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AN ASSESSMENT OF THE PERFORMANCE OF INDIAN STATE-OWNED ENTERPRISES

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ABSTRACT

AN ASSESSMENT OF THE PERFORMANCE OF
INDIAN STATE-OWNED ENTERPRISES

We examine the determinants of performance of 68 Indian state-owned enterprises in the manufacturing sector for a five-year period: 1987 to 1991. Relative performance is determined using data envelopment analysis, with variations in performance patterns subsequently explained using regression analysis. We note that the performance of firms in the Indian state-owned sector is characterized by both, low performance, as well as significant and systematic variations in the performance parameters. Size is positively associated and age negatively associated with efficiency. Further, economic liberalization and reforms aimed at improving the performance of state-owned firms induces efficiency gains over time. This heterogeneity within the state-owned sector has policy implications, which we discuss. In countries which have privatized large numbers of their state-owned firms, it is often the larger, and often more profitable, establishments which have been sold to the public. Our results indicate that such a policy may not be advisable, at least in the Indian context. The state-owned firms that need the most urgent attention, and hence are candidates for the earliest privatization, are the smaller, older firms, operating in competitive environments. This finding reinforces our central thesis that firm-level analysis within the state-owned sector is useful and important for generating pragmatic policy guidelines.

1. Introduction and Background

(a) Scope of the Study

We report the results of research in which we empirically evaluate the determinants of performance for a panel of Indian state-owned firms for the period 1987 to 1991. Both the measurement and quantification of performance at the *firm level* within the state-owned sector, and determining the sources of *variation* in performance, are useful from a policy-making perspective. However, in spite of the economic importance of these issues, systematic empirical evidence is sparse. Impressions of the performance of state-owned enterprises originate in informal case studies or anecdotes (Millward, 1988). The empirical literature that does exist looks at the subjective goal orientations of managers in public enterprises (Ramamurti, 1987a), factors determining the autonomy of managers in public enterprises (Lioukas, Bourantas, and Papadakis, 1993), cultural sources of excellence in well-performing state-owned firms (Khandwalla, 1990), or at comparing the performance of private and state-owned enterprises in competitive environments (Boardman and Vining, 1989). Further, empirical work specifically addressing the issue of performance of the state-owned sector has largely focused at either the sectoral level (Bhaya, 1990), or used individual case studies (Khandwalla, 1990), and to our knowledge, there is an absence of studies which analyze the determinants of performance in state-owned enterprises in a large-sample firm-level format.

We measure firm-level performance using data envelopment analysis, a technique useful for a comparative evaluation of firm-level efficiencies. We then explain variations in performance of these Indian state owned enterprises using a pooled cross-sectional regression analysis. This approach is consistent with the recommendations of Charnes, Cooper and Rhodes (1981) who note that combining DEA and regression analysis permits fine-grained efficiency analysis of firms where traditional performance methods have not proven to be useful. The paper unfolds as follows. In the next section we discuss the background and motivations for the study. In section three we discuss the conceptual and contextual frameworks. In section four we discuss the empirical procedures. In section five we discuss results, and section six concludes the paper with a summary of our findings and their implications.

(b) Motivation for the Study

A central feature of diverse economies, such as France, Greece, Hungary and India, is the existence of a large number of enterprises owned by the state (Aharoni, 1986; Lioukas, Bourantas, and Papadakis, 1993). In developing and command economies their role and significance differs on two critical counts. The first is, in terms of sheer magnitude, state-owned firms constitute a larger proportion of organized industrial activity. Second, due to the closed nature of many of these economies, this sector has been generally free of competitive pressures. A privileged position, combined with an ambiguous mandate of serving social interests, has led to markedly poor performance of the state-owned sector, when measured in conventional financial terms (Jones, 1991; Newbery, 1992).

There are two reasons why the issue of noted poor performance matters. First, national industrial capabilities have been critically demonstrated to arise because of the capabilities possessed by firms (Chandler, 1993). Since state-owned enterprises constitute a significant proportion of the total value-added in these economies, the fortunes of these nations are inextricably linked to the performance of these firms. Second, industrial progress is determined not only by the rate of expansion of resources employed, as reflected in firms' capabilities, but by the way these capabilities have been *utilized.* In other words, given capabilities and resources, how managers utilize these matters most critically.

Efficient resource utilization generates surpluses, which can then be reinvested towards the creation of further capabilities. Hence, an improvement in the efficiency of these firms can be seen to have a direct impact on the future productive capabilities of these nations by providing higher levels of re-investible surplus. For instance, Jones (1991) indicates that a 5 per cent increase in the efficiency of state-owned enterprises, *without any changes in prices or* *investment*, would result in freeing resources of about 5 per cent of GDP in Egypt, or reduce 50 per cent of direct taxes in Pakistan, or fund a 150 per cent increase in Govt. expenditures in education, health, culture and science in China.

The poor performance of these enterprises has prompted calls for widespread reexamination of this sector's role, and closure, privatization, and reorganization are some of the alternatives that have been suggested (Ramamurti, 1991). These solutions have, in general; focused on the sector as the unit of analysis. However, there are a number of reasons why analysis at the firm level may provide additional insights. Firstly, firm-level analysis can identify performance differentials *between* firms in the state-owned sector, and thus draw attention to those that need most urgent attention. Such an analysis can help in drawing up a schedule of priorities for policy makers, who can then focus aggressively on select firms, or groups of firms, in terms of implementing solutions.

The drawing up of a schedule has pragmatic policy implications, since it is not clear that any of the solutions noted above can be collectively and simultaneously applied to the sector as a whole, given the magnitude of this sector in most of these economies. This intuition finds corroboration in the slow pace of privatization, closure and reorganization in the economies which have attempted to implement these solutions on a large-scale basis (Laban and Wolf, 1993). Since across-the-board privatization or closure is infeasible, we suggest that a priority schedule that designates certain segments of the state-owned sector as demanding of more urgent attention is normatively desirable. Therefore, firm-level analysis can prove useful in developing privatization lists in which the more inefficient corporations are tackled first, and the more efficient corporations targeted for action in later periods.

Second, based on firm-level analysis, if the variations in performance can be systematically related to other observable characteristics of the enterprise, then an additional perspective can be obtained on the problem of inefficiency. For instance, finding that firms with certain attributes, or operating in particular market environments, are significantly poorer performers relative to others can form the basis of specifically-targeted policies addressing firms with these characteristics, or operating in such environments. Hence, a systematic analysis of the factors affecting the variations in efficiency helps to provide useful inputs into the policy-making process.

