the years 1969–1961 to 1982–1983 for four industries: cement, cotton textiles, electricity and iron and steel. The latter two industries, they claim, are primarily in the public sector, while the first two are owned predominantly by private interests. The authors find no evidence of allocative inefficiencies in general, and each of them are relatively as efficient as one another. Ramaswamy and Renforth (1994) use 1988–1989 to 1992–1993 accounting data for a non-randomly chosen and matched sample of 55 firms each from the private and public sectors. Using the same measures as Bhaya (1990), they conclude that managerial efficiency differences do not exist between the two sectors, though public sector firms are again found to be less profitable.

These studies contradict theory and belief with respect to public sector performance. However, each study suffers from biases which call the results into question. Bhaya (1990) uses very simplistic techniques, a narrow time-window, and eye-balling procedures as analytical methodology to reach his conclusions. Jha and Sahni (1992) are more rigorous, but restrict their study to four sectors only. They also evaluate allocative efficiency, and no conclusions with respect to technical or managerial efficiency can be made based on their study. Ramaswamy and Renforth (1994) also have a narrow time-window, their study suffers from the same methodological shortcomings as the one by Bhaya (1990), and also from maximum sample-selection bias. They non-randomly choose 55 firms each from the private and public sectors, and, given the wide heterogeneity of private sector firms in India, it is easy to choose a number of them which are similar to their public sector counterparts in efficiency characteristics.

3. Emprical analyses

3.1. *Data and context*

To calculate comparative efficiency patterns over the period 1973–1974 to 1988–1989, data generated by the Annual Survey of Industries (ASI) in India are used. The ASI data relate to the organized sector of manufacturing industry and have seen prior use (Ahluwalia, 1991). The factory sector summary is used as the data-source for this study. From the data set, labor and capital inputs as well as output measures can be identified.

The advantage of using this data is that information for the entire Indian industry is available. This includes information on firms owned by the governments of the various states in the Indian Union which are also substantial players in the industrial arena, and whose performance has never been empirically analyzed. The characteristic of this particular data-base is that data are aggregate because of the reporting policies of the Department of Statistics of the Government of India. However, the aggregation issue is unavoidable since information on a key variable, that of firm-level employment, is just not available for private sector firms. Hence, any comparative study of efficiency has to use a data-base such as this. Aggregate data also helps avoid any sample-selection biases, since data on the entire industrial population is considered for comparative efficiency assessment purposes.

Since 1956, every conceivable sub-sector of Indian industry has seen their presence of state-owned firms. Apart from defense firms, traditionally in the public domain, generation of atomic and non-atomic power, manufacture of aircraft, heavy machinery, and equipment for rail and sea transport are among activities carried out exclusively by state-owned firms. At present, state-owned firms also manufacture products such as aluminium and non-ferrous metals, chemical intermediates, iron and steel, drugs and fertilizers, and are involved in diverse activities such as construction, engineering consultancy, farming, handicrafts retailing, shipping, coal mining, oil refining, commodity trading, and software consultancy. State-owned firms operate in many consumer-goods industries such as condoms, hotels, handicraft retailing, food products, televisions and consumer electronics where competition among players is very high, and in general are subject to the same institutional and regulatory forces that private firms have to face with regard to day-to-day operations. Data for firms undertaking these activities are included within the data that are analyzed.

Three inputs and one output are used in the computation of an efficiency index for each observation. The inputs are rupee values of fixed and working capital, and the actual number of staff employed. The output variable is net value added, expressed in crores of rupees (a crore is equal to ten million) which is a standard measure of firm-level output (Jackson and Palmer, 1988). In the contemporary literature on efficiency measurement both value added and gross output are concomitantly used to measure output. However, Griliches and Ringstad (1971) advance arguments in favor of using value added because it facilitates comparison of results for firms which may be heterogenous in material consumption. Second, inclusion of material as an input may lead to the problem that all variation in efficiency may be captured by materials consumption, thus obscuring the role of physical and human capital utilization.

A further choice arises between the use of either gross or net value added as the output measure. Denison (1974) makes a case for the use of net value added on theoretical grounds by arguing that, since gross value added includes a measure of capital consumption, there is no rationale as to why capital consumption ought to be maximized rather than minimized. Nevertheless, value added captures hybrid aspects of firms' activities, as Diewert (1978) has noted. First, it captures a production relationship between primary factors and output. This relationship is based on managements' capabilities. Second, it also captures a profit-generating relationship between firm-specific capital and firms' output, which, while also dependent on endogenous management capabilities, is highly dependent on exogenous demand and supply conditions, since these conditions determine the prices a firm is able to charge for its outputs. In the context of state-owned firms in developing countries, administered price regimes may be in operation, and governments use state-owned firms to operate as indirect tax collectors (Reddy, 1990). In the case of India, this is particularly true for state-owned oil firms. Thus, there may be a large element of windfall price-gains captured in the value added measure for each firm.

