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An Assessment of the Performance of Indian State-Owned Enterprises

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Abstract

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 establishments which have been sold to the public. The state-owned firms in the manufacturing sector that can be candidates for privatization are the smaller and older manufacturing firms. These firms may also be easier to dispose of to private investors. This finding reinforces our central thesis that firm-level analysis within the state-owned sector is useful and important for generating pragmatic policy guidelines.

Keywords: State-owned enterprises, economic reform, efficiency analysis

1. Introduction

(a) Scope of the Study

We report the results of resesarch in which we empirically evaluate the determinants of performance for a panel of Indian state-owned manufacturing firms for the period 1987 to 1991. Both the measurement and quanitification 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, 1987), 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 manufacturing 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

In developing economies the role of state enterprises is critical. In terms of magnitude, state-owned firms constitute a larger proportion of organized industrial activity. Also, due to the closed nature of many of these economies, this sector has been generally free of competitive pressures, and this 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 (Newbery, 1992). Yet, state-owned enterprises constitute a significant proportion of the total manufacturing value-added in these economies, and the fortunes of these nations are inextricably linked to the performance of these firms. since industrial progress is determined not only by the rate of expansion of resources employed, as reflected in investments, but by the way these resources have been utilized.

Efficient resource utilization generates surpluses, which can then be reinvested towards the creation of further capabilities. Hence, an improvement in the efficiency of these manufacturing 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.

Solutions to the low performance of state enterprises have focused on the sector as the unit of analysis; however, analysis at the firm level may provide additional insights, since,

firm-level analysis can identify performance differentials between firms in the state-owned sector. Such an analysis can help in drawing up a schedule of priorities for policy makers, who can focus aggressively on select firms.

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, such as manufacturing versus service or financial sector firms, 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

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 there is a great deal of heterogeneity between firms and firm-level factors can explain a significant amount of performance variations (Nelson, 1981). 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.

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 Jalan (1991) and 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" (Nayar, 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

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; Thore, Kozmetsky and Phillips, 1994). 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. There is a very large literature on DEA, and we do not go into detail in this paper. Readers may refer to the pieces by Majumdar (1995) and Seiford and Thrall (1990).

Charnes, Cooper and Rhodes (1978) [CCR] generalize the Farrell (1957) output-input measure of efficiency to a multiple output-input case, using a fractional mathematical program in which the ratio of the weighted outputs to weighted inputs of each observation is maximized. This non-parametric programming approach (data envelopment analysis [DEA]) uses observed input and output observations of firms (decision-making units [DMUs]), that use same inputs to produce same outputs, though in varying amounts, to characterize a production possibility set, and, thereafter, to determine an efficient subset based on the observed data. For each observation a statistic, which is a ratio measure of efficiency, is calculated.

The generalized DEA model (Golany and Roll, 1993) can be presented by means of the following mathematical programming formulation:

$$\text{Max } e_{0,0} \tag{1}$$

subject to:

$$e_{j,0} \leq 1, \forall j \tag{2}$$

$$\mu_{r0} \geq \in, \forall r \tag{3}$$

$$\nu_{i0} \geq \in, \forall i \tag{4}$$

where $e_{0,0}$ is a measure of efficiency for every firm-level observation that is being evaluated, $j = 1, \ldots n$ is the index for all observations, 0 being used as the index for the observation specifically evaluated, and $r = 1, \ldots R$ is the index for the outputs, ($y_{rj} \geq 0$ is output r of observation j); $i = 1, \ldots I$ is the index for the inputs, ($x_{ij} \geq 0$ is input i of observation j); $e_{j,0}$ is the relative efficiency of observation j, when observation 0 is evaluated; μ_{r0}, ν_{i0} are the output and input weights, respectively, associated with the evaluation of observation 0; and $\in$ is a non-Archimedean infinitesimal quantity.

In (2), the input (x_{ij}) and output (y_{rj}) factors are known quantities observed from the activities of the observations and the factor weights (μ_{r0} and ν_{i0}) are the decision variables. Defining,

$$e_{j,0} = \sum_{r=1}^{R} \mu_{r0}\ y_{rj} / \sum_{i=1}^{1} \nu_{i0}\ x_{ij} \tag{5}$$

yields the CCR model. Similarly, defining the relative efficiency measure as,

$$e_{j,0} = \sum_{r=1}^{R} \mu_{r0}\ y_{rj} - u_0 / \sum_{i=1}^{I} \nu_{i0}\ x_{ij} \tag{6}$$

where u_0 is an unconstrained decision variable yields the Banker, Charnes and Cooper (1984) [BCC] model.

Banker, Charnes and Cooper (1984) extend the CCR methodology in an important way. The efficiency parameter generated by the CCR algorithm for each observation includes the effects of both scale and technical efficiencies that the observations are able to attain. Banker, Charnes and Cooper (1984) analytically demonstrate that the CCR efficiency score can be broken up into two separate components; the first is a pure technical efficiency component, as to whether firms are able to attain maximum possible output with their input bundles at existing scale size, and, in the algorithm that BCC develop, the technical efficiency score generated captures the pure resource-conversion efficiencies attained by firms, irrespective of whether these firms enjoy increasing, decreasing or constant returns to scale.

(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.

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. 39 = $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.

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. 39 = $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	Employees Net Fixed Assets	Employees Net Fixed Assets
Deflated:	No	Yes	No	Yes

(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 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 (Ahluwalia, 1991) are concomitantly used to measure output. Griliches and

Ringstad (1971) advance arguments in favour of using value added because it facilitates comparison of results for manufacturing firms which may be heterogeneous in material consumption. 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. The use of value added or gross output, however, often depends on data availability.

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 management's 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.

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.

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-à-vis scores obtained by using gross fixed assets as inputs can indicate measurement problems

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.