2. Conceptual & Contextual Issues

(a) Conceptual Issues Related to State-Owned Firms' Performance in General

The standard model of the effect of ownership on performance is the property rights model (Boardman and Vining, 1989). In contrast to private corporations, where ownership is transferable and can be subject to transactions in the market for corporate control, in state-owned enterprises it is not so. A number of other reasons, such as differences in monitoring, the nature of incentives between state-owned and private sector firms, and associated free-rider problems, have been suggested as reasons for behavioral differences between the two sectors (Nayyar, 1990; Putterman, 1993). As a result of these factors, managers in state-owned enterprises have less incentives towards superior performance. While such frameworks are useful in understanding performance differences *between* private and state-owned firms, a unifying framework which explains performance differences *among* a group of state-owned firms is lacking.

Basing ourselves on literature dealing with performance analysis (Capon, Farley and Hoenig, 1990; Caves, 1992) we suggest that performance differences among state-owned firms can be explained as arising from firm-specific characteristics, characteristics specific to particular institutional environments, and characteristics which are generic to the overall environment. It is widely recognized that firm-level factors can explain a significant amount of performance variations (Aharoni, 1993) as compared to industry characteristics. Simultaneously, competitive intensity and resource scarcity in the business environment (Lawrence and Dyer, 1983) engender behavioral patterns which may or may not be efficiency- inducing. However, industry or sector specific forces generate incentives (Powell & DiMaggio, 1991) which also affect performance. These need to be taken into account.

(b) Contextual Issues Related to the Indian Experience with State-Owned Firms

In the first four decades since independence, the Indian economy has been characterized by an ever-increasing role played by state-owned enterprises (Marathe, 1989). While in 1951 there were three such firms, by the 1980's there were over two hundred industrial and commercial undertakings owned by the central government. These undertakings had almost $30 billion invested in them. Their impact is better assessed by the facts that the share of these firms in net domestic product from manufacturing alone is around twenty five per cent, and they account for more than two-thirds of fixed capital investment in the organized manufacturing sector (Rosen, 1988). Further, their dominance of the infrastructural sectors implies that inefficiencies in their performance creates inefficiencies in downstream private sector user-industries (Bhagwati, 1993).

Since 1956, when the role of state-owned enterprises was clearly articulated as reaching the "commanding heights" of the economy, almost every conceivable sub-sector of Indian industry has seen the presence of these firms (Marathe, 1989). Apart from defense firms, which are 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 all industries exclusively run by state-owned firms. State-owned firms are active in every sector of the economy, from petrochemicals and manufacturing to mining, trading, and services and, as Joshi and Little (1994) note, of the top twenty-five largest corporations in India twenty are state-owned firms. However, in this study we restrict our focus specifically to state-owned firms in the manufacturing sector. Given our agenda of relative performance evaluation, such a focus is necessary, so as to ensure comparability across firms.

The performance of Indian state-owned firms has been notably below par. Mere profitability review, however, is assumed to ignore the socio-economic objectives associated with state-owned enterprises. These socio-economic objectives include the promotion of income and wealth redistribution, creation of employment, promotion of regional development, promotion of import substitution, and being "model employers" (Nayyar, 1990). But there is now recognition that substantial improvements in the efficiency of state-owned enterprises, so as to provide a reasonable return, is critical for economic progress given the large investments that have been made in them (Jalan, 1991; Joshi and Little, 1994).

3. Empirical Analysis of Firms in the Indian State-Owned Sector

(a) The Use of Data Envelopment Analysis in State-Owned Firms' Efficiency Measurement

Data envelopment analysis (DEA) is a linear programming based technique that converts output and input measures into a single comprehensive measure of firm-level performance without making any assumptions as to underlying technology or functional form. This is attained by the construction of an empirically-based resource-conversion frontier. The philosophy behind DEA is predicated by the fact that a frontier transformation function empirically captures the underlying processes defining firms' activities, and maximum possible output given inputs, or minimum inputs required given outputs, can be specified.

The use of a frontier model can, first, define what performance levels are feasible for a set of state-owned firms making up an empirical sample. Even the most efficient firms in the sample being evaluated may be relatively inefficient if a group of private firms were also to be included in the comparator set. Of course, the opposite could also be true. Hence, results obtained for a frontier model are relevant only for the sample of firms in the data set. Second, deviations from the frontier can be interpreted as a manifestation of inabilities to be managerially competent. Third, information about the distance of each firm from the frontier over time yields insights about what is the rate and direction of change in its resource utilization patterns. In other words, are its managerial capabilities getting better, or worse, and by how much?

The measurement of performance for state-owned enterprises is complicated by an absence of clearly quantifiable objectives, and multiplicity of goals. Differing perceptions of public interest and conflicting instructions further compound the problem of performance evaluation (Aharoni, 1981), and purely financial indicators of performance are inappropriate (Smyth and Mayston, 1986; Tulkens, 1992). From a pragmatic perspective, DEA is useful in performance analysis even if financial statement data are used (Smyth, 1990). An ideal performance measure can never be specified, given the heterogeneity of objectives and management capabilities. No one way of how best to do things can ever be specified, since there is causal ambiguity in how firms operate. However, based on data of what firms have done, empirical functions can be derived based on what is actually attainable among a group of firms being evaluated. Using the results, an assessment of which are the seemingly more managerially-competent firms is possible.

(b) Technical Specifications of DEA Models

As developed by Charnes, Cooper and Rhodes (1978), Farrell's (1957) output-input measure of performance is generalized to a multiple output-input case by means of a fractional mathematical program, where 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 firm-level observations being evaluated. The data used for each observation j (where j are the observations: j=1,2,....k....n) are as follows: each observation consumes varying amounts of m inputs to produce s outputs. Specifically, observation j consumes $X_j = \{x_{ij}\}$ of inputs (i = 1,....m) and produces amounts $Y_j = \{y_{rj}\}$ of outputs (r = 1,....s). It is assumed that $x_{ij} > 0$ and $y_{rj} > 0$. The s x n matrix of output measures is denoted by Y and the m x n matrix of input measures is denoted by X.

For the k^{th} 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:

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

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 multiple 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.

The DEA procedure takes each observation's idiosyncrasies 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; for a firm which has multiple observations over time, they can vary over each period of time. 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 particular capabilities.

Without any more constraints (1) is unbounded. Additional constraints are introduced with respect to every other firm-level 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:

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

subject to:

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

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

$v_i > 0$ (for i = 1, 2, ...m) (5)

The constraint in (3), therefore, 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) can be translated into a linear program using the transformation developed in Charnes and Cooper (1962). Specifically, the transformation involves computation of two new variables: $\mu = \frac{u}{vX_k}$ and $\nu = \frac{v}{vX_k}$ to make the fractional programming problem a linear programming problem. The linear programming problem for the k^{th} observation being evaluated now is:

$$\max_{\mu,\nu} w_k = \sum_{r=1}^{s} \mu_r y_{rk} \Big/ \sum_{i=1}^{m} \nu_i x_{ik} \quad (6)$$

subject to:

$$\sum_{i=1}^{m} \nu_i x_{ik} = 1 \quad (7)$$

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

$\mu_r > 0$ (r = 1, 2, ...s) (9)

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

In (6) w_k is the objective function value for the 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.