To create value necessitates acquisition and configuration of capabilities, which are encapsulated in physical, liquid and human capital. Capital inputs, both physical and working capital, are also expressed in crores of rupees. Human capital inputs are expressed in thousands of employees. To deflate variables expressed in rupees the wholesale price index is used; the capital inputs and the output values are then expressed in constant rupees.

Capital inputs can be book-values of physical capital given in ASI data, however, in measuring capital input, the use of undeflated amounts lead to inaccuracies. The book value series is deflated by a price index. The weakness of the approach is that it does not take into account assets of different vintages bought at different points of time. Conversely, major lacunae of the perpetual inventory method, which can take into account the different-vintage issue, are the two key assumptions, for some base year of an amount as beginning capital stock, and an annual rate of capital consumption. Therefore, efficiency parameters obtained by different researchers can vary amongst themselves, because each researcher may choose to base analysis of idiosyncratic assumptions as to the base capital values and rate of capital consumption.

The ASI data reported by individual enterprises are collected at the factory level. For public reporting purposes, data classified by ownership category are released only in aggregate. Thus, for every year there are four observations with respect to output and inputs, given the existence of four ownership categories. However, time-series observations for each ownership category are available for each year between the period 1973–1974 to 1988–1989; thus, for each category there are sixteen available observations. Pooling data by ownership category and time yields sixty-four observations to be used for comparative efficiency assessment. The ASI coverage and almost two decades of time-series data yield rich information on the entire population of enterprises that make up the organized industrial sector of India.[6]

The analyses involve calculating and comparing efficiency for the 16 years between 1973–1974 and 1988–1989. For each year and each ownership category an efficiency score is calculated, and to statistically assess performance differences between various ownership categories, the scores for each category are averaged for the sixteen-year period. Second, an issue is, have there been efficiency gains over time? Fundamental economic liberalization started in India in 1991. However, there were two spells of liberalization, one starting after 1980 when the prime minister Mrs. Indira Ghandhi commenced reforms, which her successor Mr. Rajiv Gandhi continued from 1985 onwards (Ahluwalia, 1991; Bhagwati, 1993). To test whether these had any impact, the growth rates in efficiency scores obtained for each ownership category are calculated.

3.2. *Efficiency estimation*

Data envelopment analysis (DEA)[7] is used for estimation purposes. Using observed output and input data, and without making any assumptions as to the nature of underlying technology or functional form, the DEA algorithm calculates an ex-post measure of the efficiency of each observation. This is accomplished by constructing an empirically-based frontier, and by evaluating each observation against all others included in the data set.

Two main paradigms have evolved in the construction of frontier production functions. There is the parametric approach, based on estimating regression-driven production functions, and the non-parametric approach (DEA), based on estimating linear programming models of the relative efficiency. The advantage of the non-parametric approach is that it can handle multiple outputs and multiple inputs. The data need not all be quantitative, and qualitative measures can be used as outputs or inputs. Concomitantly, both nominal and physical values can be simultaneously used as outputs or inputs, because the aim is not to estimate functional parameters, per se, as in regression-based efficiency estimation techniques, but relative measures of efficiency among observations.

The advantage of DEA is in its approach. DEA optimizes for each individual observation, in place of overall aggregation and single optimization performed in statistical regressions. Instead of trying to fit a regression plane through the center of the data, DEA floats a piece-wise linear surface to rest on top of observations. This is empirically-driven by data, rather than by assumptions as to functional forms. The only assumption made is that the piece-wise linear envelopment surface is convex. Next, the efficiency score is a bounded efficiency measure, and any observation with a score of less than 1 has measurable potential for improvement.

Charnes, Cooper, and Rhodes (1978) [CCR] generalize a multiple output-input measure of performance by means of a fractional mathematical program were the ratio of the weighted outputs to weighted inputs (an efficiency ratio) for each firm-level observation being evaluated is maximized. There are a total of n observations being evaluated. The data used for each observation j (where j are the observations: $j = 1, 2, \ldots k \ldots n$) are as follows: each observation consumes varying amounts of m different inpouts to produce s different outputs. Specifically, observation j consumes $X_j = \{x_{ij}\}$ of inputs $(i = 1, \ldots m)$ and produces amounts $Y_j = \{y_{rj}\}$ of outputs $(r = 1, \ldots s)$. It is assumed that $x_{ij} > 0$ and $y_{rj} > 0$. The $s \times n$ matrix of output measures is denoted by Y and the $m \times n$ matrix of input measures is denoted by X.