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 $p < .001$

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 0.99.

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.

The correlation coefficients between the different profitability ratios range between 0.60

Table 5. Profitability—DEA correlations.

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

All correlation values are significant at p. $<$ 001

and 0.92, and the maximum correlation between the DEA score and any one of the profitability ratios is 0.49. The lowest such correlation coefficient is 0.32, 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 0.61. 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 (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 much larger unit is associated with higher prestige and perquisites. For example, there are firms such as Bharat Heavy Electricals Limited and Steel Authority of India Limited which have attracted top-flight managerial and technical talent. Hence, other things being equal better managers should self-select into the larger or more prestigious manufacturing units. Therefore, larger firms' performance should be better. From the perspective of government too, it makes sense to appoint the best managers to the largest manufacturing units, as these represent the largest investments by the government in the manufacturing sector. On the other hand, there are also very large monopoly firms such as Mahanagar Telephone Nigam Limited in which the technical and managerial manpower quality is quite low. 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. 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, 1983). To survive, firms have to utilize their resources more parsimoniously, and the introduction of competition as a solution to the problem of inefficiency has been suggested for both state-owned firms and regulated monopolies (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 investigation commissions of enquiry into economic issues were appointed, and one in particular: the Arjun Sengupta Committee made far-reaching recommendations in respect of state-owned enterprises management, which Mr. Rajiv Gandhi's government attempted to implement.

These reforms were operationalized by the implementation of private-sector management practices in the late 1980s 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—ownership control with the Ministry of Defence (MoD) or the Department of Textiles (DoT) in the Ministry of Commerce.

MoD—a 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 MoD variable.

DoT—one of the fall-outs of Indian industrial policy has been the near-death of a number of firms as a result of owners' malfeasance (Nayar, 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 $MoD|r| = .63$. 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 auto-correlation, 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.

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	0.000	1.00					
5. DATE 2	0.000	0.008	0.000	−0.25*	1.00				
6. DATE 3	0.033	0.052	0.000	−0.25*	−0.25*	1.00			
7. DATE 4	0.067	0.067	0.000	−0.25*	−0.25*	−0.25*	1.00		
8. MoD	0.085	0.170*	0.634*	0.000	0.000	0.000	0.000	1.00	
9. DoT	−0.267*	−0.007	−0.129*	0.000	0.000	0.000	0.000	−0.129*	1.00

Significant at * $p < 0.05$

The average efficiency score (*DEABI*) of the sixty-eight state-owned firms is 0.35, 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 0.714. 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.

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 MoD 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 $t \sim$ 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

Table 7. Pooled cross-section regression results.

	Dependent Variables	
	LDEABI	LDEABI
AGE	−0.00894***	—
LOGAGE	—	−0.2799***
SIZE	0.0656***	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***
MoD	0.4138	0.4017
DoT	−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	$DATE_3 = DATE_1$	$DATE_3 > DATE_1$	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 $p < .10$

error is obtained by taking the square-root of the variance. The critical t values of the one-tailed tests are 1.65 ($p < 0.05$) and 2.33 ($p < 0.01$).

As these results show all t tests are significant as hypothesized except for $DATE_4$ versus $DATE_3$. Further, the coefficient for $DATE_1$ is significantly different from zero only at the 10 percent 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.

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***
MoD	0.3288	0.3642	0.3249
DoT	−1.0619***	−0.9289***	−0.9752***
CONSTANT	−1.3215***	−1.3208***	−1.3788***
BUSE R^2	0.4257	0.4855	0.3490

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 regress these DEA scores on the set of variables used in previous regressions. The results of these regressions 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 an interesting individual result. It is also statistically the most robust result in that it remains positive and significant at a 5 per cent (or higher) level in the regressions and specifications almost without exception. The arguments of size-inefficiency (Downs, 1967) for state-owned firms in the manufacturing sector are not supported by the results. Instead, the results we obtain support our conjecture that the larger state-owned manufacturing 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 manufacturing corporations, can obtain the best talent from technical and management institutions.

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, since the manufacturing firms account for a large share of capital investment in Indian industry, 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 manufacturing 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. They may be easier to deal with, since private investors may be more willing to buy smaller firms on a going-concern basis. While the monopoly 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.

We must stress, however, that our results apply only for manufacturing sector firms. Service sector firms, such as hotel enterprises, or financial sector firms owned by the Indian state are also large. Firms such as Indian Airlines, and banks such as the State Bank of India are extremely large relative to their private sector counterparts, unlike manufacturing sector firms which do have large private sector competitors. Also, service and financial sector firms are for the most part monopolies and union power is very strong in these organizations (Nayar, 1990). Therefore, size and inefficiency may turn out to be correlated if service or financial sector firms are studied.

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 DoT results essentially reflect our expectations at the start of the analysis. The performance of firms under the control of this department is dismal, even in comparison to the generally inefficient state-owned firms. The coefficient on the MoD 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 manufacturing 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 in the manufacturing sector need 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 manufacturing enterprises, given the institutional constraints that impact on the behavior of Indian industry. The results, however, may differ if service or financial sector firms are studied.

In countries which have privatized large numbers of their state-owned firms, for pragmatic reasons it is often the large and profitable establishments which have been sold. The best examples of this are from the United Kingdom, where in the 1980's a large number of profitable state-owned monopolies, such as Amersham International, British Aerospace, British Telecom and British Gas were sold. Conversely, there have been difficulties priva-

tizing 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, is influencing current privatization policy in India. However, the inability or unwillingness to deal with those firms which are smaller and older, 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 highly-successful state-owned firms to privatize. Conversely, the smaller, lesser-known firms may continue to be a drag on the public purse.

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 this research to the public sector. In the absence of data limitations, 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 impact of the determinants of performance.

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