In (6), w_k is the objective function value which is the efficiency score for the k^{th} observation being evaluated. 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. The optimization process in (6) is repeated n times, once for each firm-level observation for which efficiency is to be evaluated. In other words, 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 where w_k* < 1.

Design of the data-set decides whether the optimization in (6) to (10) is static or dynamic. All n observations can be taken for a particular year only. Thus, optimization for the k^{th} firm is done with respect to its cohorts for that particular year only. Information on several firms for several years can also be amalgamated to form a pooled cross-sectional time-series data set. In such a data set, when optimization of each firm's score is carried out the comparator firm-level observations are those belonging to different time-periods, and there is comparison over time of the relative efficiency of each such firm. A comparison of relative efficiency characteristics for each of the j observations is carried out with respect to observations belonging to the same year as the compared observation, as well as with respect to those observations belonging to different years. Hence, within the DEA framework dynamic optimization analysis can be carried out.

The advantage of DEA lies in its approach. Since DEA is a methodology oriented to frontiers rather than central tendencies, the algorithm optimizes for each individual firm-level observation, in place of overall aggregates and the single optimization normally performed in statistical regressions (Seiford and Thrall, 1990). In regressions where cross-sectional time-series data are pooled, the statistical package generates a single set of parameters for the entire data set. DEA, on the other hand, generates observation-wise parameters; in dynamic analysis there is the certainty of knowledge that these parameters have been derived after a comparison of that observation with respect to observations which belong to other time-periods. Hence, inferences of dynamic efficiency patterns are feasible.

There are two theoretically distinct approaches to efficiency measurement within the DEA paradigm. The first method is propounded by Charnes, Cooper and Rhodes [(CCR)] and the CCR efficiency measure is a total efficiency measure which comprises of technical and scale efficiency components. In extending the CCR model, Banker, Charnes and Cooper (1984) [BCC] show that the CCR efficiency score can be broken up into a measure of scale efficiency, and another for pure technical or managerial efficiency given the scale of operations each observation is presently at. This is achieved by assuming that variable returns to scale exist for firms, 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 either negative (increasing returns to scale may exist), or 0 (constant returns to scale may exist) or positive (decreasing returns to scale may exist) for each k^{th} observation. The efficiency score that is generated by the BCC model is one of pure technical efficiency.

The concept of technical efficiency is well-known in the literature. The concept of scale efficiency, as used in DEA studies, requires definition. Following Stigler (1968), the concept of economies of scale can be defined as the general mapping of the relationship between the quantity of use of a combination of productive resources and the rate of output of firms. This mapping is operationalized via three concepts: increasing returns to scale - whereby for a proportionate increase in inputs there is a greater than proportional increase in outputs; constant returns to scale - where for a proportionate increase in inputs there is an equivalent proportionate increase in output; and decreasing returns to scale - where for a proportionate increase in inputs there is less than a proportional increase in output.

Within an industry setting firms of different sizes can exist because each firm may operate at a different optimal efficient scale of output generation (Silberston, 1972). Because of historical as well as behavioral reasons, there may be no one optimal size for the industrial sector in general dictated purely by technological considerations of economies of scale, but for each firm there may be one best size. The concept of scale efficiency specifically measures the extent to which firms deviate from their minimum efficient scale, which is the point on the cost curve where constant returns to scale exist. They may either enjoy increasing returns to scale, or suffer from decreasing returns; in the DEA literature *the distance between their present scale of operations and optimal scale is the extent of scale inefficiency* (Banker, Charnes and Cooper, 1984). The enjoyment of technical and scale efficiencies may be correlated with size, in which case *economies of scale* are presumed to exist.

(c) Sample and Data on Indian State-owned Firms for Which Performance is Assessed

Our sample consists of sixty eight Indian state-owned enterprises in the manufacturing sector for which we have firm level data for 5 years: 1987 to 1991. Data are obtained from the Centre for Monitoring the Indian Economy in Bombay, India. The descriptive statistics for the sample are given in Table 1.

*********************** Insert Table 1 Here ***********************

As shown by the table of descriptive statistics, there is wide variation in the sample of state-owned firms we study. The mean value-added is Rs. 675 million while the standard deviation is Rs. 1.72 billion and the range is Rs. 12.4 billion (Rs. 31 = $1). However, the third quartile (75%tile) is Rs. 444 million, suggesting a significant skewness towards smaller firms. Similar variation is revealed by the distribution of gross fixed assets, employees and sales. Mean gross fixed assets are Rs. 3 billion, while the range is Rs 98 billion. The 3rd quartile is Rs. 1.4 billion. With respect to sales, the average value is Rs. 3 billion, while the range is Rs. 61 billion, and the third quartile is Rs. 2.3 billion. Actual employee numbers range between 139 and 198,423. The mean is 12,361, while the third quartile is 15,402. These data show that while there are a few substantially large firms in existence, on the whole the manufacturing segment of the Indian state-owned sector comprises of a large number of small firms.

(d) Inputs, Output and Models Estimated

We estimate a number of performance models, using different inputs and outputs, all using the BCC algorithm. The distinction between the BCC and CCR models have been discussed in the earlier sub-section. The DEA models estimated are tabulated in Table 2. In the base model, we use one primary output: *net value added by operations*. Value added is commonly used to capture firm-level output (Jackson and Palmer, 1988), and its use in the present study is also consistent with other studies of Indian productivity (Ahluwalia, 1991; Goldar, 1986). To create value necessitates acquisition and configuration of firm-level capabilities (Prahalad and Hamel, 1990). Capabilities are encapsulated in physical capital and human capital, and we therefore use two inputs: total of firms fixed assets and number of employees. While in the short-run, the amount of fixed assets and the number of employees may be fixed, the usage of fixed assets and employees is under the discretion of management (Bhaya, 1990).

In the contemporary literature on efficiency measurement (Caves, 1992) both value added and gross output are concomitantly used to measure output. However, Griliches and Ringstad (1971) advance arguments in favour of using value added because it facilitates comparison of results for manufacturing 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. For example, Harris (1992) compares inefficiency estimates for Australian industry using both value added and gross output as measures and concludes that the gross output-based inefficiency estimates may be invalid because of the correlation between material inputs and the error term. 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 both Bruno (1978) and Diewert (1978) have noted. First, it captures a "production relationship" between primary factors and firms' output. This relationship is based on managements' capabilities. Second, it also captures a "profit-generating relationship" between firm-specific human and physical 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 often 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. We control for this problem by only including manufacturing firms in our sample, and particularly exclude oil-sector and trading-sector state-owned firms which operate under special price regimes.

To check the robustness of our results, and account for the possibility of inflation affecting our measure of efficiency, we also estimate DEA models under a number of different specifications of value added and assets. Specifically, we use two measures of the fixed assets variables (gross fixed assets and net fixed assets) and run the analysis for both these variables with and without inflation adjustments.