For the kth observation (among the j total observations) for which efficiency is being evaluated, the objective of the empirical exercise is to maximize the value of h_k which is the ratio of outputs to inputs, and the values of u and v; this function is expressed as

$$h_k(u,v) = \sum_{r=1}^{s} u_r y_{rk} / \sum_{i=1}^{m} v_i x_{ik} \tag{1}$$

In the above expression, h_k is a ratio measure of performance as to how efficient each observation was with regard to converting a set of inputs jointly and simultaneously into a set of outputs. For each k_{th} observation, y_{rk} are the outputs which result from the conversion of x_{ik} inputs; u_r and v_i are weights which are calculated as values to be assigned to each output and input in order to maximize the efficiency rating, h_k, of the observation being evaluated.[8]

Without any more constraints (1) is unbounded. Additional technological constraints are introduced with respect to every other observation to reflect the condition that the efficiency ratio be less than or equal to unity, or in other words, no observation can be super-efficient. The mathematical programming problem that results is:

$$\max h_k(u,v) = \sum_{r=1}^{s} u_r y_{rk} / \sum_{i=1}^{m} v_i x_{ik} \tag{2}$$

subject to:

$$\sum_{r=1}^{s} u_r y_{rj} / \sum_{i=1}^{m} v_i x_{ij} \leq 1 \qquad (\text{for } j = 1, 2, ...0, ...n) \tag{3}$$

$$u_r > 0 \qquad (\text{for } r = 1, 2, ...s) \tag{4}$$

$$v_i > 0 \qquad (\text{for } i = 1, 2, ...m) \tag{5}$$

The constraint in (3) ensures that the ratio measure of performance is not greater than one for any observation in the entire observation set, while the constraints in (4) and (5) are positivity constraints and are strictly greater than zero. (2) to (5) is a linear fractional programming problem, non-convex and difficult to solve. To do so, the fractional program in (2) is translated into a linear program using a transformation which involves computation of two new variables: $\mu = \frac{u}{vX_k}$ and $\nu = \frac{v}{vX_k}$ to make the linear fractional programming problem a linear programming problem. The linear programming problem for the kth observation being evaluated now is:

$$\max_{\mu,\nu} w_k = \sum_{r=1}^{s} \mu_r y_{rk} / \nu_i x_{ik} \tag{6}$$

subject to:

$$\sum_{i=1}^{m} \nu_i x_{ik} = 1 \tag{7}$$

$$\sum_{r=1}^{s} \mu_r y_{rj} - \sum_{i=1}^{m} \nu_i x_{ij} \leq 1 \qquad (j = 1, 2, ...k, ...n) \tag{8}$$

$$\mu_r > 0 \qquad (r = 1, 2, ...s) \tag{9}$$

$$\nu_i > 0 \qquad (i = 1, 2, ...m) \tag{10}$$

In (6), now w_k is the objective function value for the observation being evaluated, and is the efficiency score to be calculated for the k*th* observation being evaluated. In the L.P. in (6) the weighted sum of outputs that can be obtained is sought to be maximized, subject to the constraint that the weighted sum of inputs equals unity in (7). (8) is a constraint postulating that outputs cannot be less than inputs, and (9) and (10) are positivity constraints.

Each DEA model seeks to determine which subsets of the n observations determine parts of an envelopment surface. In the L.P. formulation the optimal value (optimal = *) of w_k^* is an efficiency indicator which measures the distance a particular firm-level observation lies from the frontier. The k*th* firm-level observation is efficient if $w_k^* = 1$ in (6). This observation is inefficient if it does not lie on the frontier or $w_k^* < 1$.[9] The optimization process in (6) is repeated n times, once for each firm-level observation for which efficiency is to be evaluated. That is, the L.P. is solved with $(X_k, Y_k) = (X_j, Y_j)$ for $j = 1, 2, ...k, ...n$. Each time the optimization is carried out data for other observations form part of the constraint set. The objective function values obtained partition the data-set into two parts: one consisting of efficient observations and the other consisting of observations which are inefficient and were $w_k^* < 1$.

In extending the CCR model, Banker, Charnes, and Cooper (1984) [BCC] show that the CCR efficiency score can be broken up into measures of scale efficiency, and pure technical efficiency given the scale of operations each observation is presently at. This is achieved by assuming that variable returns to scale exist, and adding a variable $\tilde{u}_k$ in the objective function in (6). The result of adding this variable is that hyperplanes for each observation do not pass through the origin, unlike in the CCR model where all hyperplanes go through the origin because constant returns to scale are assumed. In the constraint set, this variable is unconstrained in that it can take on values which are negative (increasing returns to scale exist), or 0 (constant returns to scale exist) or positive (decreasing returns to scale exist) for each kth observation.