In Table 2 we list the various DEA models that we have estimated.

*********************** Insert Table 2 Here ***********************

We first compute two sets of DEA scores using gross fixed assets as one of the inputs: *DEABI* and *DEAVAGDF*. *DEABI* is the base-model DEA score, derived using gross fixed assets and number of employees as the inputs and value-added as the output, with no adjustments made for inflation in either value-added or gross fixed assets. *DEAVAGDF* is the DEA score derived using inflation-adjusted values of gross fixed assets and value-added. The wholesale price index for manufacturing is used as the deflator for both variables, an approach consistent with prior empirical work (Goldar, 1986). Using 1987 as the base year, the index is used to deflate the values of gross fixed assets and value-added for all the subsequent years. As Table 3 indicates, the distributions of the two scores are very similar, and Table 4 shows that the correlation between them is 0.98.

******************** Insert Table 3 and 4 Here ********************

Thereafter, we compute two more sets of DEA scores using Net Fixed Assets as an input variable in place of gross fixed assets: *DEAVAN* and *DEAVANDF*. Since capital vintage and depreciation effects can vitiate the analysis, the computation of these scores represents an attempt to check the sensitivity of the DEA scores to the use of different measures of the assets variable. A large discrepancy between scores obtained by using net fixed assets vis-a-vis scores obtained by using gross fixed assets as inputs can indicate measurement problems stemming from depreciation and vintage effects. For the first set of scores (*DEAVAN*) no adjustment is made for inflation in any of the variables. For the second set of scores (*DEAVANDF*) net fixed assets and value-added are both deflated using the wholesale price index for manufacturing. As Table 3 indicates, the distributions of the two variables are similar and the correlation between the scores is 0.97. Also of note is the fact that the correlations between the scores derived with net fixed assets as the input variable and the corresponding scores derived with gross fixed assets as the input variable are also high, with r=0.96 for the measures unadjusted for inflation, and r=0.97 for the measures adjusted for inflation (see Table 4). The DEA results are, thus, robust to a variety of specifications. The Cronbach's alpha between the four DEA Scores is .99.

While it is hard to disentangle the "production relationship" and "profit-generating relationship" components of value-added that we have earlier referred to, a test to evaluate how far market or price distortions may affect the composition of value added is to correlate various profitability measures with DEA-generated efficiency indices which have used value added as the output measure. We calculate a series of profitability ratios for the 68 firms that we study for the five-time periods. These ratios are: *OPERMGN*-ratio of operating profit to net sales, *NETMGN*-ratio of net profits to net sales, *OPERASS*-ratio of operating profits to gross fixed assets, *NETASS*-ratio of net profit to gross fixed assets, and *NNETASS*-ratio of net profit to net fixed assets. The correlation matrix between the primary DEA score (*DEABI*) and these measures of profitability and given in Table 5.

*********************** Insert Table 5 Here ***********************

The correlation coefficients between the different profitability ratios range between .60 and .92, and the maximum correlation between the DEA score and any one of the profitability ratios is .49. The lowest such correlation coefficient is .32, between *DEABI* and *NNETASS*. Given the sample-size, all correlation coefficients turn out to be significant; however, we also compute the Cronbach's alpha between the base DEA score, *DEABI*, and *NETMGN* which is estimated to be .61. This indicates that the underlying dimensions of performance which *DEABI* and *NETMGN* capture are not identical.

(e) Regression Model, Variables and Hypotheses

Dependent Variable

To evaluate differences in performance, as revealed by the DEA scores, we use a log-transformed version (the DEA scores range between 0 and 1 and are limited to a half-normal distribution; transformation converts this into a log-normal form) of these scores as the dependent variable in a regression model. This enables a second-order assessment of performance. We run separate regressions using different DEA scores (*DEABI*, *DEAVAGDF*, *DEAVAN*, *DEAVANDF*) as the dependent variable in each, so that the sensitivity of the explanatory variables to different specifications of the dependent variable can be assessed, using the logged versions of the scores as the dependent variable in each case. The independent variables are discussed next.

Firm-specific Factors:

AGE: The relationship between firm age and performance has been examined extensively (Hannan and Freeman, 1989). The thesis of structural inertia argues that older firms, being set in their ways, find it difficult to change their established routines (Hannan and Freeman, 1989). Firms operate through sets of routines, which enables them to function in a standardized fashion and ensure reliability in their performance. However, this reliability comes at a cost. As evolution proceeds, and times change, the organization finds itself unable to adapt, as the very standardization that ensures reliability becomes a blockage. Thus, over a period of time the organization can fall increasingly out of line with its external environment. In a market context, such an outcome eventually leads to organization failure due to the logic of natural selection.

In the context of the state-owned sector, the absence or relatively muted presence of market signals implies that over a period of time firms become progressively outdated in their modes of thought and action but bureaucratic practices prevent a commensurate evolution in organizational routines to catch up with the times. However, such firms, even though inappropriately managed, may still survive in the state-owned sector through the immortality conferred by taxpayer support and the soft-budget constraint. Accordingly, we expect age to be associated with relative inefficiency. The incorporation year for each firm is given; computing age is not problematic.

SIZE: The relationship between firm size and efficiency is unclear, a-priori. The organizational theory and strategy perspectives provide ambiguous predictions on the effect of size. On one hand, larger size enables greater differentiation and specialization, and should lead to higher efficiency (Penrose, 1959; Prescott and Vischer, 1980). On the other, it makes the managerial task more difficult due to increased coordination requirements (Downs, 1967). Further, increased size tends to be associated with higher bureaucratization, bringing into play many of the issues discussed in the context of age. Thus, the final prediction, based purely on theoretical considerations, is unclear.

The institutional setting of our research provides another argument with respect to size effects. In the context of the Indian public sector, managing a larger unit is associated with higher prestige and perquisites (Williamson, 1964). Hence, other things being equal better managers should self-select into the larger or more prestigious units. From the perspective of government, it makes sense to appoint the best managers to the largest units, as these represent the largest investments. The overall effects of the various arguments remain unclear and must be empirically resolved. Size is measured by taking the natural log of sales. This is a standard approach (Scherer and Ross, 1990).

MONOPOLY: Monopoly status, in general, is associated with inefficiency (Scherer and Ross, 1990). A monopolist can deviate from cost minimization conditions associated with a competitive environment, and there are strong behavioral arguments that indicate this to be the case. In general, a monopoly faces lesser pressure on prices and costs than that which would provide incentives for achieving cost-savings (Scherer and Ross, 1990). Further, the absence of competition implies that there is no external standard that the monopolist can use to judge the efficiency of its own operations. Hence, even given the motivation to be efficient, a monopolist may simply lack the information required for comparative bench-marking which spurs better performance (Carlton and Perloff, 1990). Finally, from a share-holder perspective, the absence of competitive yardsticks to judge the performance of a monopoly's managers implies that the ability of owners to monitor and control the managers may be impaired. This may foster inefficiency (Tirole, 1988).