3.3. *Efficiency growth rates*

To calculate efficiency growth rates, an exponential efficiency-time relation is initially specified, as follows:

$$E_t = x(1 + r)^t \mu t \tag{11}$$

which can be linearized as follows:

$$\text{Ln } E_t = a + bt + ut \tag{12}$$

where E_t = an efficiency ratio generated by the DEA program for each sector and time-period.

$$\begin{aligned} t &= \text{time in discrete years } (t = 1\ldots16); \\ a &= \ln x = \text{a constant}; \\ r &= \text{annual compound growth rate}; \\ b &= \ln(1 + r) \\ ut &= \ln \mu t \sim \text{ind}(0, \sigma^2) \end{aligned}$$

The exponential form is chosen for the following reason. If progress is assumed to be dynamic, then efficiency in a given year is more likely to be at least a constant percentage of efficiency in the previous year and not a constantly diminishing percentage of it. The coefficient on time, b, is the continuous rate of growth, but given the range of values it closely approximates the annual compound growth rate, and the estimates of b are taken as the growth rates. A basic problem which arises in the fitting of equation (12) to the full time-series data is that the growth rate in a given period can differ from the growth rates of efficiency in the various sub-periods. The estimated growth rates in efficiency in each period can be higher or lower than that of the entire period, depending on the nature of policy regimes in place. Thus, sub-period growth rates in efficiency are estimated for the years: 1973–1980 and 1981–1988 separately.

The variations in growth rates shown by estimates of equation (11) raise an issue as to whether these rates are constant. Efficiency growth rates can accelerate or decelerate. To incorporate such possibilities and evaluate the rate of change in efficiency for the full period as well as for the two sub-periods, a log-quadratic equation is estimated, as follows:

$$\ln E_t = a + bt + ct^2 + ut \tag{13}$$

A significantly positive value of c indicates an acceleration in the growth rate of efficiency; a significantly negative value indicates deceleration.

The inclusion of time squares on the right-hand side in (13) introduces a multi-collinearity problem. This is solved by normalizing time in mean deviation form. That is, it is set to zero on the mid-point of the time series. This procedure is followed for the full series as well as for each of the two subperiods. This normalization makes time and its square orthogonal. The normalization of time only affects b. The estimate of c and its standard error are invariant with respect to the normalization. In the log-quadratic estimation, the value of b is the same as in the log-linear model. The standard error of b is the measure of instability of the growth rate of efficiency. If it is assumed that the log-quadratic form is a better estimator of the true trends in the growth rate of efficiency, the instability measure of b is also improved, since systematic specification errors are cleansed from the data.

4. Results

4.1. *Comparative efficiency patterns*

The BCC DEA algorithm, which makes no assumptions as to the returns to scale characteristics of the different observations, is used to calculate relative efficiency scores. The detailed scores for each ownership category by each year are given in Table 2. The descriptive statistics of the scores are given in Table 3, and form the basis of the subsequent discussion.

The sectors of Indian industry owned by the central government and the governments of the various Indian states have average efficiency scores of 0.658 and 0.638, on a scale of 0 to 1, respectively for the period between 1973–1974 and 1988–1989. Comparatively, the sector of Indian industry owned jointly by a combination of government and private owners has a score of 0.912. The privately-owned segment of Indian industry has a score of 0.975 for the same period. It is reiterated that these are comparative scores only. If data for later years are used, the resultant average scores may very well change. If a sector, say the mixed enterprise sector, is dropped from the computations, again the relative scores may very well change.

Prima facie, the results reveal that government-owned firms are less efficient than firms in the mixed or the private sector. The data also reveal that in the Indian context mixed sector firms are more efficient than government-owned firms, but less efficient than those in the private sector, while the private sector is comparatively the most efficient sector of Indian industry. The variation in the patterns of DEA-derived scores are also of interest. The central and state government sectors have considerably higher variation in their

Table 2. Efficiency scores for four sectors of Indian industry: Computations for the years 1973–1974 to 1988–1989

	Central government sector	State government sector	Joint sector	Private sector
1973–74	0.596	0.656	1.000	0.908
1974–75	0.746	0.474	1.000	1.000
1975–76	0.597	0.676	0.922	0.866
1976–77	0.613	0.256	0.815	0.952
1977–78	0.544	0.582	0.912	0.959
1978–79	0.483	0.726	0.888	1.000
1979–80	0.466	0.498	0.757	1.000
1980–81	0.474	0.447	0.731	1.000
1981–82	0.608	0.579	0.857	0.988
1982–83	0.671	0.620	0.888	0.952
1983–84	0.525	0.762	0.954	1.000
1984–85	0.555	0.657	1.000	1.000
1985–86	0.879	0.892	0.925	1.000
1986–87	0.819	0.976	0.984	0.998
1987–88	0.951	0.618	0.962	0.969
1988–89	1.000	0.787	1.000	1.000

Table 3. Descriptive statistics for the efficiency scores: 1973 to 1988

Parameter	Central government	State government	Joint sector	Private sector
Mean	0.658	0.638	0.912	0.975
Standard deviation	0.171	0.176	0.086	0.039
Coefficient of variation	0.260	0.275	0.094	0.045
Maximum	1.000	0.976	1.000	1.000
75% tile	0.782	0.744	0.992	1.000
Median	0.602	0.638	0.924	0.999
25% tile	0.534	0.538	0.872	0.956
Minimum	0.466	0.256	0.731	0.866
Range	0.534	0.720	0.269	0.134
Inter-quartile deviation	0.248	0.205	0.120	0.044

efficiency scores as compared to the mixed and private sectors. The standard deviation (coefficient of variation) of the scores are 0.171 (0.260) and 0.176 (0.275) respectively, compared to standard deviations (and coefficients of variations) of 0.086 (0.094) and 0.039 (0.045) for the mixed and private sectors.

Data on the maximum, 75th percentile, median 25th percentile and minimum scores are given, and the range and the inter-quartile deviations for the four sectors reveal the existence of considerable variation in the scores for the central and state governments-owned portions of Indian industry. While the mixed sector scores do not vary as much as those for the government sectors, they do vary more than the scores for the private sectors. The data show that the range and inter-quartile deviation of the score for the mixed sector, at 0.269 and 0.120 respectively, are higher than those of the private sector which are 0.134 and 0.044.

The greater variation noted in the scores for the government-owned sectors has a key implication. While the average efficency of the government-owned sector is lower than that of the mixed or private sectors, the scores have fluctuated considerably, suggesting that performance of state-owned enterprises has been relatively volatile. A glance at Table 3 reveals that the efficiency scores for the central government-owned sector were around the 0.5 mark during much of the seventies and early eighties, but rose considerably after 1985–1986. It is feasible that after the installation of Rajiv Gandhi's government in late 1984 the liberalization that was undertaken had some impact, and this shows up in the higher scores for the last four years in the present dataset. Comparatively, the portion of Indian industry owned by the state governments, prima facie, shows no discernable pattern in its efficiency scores for the sixteen years studied.

Table 4 presents the results of a statistical test carried out to evaluate whether the average efficiency score for each ownership category differ significantly from each other. The non-parametric procedure carried out is the one suggested by Wilcoxon (1945).

As shown in Table 4, statistically there is no difference between the efficiency of the central government-owned sector and that part of Indian industry owned by the various state governments, and the Wilcoxon z statistic comparing differences in average scores is almost negligible (with a p value almost unity at 0.96). The central government-owned sector is statistically higher inefficient than both the joint sector and the private sector (with the associated p values being 0.00). Similarly, the sector owned by the state governments is also statistically less efficient than either the joint or the private sectors (again p values are 0.00). Finally, the joint sector is also significantly less efficient than the private sector. However, while the efficiency difference is statistically significant, the significance is not as strong (the p value is 0.02) as it was with respect to efficiency differences between the central or state-government-owned sectors and the joint or private sectors.

It has been remarked that in the post-1980 period industrial reforms started taking place in India. Differences in scores for each ownership category are

Table 4. Non-parametric test results comparing pair-wise efficiency scores among the different sectors

Period: 1973 to 1988

	State government sector	Joint sector	Private sector
Central government sector	0.00 (0.96)	3.41 (0.00)	3.41 (0.00)
State government sector		3.52 (0.00)	3.52 (0.00)
Joint sector			2.27 (0.02)

Note. The test compares whether the row efficiency score is significantly less than the column efficiency score. The upper number in each cell is the Wilcoxon test z value. The lower number, in parentheses, is p value.

Table 5. Non-parametric test results comparing pair-wise efficiency scores among the different sectors

Period: 1973 to 1980

	State government sector	Joint sector	Private sector
Central government sector	0.00 (1.00)	2.52 (0.01)	2.52 (0.01)
State government sector		2.52 (0.01)	2.52 (0.01)
Joint sector			1.751 (0.08)

Note. The test compares whether the row efficiency score is significantly less than the column efficiency score. The upper number in each cell is the Wilcoxon test z value. The lower number, in parentheses, is the p value.

separately tested for the years 1973 to 1980 and 1981 to 1988 respectively to identify if the pattern of differences noted for the overall period stay the same in two sub-periods, one of which is pre-reforms and the other post-reforms. The results are given in Table 5 and 6.