In the context of the state-owned sector these arguments are relevant. The absence of a profit motive implies that the duality of microeconomic theory, where profit maximization implies cost minimization, may be less than relevant. Further, the multiplicity of objectives may confound performance measurement to an even greater extent in the state-owned sector, leading to the information and control problems mentioned above.

On balance however it appears that there is little reason to expect a positive relationship between monopoly status and efficiency, and a priori, we expect a negative relationship to exist between *MONOPOLY* and efficiency. The measure is a dummy variable which is coded 1 if the firm is a monopoly and 0 otherwise.

General Environmental Factors:

The introduction of competition increases the number of firms fighting for the same stock of resources in their environments. There is no longer taken-for-granted resource supply (Lawrence and Dyer, 1982). To survive, firms have to utilize their resources more parsimoniously, and the introduction of competition is seen as a solution to the problem of inefficiency has been suggested for both state-owned firms and regulated monopolies (Majumdar, 1994; Newbery, 1992).

The Indian experience, where since the mid-1980s there has been increasing competition facing firms (Marathe, 1989), provides a natural experiment to evaluate this argument empirically. Further, it provides the context of an environment wherein competition has long been absent or muted, and levels of inefficiency are historically high. Thus, there is both motivation and opportunity for increased efficiency in the state-owned sector, and the arguments made above should come into play.

The recent *reforms by storm*, which commenced in 1991, include relaxation of industrial controls and legislative restraints in the domestic private sector, an increase in foreign participation in the economy, and the opening up of industries that were earlier reserved for state participation to the private sector. However, *reforms by stealth* were introduced in 1980, by prime minister Mrs. Indira Gandhi, and later prime minister Mr. Rajiv Gandhi continued *reforms with reluctance* from 1985 onwards (Bhagwati, 1993). In particular, during the closing period of Mrs. Gandhi's regime, a series of investigate commissions of enquiry into economic issues were appointed, and one in particular: the Arjun Sengupta Commission made far-reaching recommendations in respect of state-owned enterprises management, which Mr. Rajiv Gandhi's government attempted to implement (Trivedi, 1992).

These reforms were operationalized by the implementation of private-sector management practices in the late 1980's captured via documents between state-owned enterprises' management and the controlling ministries which were called "memorandums of understanding" spelling out explicit performance parameters which the enterprises were to attain on a year-to-year basis (Trivedi, 1992). Hence, it is reasonable to expect that over time there has been a distinct movement away from the business as usual philosophy of the state-owned sector. Given this increasing liberalization over the period under study, we, therefore, expect a positive and secular time-trend in the efficiency of firms. In our model, we operationalize time as a set of dummy variables. The variables $DATE_1$ through $DATE_4$ denote the years 1988 through 1991, with 1987 being the omitted category. We expect the coefficients of later-year dummies to be greater than those of all preceding years.

We also control for two other institutional variables that could conceivably affect the operating efficiency of the units in question - association with the defence or textile sectors:

DEFENCE - a certain number of firms, subject to day-to-day control of the Ministry of Defence are run as ostensibly commercially-oriented firms. Since the decisions undertaken in these firms follow the dictates of national defence policy, are impacted by the defence budget, and their transactions are subject to supervision by the armed forces, it is possible that their behavior may differ systematically from the rest of the state-owned sector. We code these firms as 1, and code all other firms as 0 on the *DEFENCE* variable.

TEXTILES - one of the fall-outs of Indian industrial policy has been the near-death of a large number of firms as a result of their owners' malfeasance (Nayyar, 1990). Consequently, the government has taken over these firms so as to continue worker employment. The problem has been particularly acute in the textiles sector (Mazumdar, 1991). Hence, there is a priori reason to believe that performance of firms in the state-owned textile sector may be markedly inferior to other state-owned firms. Such firms were coded as 1 on this variable while all other firms were coded as 0.

(f) Estimation Procedure for the Regression

We use a pooled cross-section study design with sixty-eight firms and five time periods. We conduct a series of heteroskedasticity tests which reveals the presence of heteroskedasticity. Further, computation of the pooled Durbin-Watson statistic (Bhargava, Franzini & Narendranathan, 1982) reveals distinct serial correlation among the residuals. A simple check for collinearity, another potential problem, reveals no large significant correlations between most of the variables, except that *MONOPOLY* is correlated with *DEFENCE* $|r| = .63$. No other correlation of greater than 0.4 is observed among any of the variables.

Using the above information, we decide to use the generalized least squares procedure suggested by Kmenta (1986). This procedure allows the specification of a general form of the variance-covariance matrix of the residuals, with heteroskedasticity and first order autocorrelation, being both permissible. Further, given our small time-series dimension (T=5), we opt to use the sample correlation coefficient approach to estimating ρ - the autocorrelation coefficient (Kmenta, 1986). This provides a consistent estimate of ρ and ensures that it is confined to the interval -1 to +1. The results of this estimation form the basis of our further discussions.

4. Results

(a) DEA Efficiency Estimates for the Indian State-Owned Firms Evaluated

The DEA-generated managerial efficiency scores are discussed briefly first. The pattern for all five years are reviewed together. Details of the scores are given in Table 3, to which we have already made an earlier reference.

The average efficiency score *(DEABI)* of the sixty-eight state-owned firms is .35, on a scale of 0 to 1. This implies that there are only a few truly efficient firms in the sample, but relatively all the other firms are inefficient. There is also significant variation in such inefficiency patterns. The standard deviation of the scores is 0.25, and the coefficient of variation is .714. However, the results are significantly skewed towards inefficiency. The median efficiency score is 0.27 and the 75th percentile score is 0.46. The inter-quartile deviation is only 0.28 and this parameter suggests the magnitude of inefficiency that exists in the Indian state-owned sector, with the majority of the sample firms studied being skewed towards inefficiency.

(b) Regression Results

The correlation matrix for the regressors is presented in Table 6, and the results of the pooled regression, where the dependent variables is logged *DEABI* are reported in Table 7.

***************** Insert Tables 6 and 7 Here ****************

The models explain between 35 and 69 percent of the variance in the DEA scores. For the base DEA score, where logged DEA is the dependent variable, the model explains 44 percent of the variance in efficiency. As can be noted, the coefficients for *SIZE*, and three of the four *DATE* variables are all positive and significant. The coefficient of the $DATE_1$ variable is positive, as expected, but not significant. The coefficient of *AGE* is negative and significant. We use both *AGE* and *LAGE* (log of *AGE*) as regressors, as Table 7 indicates. The results are almost identical. The coefficients for *DEFENCE* and *MONOPOLY* are not significant. Further, the four *DATE* coefficients follow the pattern predicted by us, with each *DATE* variable being larger in magnitude than the preceding ones. In Table 8 we display the results of the 6 t-tests conducted to establish this result statistically.