The test results establish that for both periods, 1973 to 1980 and 1981 to 1988, the private sector is more efficient than any other sector. The joint sector is more efficient than the government-owned sectors, while being less efficient that the private sector. The government-owned sectors are made up

Table 6. Non-parametric test results comparing pair-wise efficiency scores among the different sectors

Period: 1981 to 1988

	State government sector	Joint sector	Private sector
Central government sector	0.14 (0.88)	2.10 (0.04)	2.19 (0.03)
State government sector		1.68 (0.09)	2.38 (0.01)
Joint sector			2.521 (0.01)

Note. The test compares whether the row efficiency score is significantly less than the column efficiency score. The upper number in each cell is the Wilcoxon test z value. The lower number, in parentheses, is the p value.

of the central government-owned and state government-owned enterprises, and between themselves there are no performance differences in either of the two sub-periods.

4.2. *Efficiency growth rates*

The results point out that the private sector is more efficient in the Indian context, for the period studied as a whole as well for two sub-periods. Growth rate estimations help establish whether there is time-wise increase in sectoral efficiency patterns. Estimates are in Table 7.

In the period 1973 to 1988, central government enterprises' efficiency has grown at the rate of 2 percent and the efficiency of those owned by state-governments at 3.45 percent per annum, respectively. Both trends are significant; however, an accelerative pattern is noted for the central government-owned sector. Joint sector efficiency has not risen or fallen significantly, while that of the private sector has grown at a rate of 0.47 percent per annum, a trend which is significant. A review of the results for the two separate time-periods reveals interesting dynamics at work. For the period 1973 to 1980, efficiency declined at the rate of 9.1 percent per annum, 1.67 percent per annum and 4.27 percent per annum for the central government-owned, state governments-owned and mixed-sector enterprises, the trends being significant for the central government-owned and the mixed sectors. Private sector efficiency rose at the rate of 1.33 percent per annum. Between 1981 and 1988, central and state-government-owned enterprises' efficiency rose at the rate of

Table 7. Sectoral percent growth rates in efficiency over time

	Central government sector	State Government sector	Mixed sector	Private sector
Overall period: 1973 to 1988				
Growth rate (+/-)	2.00**	3.45**	-0.10	0.47**
	(2.04)	(2.25)	(0.21)	(2.41)
Acceleration (+)/	1.20**	0.29	0.29**	-0.07*
Deceleration (-)	(4.97)	(0.80)	(2.59)	(1.38)
Period 1: 1973 to 1980				
Growth Rate (+/-)	-9.10**	-1.67	-4.27**	1.33**
	(2.98)	(0.28)	(4.25)	(1.70)
Acceleration (+)/	-0.62	0.96	-0.23	0.12
Deceleration (-)	(0.41)	(0.32)	(0.46)	(0.32)
Period 2: 1981 to 1988				
Growth rate (+/-)	10.78**	3.78*	0.72	0.20
	(3.92)	(1.46)	(0.58)	(0.63)
Acceleration (+)/	1.49	-1.72**	0.02	-0.01
Deceleratin (-)	(1.08)	(1.36)	(0.03)	(0.60)

Absolute t-statistics in parentheses; ** p ¡ .05 and * p ¡ .10 (one-tailed).

10.78 and 3.78 percent per annum respectively, while the mixed sector and private sector efficiency rose at 0.72 and 0.20 percent per annum respectively.

There are several implications of the rising trends in the efficiency of the central government-owned sector. From the early 1980s, several industrial-sectors reforms were commenced, and the public sector was made the target of policy makers' critical attention. In the mid-1980s, a committee headed by Dr. Arjun Sengupta, then economic adviser in the prime minister's office, recommended several far-reaching changes in public sector management and control practices. These were being implemented, albeit slowly, over the latter part of the 1980s and the improvements in efficiency bear out that they have had some impact in making the public sector more efficient than it had been, relative to its own base.

4.3. *Discussion of results*

The state-owned and the mixed sectors account for two-thirds of contemporary capital investment in India, but are significantly inefficient compared to the private sector. If there has been a retrogression in India's industrial capabilities up to the 1980s, as authors (Ahluwalia, 1991; Bhagwati, 1993) have suggested, then the analyses carried out suggest that the government-owned sector must bear a great deal of the blame. The mixed sector, however, is significantly efficient compared to the state-owned sector, and in India is an important player in the industrial arena. The joint sector consists principally of petroleum firms. Their performance helps to redress the situation towards ensuring the efficient use of public resources.