The 6 t-tests test the hypothesis that efficiency scores will be increasing over time for the firms in our sample. We test the prediction: $DATE_i > DATE_j$ for $i > j$. The appropriate t-tests are of the form: t = $(DATE_i - DATE_j)$ / Standard error $(DATE_i - DATE_j)$ where t ~ Student's t distribution. Standard errors for $(DATE_i - DATE_j)$ are obtained from the variance covariance matrix using the following relation: variance $(DATE_i - DATE_j)$ = variance $(DATE_i)$ + variance $(DATE_j)$ - 2 covariance $(DATE_i\ DATE_j)$. The standard error is obtained by taking the squareroot of the variance. The critical t values of the one-tailed tests are 1.65 ($p < 0.05$) and 2.33 ($p < 0.01$).

*********************** Insert Table 8 Here ***********************

As these results show all t tests are significant as hypothesized except for $DATE_4$ versus $DATE_3$. Further, the coefficient for DATE1 is significantly different from zero only at the 10% level indicating that performance improvements in 1988 over 1987 were probably marginal. Thereafter, in 1989 and 1990 there were significant performance improvements over the previous year. While the coefficient of $DATE_4$ is larger than that of $DATE_3$, the difference between them is not statistically significant. This would seem to indicate that increases in efficiency are beginning to slow down in the fifth year, after 3 years of sustained improvement. There is also the possible impact of uncertainty induced in managers as a result of the political upheavals that took place between 1990 and 1991, which may have led to only an insignificant rise in performance between those years.

As earlier noted, we estimated separate regressions with the dependent variable being scores from each of the DEA models that were run. These regressions help to test the sensitivity of our results. The regressions are given in Table 9.

*********************** Insert Table 9 Here ***********************

As Table 9 shows, regression coefficients in all operations are broadly similar to each other, and of similar significance. As a further check on our empirical procedures, we also estimate a set of DEA models with sales as the output, with the inputs being employees and gross fixed assets. Thereafter, we regressed these DEA scores on the set of variables used in previous regressions. The results of these regession are similar in every respect to the regression results that we have earlier reported, and which are displayed in Table 7.

(c) Discussion of Results

Our results support two of our predictions. The notion that state-enterprise reform can lead to improvement in the efficiency of the incumbent firms finds empirical support. Further, the notion that age of firms can be related to the efficiency of their operations is also supported. However, perhaps the most important dimension of our results is more general than either of these two findings. We find empirical evidence that efficiency is systematically related to a number of firm characteristics, and that even within the state-owned sector there exist significant performance differentials which can be explained as a function of firm-level and environmental characteristics.

The results with regard to *AGE, SIZE,* and the *DATE* variables are robust to a wide number of specifications as mentioned earlier. The significant and negative coefficient on the *AGE* variable indicates that the theoretical expectation that age can be negatively related to performance is indeed empirically borne out in the case of the Indian state-owned sector. The logic of theory indicates that this effect operates through the onset of bureaucratic rigidities. One solution to this problem of rigidity is to introduce a shock to the organizational system. In the case of the Indian public sector an appropriate shock suggests itself: privatization. A change in ownership and incentive structures may well provide the shock that can break the inertia and rigidities that have set in. The lower levels of efficiency of the older corporations make a case for early privatization, or dissolution, of the older corporations.

The positive coefficient of the *SIZE* variable is perhaps our most interesting individual result. It is also statistically our most robust result (along with the *TEXTILE* variable) in that it remains positive and significant at a 5 per cent (or higher) level in our regressions and specifications almost without exception. The arguments of size-inefficiency (Downs, 1967) are not supported by our results. Instead, the results we obtain support our conjecture that the larger state-owned corporations are probably better managed. They can attract better talent. In developing countries labor markets are significantly segmented (Mazumdar, 1983). Therefore, one group of state-owned firms, the larger corporations, can obtain the best talent from technical and management institutions, even compared to private sector firms, as has been demonstrated with a case study for the state-owned Bharat Heavy Electricals Ltd (Ramamurti, 1987b).

Conversely, the smaller state-owned firms do not have a prestige value associated with them, nor are they repositories of technological capabilities which the large state-owned firms are also able to purchase. The talent that the smaller and marginal firms often attract are those for whom employment in state-owned firms is the last resort. The larger firms can also acquire greater power vis-à-vis the smaller firms in facing up to the civil servants in their controlling ministries and can resist political and bureaucratic interference. While we do not have incontrovertible evidence of the causal process that leads to the observed relationship between size and efficiency, we do find strong evidence for the observed relationship itself. The smaller public sector firms are significantly and notably inefficient relative to the larger ones. Hence, if privatization is a priority our results indicate a need to focus upon the smaller corporations first.

The *MONOPOLY* variable suffers from some multi-collinearity with respect to *DEFENCE*. Given the nature of our data, we cannot completely separate the confounding effects. Hence, the results on this variable need to be cautiously interpreted. While the coefficient is negative, as expected, it is not significant. Hence, we cannot claim to have substantiated our a priori expectation of a negative effect of monopoly. However, we do note that, on average, manufacturing monopolies in the Indian state-owned sector are not better performers than firms operating in competitive environments.

Nevertheless, the impact of firm-specific factors can be tempered with a brief analysis of the impact of general environmental factors on efficiency. Since the 1980s there has been significant disquiet about the performance of state-owned firms (Bhagwati, 1993; Jalan, 1991; Joshi and Little, 1994; Marathe, 1989). Several measures to privatize or otherwise divest them from state-owned control have been proposed and management process reforms have also been undertaken. The threat of loss of job security, and intra-firm pecuniary advantages, likely to arise in a liberalized environment do seem to have induced performance improvements.

Compared to the base year of 1987, the efficiency scores for all subsequent years, 1988 to 1991, have monotonically risen. Hence, the assumption that industrial reform induces managerial efficiencies cannot be disproved, at least in the Indian context.

The *TEXTILES* results essentially reflect our expectations at the start of the analysis. The performance of firms in this sector is dismal, even in comparison to the generally inefficient state-owned firms. The coefficient on the DEFENCE variable is positive but not significant, indicating that, in terms of performance, enterprises with a defence affiliation are not likely to be more or less efficient than all other enterprises.

5. Conclusions

Our study of sixty-eight state-owned firms in India, over a five-year period: 1987 to 1991, reveals a low level of efficiency in resource utilization on average: less than 0.35 on a scale of 0 to 1. Of course, these results apply only to the 68 firms studied, but given that these firms are major players in the Indian industrial scene, there is significant potential to improve economic performance even with the resources available. While the low performance of this sector is widely known and acknowledged, the magnitude of the figure, and the accompanying waste of resources that is indicated, casts a new light on the urgency of the problems of Indian state-owned firms. Industrial progress is a function of both the level of investment in resources, as well as the efficiency with which they have been utilized. Given estimates of the size of the state-owned sector in India, if national industrial capabilities are encapsulated in firms, the performance of firms we study have probably led to a significant holding back, or perhaps even retrogression, of Indian industrial performance.

Further, we find that there exists significant variation in the efficiency performance of the firms in our sample. To explain these variations in performance, we use a framework drawn from existing management literature. We find that, as posited, firm-specific characteristics: age, size, market status, generic environmental factors: increasing competitive intensity, as well as institutional characteristics all affect the performance of state-owned enterprises.

Our results provide public policy implications in suggesting that discussions about the solutions to public enterprise problems must account for the heterogeneity of firms within the state-owned sector. The results suggest that both firm-level as well as sectoral characteristics need to be used to identify the worst performers within the public sector. Policies and actions, such as privatization and closure, can be tailored to specific contexts keeping in mind these micro firm-level factors. Further, our study draws attention to the need for developing a schedule of priorities in terms of the enterprises to be targeted for remedial action. On the basis of our analysis it appears that the smaller and older firms need the most immediate attention. The conventional assumption that a monopoly firm is in maximal need of institutional attention is not fully-sustained in the context of Indian state-owned enterprises, given the institutional constraints that impact on the behavior of Indian industry.

In countries which have privatized large numbers of their state-owned firms, for pragmatic reasons it is often the larger, and often more profitable, establishments which have been sold to the public. The best examples of this are from the United Kingdom, where in the 1980's a large number of the profitable state-owned monopolies, such as Amersham International, British Aerospace, British Telecom, British Gas, and firms in the power sector were sold off to the public. Conversely, there have been difficulties privatizing loss-making units such as British Coal, the various shipyards and the railway system. The assumption is that profitable firms are more attractive from an investment point of view, which is not necessarily invalid, and is influencing current privatization policy in India. However, the inability or unwillingness to deal with those firms which are smaller, older, and face competitive environments, but are low performers, may only compound future problems. Given the descriptive statistics in Table 1, it is unlikely that there will be a large number of huge, highly-successful state-owned firms to privatize. Conversely, the smaller, lesser-known firms may continue to be a drag on the public purse. If additional deadweight losses are to be avoided in the future, it is important to tackle these firms. For example, disposing of handicraft-retailing and hotel operations to private sector firms also operating in those sectors may be a viable proposition, since the private firms can acquire distribution outlets and physical facilities, and apply better management skills in enhancing resource utilization. Welfare consequences may, therefore, be significantly enhanced.

Next, our tool of performance measurement, data envelopment analysis, provides a quantitative basis for assessing the comparative performance of state-owned units. Hence, it offers an objective measure of the quality of management abilities in state-owned corporations, and is an important addition to the armory of government departments seeking to monitor the performance of state-owned enterprises. Efficiency audits, in which exercises of the kind conducted by us are performed on an annual basis for all state-owned enterprises, can be made a part of the review and evaluation process. The data for conducting such analyses are readily available, given that state-owned enterprises collect and report detailed data, and the results can provide a quantitative assessment of the quality with which managerial tasks have been carried out in an important sector of the economies of many countries.

Our study has been exploratory in nature, given the absence of a stream of similar empirical work. We suggest a number of other directions for research. First, the study itself needs to be duplicated in different national circumstances. Second, we confine our research to the public sector. However, for the privatization doctrine to be strengthened there is need to examine firms in the private and the public sector jointly. In the absence of data limitations, which we face, a similar study ought to include a panel of both private and state-owned firms, so as to make a joint assessment of the relative determinants of performance. A third extension can be via decomposition of indices to estimate specific input productivity. In the current study we have examined two factors of production, labor and capital. In the interests of brevity, our reported results do not provide information on whether firms are relatively inefficient in their labor usage, their capital usage or both. Such decomposition is feasible using the DEA algorithm. Decomposition and analysis of the scores at this level of detail can then provide guidelines for both management and public policy.

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TABLE 1: Descriptive Statistics for the Sample Firms[1]

	Value-Added	Gross Fixed Assets	Employment (Actual)	Sales	Age (Years)
Mean	675.75	3044.23	12,361	3042.89	25
Standard Deviation	1717.90	12084.57	26,201	8082.98	15
Range	12434.60	97846.84	198,284	61366.37	66
Inter-Quartile Deviation	373.91	1307.96	13,873	2111.44	15
Maximum	12441.90	97858.70	198,423	61408.34	71
75%tile	444.42	1448.50	15,402	2299.85	30
50%tile	197.60	387.76	3,463	752.53	22
25%tile	70.51	140.54	1,529	188.42	15
Minimum	7.30	11.86	139	42.00	5

1 All figures are five-year (1987 to 1991) averages; financial figures are presented in Rupee millions (Rs 31=$1).

TABLE 2: DEA Models Estimated

	DEABI	*DEAVAGDF*	*DEAVAN*	*DEAVANDF*
Output:	Net Value Added	Net Value Added	Net Value Added	Net Value Added
Inputs:	Employees Gross Fixed Assets	Employees Gross Fixed Assets	Employee Net Fixed Assets	Employees Net Fixed Assets
Deflated:	No	Yes	No	Yes

TABLE 3: Efficiency Results for the Sample Firms[1]

	DEABI	*DEAVAGDF*	*DEAVAN*	*DEAVANDF*
Number of firms	68	68	68	68
Mean Efficiency Score	0.347	0.371	0.369	0.391
Standard Deviation	0.251	0.256	0.248	0.258
Range	0.947	0.948	0.955	0.943
Inter-Quartile Deviation	0.282	0.284	0.292	0.326
Maximum	0.981	0.994	0.991	0.992
75%tile	0.462	0.476	0.477	0.531
50%tile	0.267	0.306	0.278	0.309
25%tile	0.180	0.192	0.185	0.205
Minimum	0.035	0.046	0.035	0.049

1 All figures are five-year (1987 to 1991) averages. Detailed firm-wise and year-wise efficiency scores are given in Appendix 1 for the *DEABI* scores.