The results obtained have several implications from the point of view of theory. Recollect that the DEA score calculated using the BCC algorithm is a precise measure of efficiency for each observation. In comparison with the private sector, which is almost fully-efficient in a relative sense, because the average score is 0.975 on a scale of 0 to 1, government-owned firms are just about two-thirds as efficient, and these efficiency differences are strongly significant. Ownerhsip does strongly matter in influencing industrial performance in the Indian context.

Efficient resource utilization helps generate surpluses, which can be reinvested towards the creation of further resources. Hence, improvements in efficiency have an impact on the future productivity capabilities of nations by providing higher levels of reinvestible surplus. For example, Jones (1991) indicates that a 5 percent increase in the efficiency of state-owned enterprises, without any changes in prices or investment, would result in freeing resources of about 5 percent of GDP in Egypt, or reduce 50 percent of direct taxes in Pakistan, or fund a 150 percent increase in government expenditures on education, health, culture and science in China. The release of a similar quantity of resources can transform Indian industrial performance.

There are some possible explanations as to why state-owned entities show lower efficiency. They have been prey to inappropriate location and technology choice decisions, irrational product mixes, and imposed marketing arrangements. These decisions have been made for political considerations, and have not been based on economic criteria (Bardhan, 1984; Bhagwati, 1993). As a result, few choices and incentives are given to managers to maximize economic residue, and neither are they accountable for attaining efficiency because ambiguous and non-economic objectives have driven decision-making. For example, in the Indian context these socio-economic objectives include the promotion of income and wealth redistribution, creation of employment, promotion of regions, promotion of import substitution, and being “model employers” (Marathe, 1989). Also, in the Indian context state-owned enterprises have been used to implement government policy with regard to stabilizing commodity trade, or in making transfer payments to various specific sections of the community (Jalan, 1991).

However, other key reasons as to why government-owned enterprises are likely to be less efficient relate to the type of monitoring managers in these enterprises are subject to. In the Indian context, government-owned enterprises are subject to the detailed oversight of the parent departments, as well as legislative oversight by committees on public undertakings of the central and states' legislatures. Therefore, the issue of ownership diffuseness is not a problem. Yet, enforcement of legislative committee findings does not take place (Chaudhuri, 1994; Marathe, 1989), and the disciplining hand of the capital market is also absent. Consequently, attaining efficiency is not a primary managerial motivation in the government-owned sector.

Second, the identity of owners is a factor arising from which government-owned enterprise managers tend to become agents without principals. Controlling-department bureaucrats, then, become de-facto owners of such government enterprises. However, a major phenomenon to emerge in India is that of state-legitimized rent-seeking which has an extremely enervating effect on efficiency (Bardhan, 1984). For example, often the creation of government-owned enterprises has been driven not by ideological or pragmatic reasons, but to create extra-pecuniary opportunities for senior civil servants or politicians (Chaudhuri, 1994).

For example, Marathe (1989: 184) quotes Mr. B.K. Nehru, a former ambassador of India to the United States, who has also held several key appointments in economic spheres, "It is simply that it has become common practice for public sector enterprises, particularly in the States, to be made into mechanisms to provide powerful politicians, who cannot be accommodated as Ministers, with salaries, perquisites, patronage and opportunities to make money through corruption." Bardhan (1984: 69–70) also writes "Senior appointments in the public sector are sometimes made more on the basis of political patronage than of merit (leading often to low morale in the ranks of the technocracy in the enterprises). Headships of public sector units, particularly under the State Governments, are indiscriminately used as political sinecures. Efficient managers who fail to satisfy the Minister's political clients are often arbitrarily transferred." The impact of such phenomenon is to create a cadre of managers in the public sector who are agents without principles.

Some authors (Vickers and Yarrow, 1988) have argued that, given differences in ownership structures, the nature of competitive conditions faced is a key factor in eliminating efficiency differences between enterprises. The data, however, do establish that given a similar competitive playing field, institutional influences felt by the owners do matter in impacting performance in India. Such evidence is contrary to what has been established in the West (Caves and Christiansen, 1980; Borcherding, Pommerehne, and Schneider, 1982). However, public sector management reforms have also had some impact, as shown by the significantly increasing trend in efficiency of the government-owned sector in the 1981 to 1988 period. Therefore, in the Indian case it is not only necessary to continue with the major liberalization to encourage industrial growth, but also to undertake speedy re-structuring of public sector management and control practices so as to realize efficiency gains.

The key limitation of the study has to be discussed. It is with respect to the data used. While it can be concluded in the aggregate that government-owned firms consume a greater quantity of inputs, relative to private firms, in generating value added, finer analysis has not been possible. Within the data for each sector, say the central government-owned sector or the private sector, are contained information on firms belonging to several different types of industries. Data of finer granularity may reveal the specific industries in which state-owned firms excel, or are particularly inefficient. However, while key micro-level information may be available for one sector, such information is not generally available for other sectors. Therefore, comparative efficiency assessment has been feasible at an aggregate level of analysis.

5. Conclusion

In this paper efficiency differences between government-owned, mixed sector and private sector enterprises in India were evaluated. Using data and basing the performance analyses for the entire Indian industrial sector, enterprises owned by the central government and the governments of various states are found to be systematically less efficient than either mixed or private sector enterprises, while mixed sector enterprises are less efficient than those in the private sector. The analyses reveal that the assumptions of theory, positing higher efficiency levels for the private sector, cannot be disproved in the Indian context, and contradict all extant comparative evidence (Bhaya, 1990; Jha and Sahni, 1992; Ramaswamy and Renforth, 1994) which have found no sectoral performance differences. Government-owned enterprises are major players in the industrial arena and the results obtained provide indication that they may be, in major part, responsible for India’s lack-lustre industrial performance.

Notes

1. The demise of command-style economies is already being attributed to behavioral issues that arise when government is the primary owner of enterprises (Roemer, 1993). Based on this premise, major reforms are taking place in most erstwhile command economies, and there is an explicit acknowledgement that private ownership will yield greater efficiencies and breed industrial success.

2. In India contributors to the equity capital of enterprises include the central government, governments of the various states in the Indian Union, private investors and governments jointly, and private investors alone. The primary way to distinguish between ownership categories is to classify them as the state-owned (public) and the private sectors. The term state-owned is used in the Indian context to include enterprises owned both by the central government and by the governments of the various states that form part of the Indian Union. The latter are called state government-owned enterprises. In subsequent empirical analysis, central government-owned and state government-owned enterprises' data are separated for efficiency estimation purposes. Though the term *enterprises* is used throughout the paper, analysis is carried out using aggregate data, as described in a later section of the paper.
3. It is argued that the comparative assessment of state-owned enterprises with other types of enterprises is not feasible because profitability review of state-owned enterprises ignores the socio-economic objectives associated with state-owned enterprises (Bhaya, 1990). Yet, for a fundamental reason, comparative efficiency analysis matters. Industrial progress is determined not only by the rate of expansion of resources employed, but by the way resources have been utilized and efficiency in resource utilization is well-acknowledged shown to be more critical to economic welfare than allocative efficiencies.
4. Marathe (1989) notes how there were less than five central government-owned enterprises in 1950–1951. Ten years later there were forty eight. By 1971–1972 there were over a hundred such enterprises and by 1980–1981 the number had increased to one hundred and eighty seven. Currently, there are almost two hundred and fifty such enterprises.
5. Data are collected for factories belonging to firms in each of these sectors, and the factory-level data are aggregated for reporting purposes annually. The data-reporting and collection is carried out under the framework of the Indian Collection of Statistics Act of 1953 by the Department of Statistics in the Ministry of Planning.
6. The Annual Survey of Industries has been carried out since 1959, and is the principal source of industrial statistics in India. The ASI extends to every part of the country, except some industrially-marginal states, and covers all factories registered under the Indian Factories Act of 1948. Essentially, all factories employing more than 10 workers and using power, or more than 20 workers and not using power have to report data. However, the ASI was not carried out for 1972–1973, and data prior to that year are not available in collated form by ownership category.
7. Theoretical details with respect to data envelopment analysis can be found in Seiford and Thrall (1990).
8. The DEA procedure takes each observation into account in the computation of its relative efficiency score. The set of weights (u_r, v_i) are implicit internal valuation schemes which are empirically determined by the algorithm, and may vary from observation to observation. This is based on a determination of which of the inputs a particular observation is particularly adept at in utilizing, or which of the outputs it is particularly adept at in generating, based on data. By assigning high weights to those inputs and output variables which an observation seems to be more adept at in utilizing, or in generating, and low weights to others, the algorithm attempts to maximize the observed performance of each observation in light of its revealed attributes.
9. In a DEA model, observations which attain a score of 1, on a scale of 0 to 1, are efficient. Observations scoring less than 1 are inefficient, based on the definition of efficiency which is the extraction of all possible output with given inputs. A DEA efficiency score provides a first-order indication of efficiency differences. If all observations come from the same environment, then if data are classified according to ownership, conclusions as to whether the ownership categories differ from others in efficiency can be drawn. Subsequently, second-order explanations as to whether such efficiency differences arise because of technical change, or other endogenous reasons, can be obtained by regressing DEA-generated scores on appropriate regressors.

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