TABLE 4: Correlation Between Different DEA Scores

	DEABI	*DEAVAGDF*	*DEAVAN*	*DEAVANDF*
DEABI	1.00	0.98	0.96	0.95
DEAVAGDF		1.00	0.93	0.97
DEAVAN			1.00	0.97
DEAVANDF				1.00

Cronbach's Alpha: 0.989
All correlation values are significant at p<.001

TABLE 5: Profitability - DEA Correlations

	DEABI	*OPERMGN*	*NETMGN*	*OPERASS*	*NETASS*	*NOPASS*	*NNETASS*
DEABI	1.00						
OPERMGN	0.49	1.00					
NETMGN	0.45	0.68	1.00				
OPERASS	0.47	0.94	0.59	1.000			
NETASS	0.37	0.63	0.88	0.67	1.00		
NNETASS	0.32	0.54	0.76	0.60	0.92	1.00	1.00

All correlation values are significant at p.< 001

TABLE 6: Correlation Matrix for Independent Variables

	1	2	3	4	5	6	7	8	9
1. AGE	1.00								
2. SIZE	0.110*	1.00							
3. MONOPOLY	0.095	0.169*	1.00						
4. DATE 1	-0.033	-0.046	.000	1.00					
5. DATE 2	.000	0.008	.000	-.25*	1.00				
6. DATE 3	0.033	0.052	.000	-.25*	-.25*	1.00			
7. DATE 4	0.067	0.067	.000	-.25*	-.25*	-.25*	1.00		
8. DEFENCE	0.085	0.170*	.634*	.000	.000	.000	.000	1.00	
9. TEXTILES	-0.267*	-0.007	-0.129*	.000	.000	.000	.000	-0.129*	1.00

Significant at * $p < 0.05$

TABLE 7: POOLED CROSS-SECTION REGRESSION RESULTS

	Dependent Variables	
	LDEABI	LDEABI
AGE	-0.00894***	-------
LOGAGE	------	-0.2799***
SIZE	.0656***	0.0857***
MONOPOLY	-0.0900	-0.1185
DATE1	0.0170	0.0204
DATE2	0.1151***	0.1198***
DATE3	0.1943***	0.1979***
DATE4	0.2149***	0.2191***
DEFENCE	0.4138	0.4017
TEXTILES	-0.9110***	-0.9391***
CONSTANT	-1.4706***	-0.9127***
BUSE R^2	0.4374	0.4426

*** p<.001
** p<.01
* p<.05

TABLE 8: T-tests of Differences Between DATE Coefficients

Number	H_0	H_A	T-stat	Results*
TEST 1	$DATE_2 = DATE_1$	$DATE_2 > DATE_1$	7.54	H_0 is rejected.
TEST 2	$DATE_3 = DATE_1$	*DATE3 > DATE1*	9.53	H_0 is rejected.
TEST 3	$DATE_4 = DATE_1$	$DATE_4 > DATE_1$	8.70	H_0 is rejected.
TEST 4	$DATE_3 = DATE_2$	$DATE_3 > DATE_2$	6.02	H_0 is rejected.
TEST 5	$DATE_4 = DATE_2$	$DATE_4 > DATE_2$	5.38	H_0 is rejected.
TEST 6	$DATE_4 = DATE_3$	$DATE_4 > DATE_3$	1.54	H_0 is not rejected.†

* $p<.05$
† rejected at $p<.10$

TABLE 9: POOLED CROSS-SECTION REGRESSION RESULTS

	Dependent Variables		
	LEAVAGDF	**LEAVAN**	**LEAVANDF**
AGE	-0.0107***	-0.0113***	-0.0109***
SIZE	0.0957***	0.0687***	0.1198***
MONOPOLY	-0.0534	-0.2949	-0.1675
DATE1	-0.0065	0.0453***	0.0023
DATE2	0.0609***	0.1609***	0.0871***
DATE3	0.1111***	0.2759***	0.1595***
DATE4	0.0833***	0.3106***	0.1529***
DEFENCE	0.3288	0.3642	0.3249
TEXTILES	-1.0619***	-0.9289***	-0.9752***
CONSTANT	-1.3215***	-1.3208***	-1.3788***
BUSE R^2	0.4257	0.4855	0.3490

APPENDIX 1:
Average DEABI Scores for the 68 Firms for 5 years
(in descending order)

	Name	DEABI Score
1.	Rajasthan Drugs & Pharmaceuticals	0.98146
2.	Bharat Earth Movers	0.93332
3.	Bharat Heary Electricals	0.93302
4.	National Textile Corporation	0.90912
5.	Indian Telephone Industries	0.90376
6.	Indian Petrochemical Corporation	0.79902
7.	Steel Authority of India	0.77404
8.	Maruti Udyog	0.77228
9.	HMT	0.69762
10.	Hindusthan Prefabs	0.68472
11.	Rastniya Chemicals and Fertilizers	0.67084
12.	Bharat Electronics	0.63678
13.	UP Drugs and Pharmaceuticals	0.62930
14.	Hindustan Aeronautics	0.55888
15.	Lagan Jute Machinery	0.43472
16.	Ferro-Alloys Nigam	0.47310
17.	Hindusthan Organics	0.47268
18.	Andaman and Nicobar Industries	0.45036
19.	Hindusthan Copper	0.42660
20.	Sponge 1 ron India	0.40436
21.	Smith Stanistreet	0.38838
22.	Indian Oil Blending	0.37902
23.	Bharat Valves	0.37796
24.	Hindustan Cables	0.37464
25.	Bharat Wagon	0.31748
26.	Iisco Stanton Pipes	0.30302
27.	Heavy Engineering Corporation	0.29408
28.	Hindustan Vegetable Oils	0.29216
29.	Cawnpore Engineering	0.28946
30.	Tungabhadra Steel Products	0.28706
31.	Garden Reach Shipbuilders	0.28664
32.	Hindustan Steelworks Construction	0.28396
33.	Bharat Dynamics	0.27382
34.	IBP Company	0.26708
35.	Electronic Corporation of India	0.26648
36.	Balmer Lawrie	0.26498
37.	National Instruments	0.25374
38.	Hindustan Antibiotics	0.24426
39.	Triveni Structurals	0.23572
40.	Hindusthan Photo Films	0.23430
41.	Burn Standard	0.22860
42.	State Farms Corporation	0.22012
43.	Fertilizers and Chemicals Travancore	0.21974
44.	Braithwaite and Company	0.21444
45.	Central Electronics	0.21086
46.	NTC (Tamil Nadu)	0.20954
47.	Hindustan Latex	0.19722
48.	Hindustan Teleprinters	0.18940
49.	Praga Tools	0.18564
50.	Mishra Dhatu Nigam	0.18386
51.	Bharat Plates and Vessels	0.18020
52.	India Firebricks	0.17980
53.	Bengal Immunity	0.17402
54.	National Jute Manufacturers	0.13286
55.	Modern Food Industries	0.13168
56.	NTC (South Maharastra)	0.12726
57.	NTC (Gujarat)	0.12146
58.	NTC (Maderas)	0.11716
59.	NTC (North Maharashtra)	0.11444
60.	Richardson and Cruddas	0.10906
61.	NTC (Delhi)	0.10542
62.	NTC (U. P.)	0.10496
63.	Mining and Allied Machinery	0.10380
64.	National Textile Corp. (A. P.)	0.09830
65.	Bharat Refractories	0.09328
66.	National Textile Corp. (H. P.)	0.06054
67.	Indian Drugs and Pharmaceuticals	0.05556
68.	Indian Iron and Steel Company	0.03492