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OWNERSHIP AND EFFICIENCY IN ENGINEERING FIRMS IN INDIA, 1990-91 TO 1999-2000

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Foreword

The paper analyzes the effect of ownership on efficiency of engineering firms in India in the 1990s, a decade of major economic reforms. Technical efficiency of firms, estimated with help of a stochastic frontier production function, is considered for the analysis. A comparison of technical efficiency is made among three groups of firms in Indian engineering: (1) firms with foreign ownership, (2) domestically owned private sector firms, and (3) public sector firms. The results clearly indicate that foreign firms in Indian engineering industry have higher technical efficiency than domestically owned firms. No significant difference in technical efficiency is found between private sector and public sector firms among the domestically owned firms. There are indications of a process of efficiency convergence – the domestically owned firms tending to catch up with foreign owned firms in terms of technical efficiency. The results show a positive relationship between international trade orientation of a firm and its level of technical efficiency. The effect of import intensity is found to be particularly strong, which signifies the efficiency raising effects of import liberalization.

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I Introduction

There have been a number of empirical studies on the effect of ownership of industrial enterprises on their efficiency. One set of studies have addressed the question, are enterprises with foreign ownership more efficient than the domestically owned enterprises, which is connected with the issue of productivity gains from foreign direct investment. Another set of studies have dealt with efficiency differences between private and public sector industrial enterprises, particularly the causes of inefficiency of public sector industrial enterprise.

Foreign owned firms are expected to be more efficient than domestically owned firms because only through greater efficiency they can compensate for the disadvantages they have in operating in a foreign location. In the case of developing countries, another and more important reason to expect foreign owned firms to be more efficient than the locally owned firms is that they have a relatively better access to advanced technology. Indeed, in many developing countries, foreign direct investment (FDI) is given a high priority and incentives are offered to attract FDI on the belief that FDI flows will bring in advanced technology and thus generate productivity gains, directly and indirectly.

Empirical studies on the link between foreign ownership and efficiency undertaken in the context of industrialized countries generally show foreign owned firms to be more efficient (e.g., Canyon et al., 2002; Collins and Harris, 1999; Girma et al., 1999). The studies for developing countries have come up with mixed results. While some studies suggest that ownership has no influence on technical efficiency (e.g., Sterner, 1990), others suggest that foreign firms have higher technical efficiency (e.g., Tu, 1990). However, on balance, the empirical evidence for developing countries seems to suggest that foreign owned firms are more efficient than domestically owned firms. To take such a position appears justified because several carefully done studies for developing countries have found a significant positive effect of foreign ownership on efficiency of enterprises (e.g., Aitken and Harrison, 1999).

On the efficiency differences between private and public sector enterprises, there appears to be greater uniformity in the findings of the studies. A number of studies have found that public sector enterprises are relatively less efficient than their counterparts in the private sector (e.g., Bitros, 2003; Chirwa, 2001; Onder et al., 2003). However, the important question is, what makes public sector enterprises less efficient, and on this question, opinions differ. Bartel and Harrison (1999), for instance, have examined the causes of inefficiency of public sector manufacturing enterprises in Indonesia and found that the inefficiency of public sector enterprises is not due to public ownership *per se*, but is attributable to the fact that they operate under a soft budget constraint. They also found that the inefficiency was relatively greater in those public sector enterprises, which were shielded from import competition.

The object of this paper is to analyze the effect of ownership on efficiency of engineering firms in India in the 1990s. Technical efficiency of firms, estimated with help of a stochastic frontier production function, is considered for the analysis. A comparison of technical efficiency is made among three groups of firms in Indian engineering: (1) firms with foreign ownership, (2) domestically owned private sector firms, and (3) public sector firms. The analysis is carried out using data for large engineering firms.

During the decade of the 1990s, major economic reforms were undertaken in India, which created a more competitive environment and improved access of firms to imported technology, capital goods and intermediate inputs. The changed economic environment must have created greater opportunities for and increased pressure on engineering firms to improve their efficiency, especially the relatively less efficient ones. Accordingly, it would be interesting to examine whether in the 1990s there was an increase in the average technical efficiency of engineering firms and a fall in the extent of inter-firm variation. Some other pertinent questions to ask are: Was the technical efficiency of foreign owned firms generally higher than that of domestically owned private sector firms and public sector firms? How far could the domestically owned firms catch up with the foreign firms in terms of technical efficiency during the 1990s? These are the questions addressed in the paper.

To outline the organization of the paper, the next section discusses briefly the method of estimation of technical efficiency and the models applied for econometric analysis. Two models are applied, one for examining convergence in technical efficiency among engineering firms, and the other for explaining inter-firm variations in technical efficiency. The latter model helps in investigating the factors that determine inter-firm differences in technical efficiency and thereby assessing the effect of ownership on efficiency. Section 3 deals with the data sources and measurement of variables for the study. Section 4 presents the estimates of technical efficiency and makes a comparison of mean technical efficiency among the three groups of engineering firms. Section 5 presents and discusses the results of econometric analysis. It is divided into two sub-sections. Section 5.1 discusses the results of the model used for examining convergence in technical efficiency. Section 5.2 discusses the results of the model used for explaining inter-firm variations in technical efficiency. The main findings of the study are summarized in Section 6.

II Methodology

II.1 Measurement of Technical Efficiency

The technical efficiency scores for the three sets of firms, i.e., firms with foreign ownership, domestically owned private sector firms, and public sector firms are arrived at by estimating a stochastic frontier production function (SFPF) using parametric techniques. SFPF, which was independently proposed by Aigner, Lovell and Schmidt (1977) and Meeusen and Van Den Broeck (1977), includes an additional random error term to frontier production function and therefore captures the effect of random factors in addition to the deterministic components (such as labour and capital). The parameters of SFPF can be estimated using the maximum likelihood method. However, one of the problems of SFPF is that there is no a priori justification for the selection of any particular distribution form of the random error term and the resulting efficiency measures may be sensitive to distributional assumption.

Since the SFPF models were first proposed, it was originally designed for analysis of cross sectional data. However, subsequently various models were introduced to account for panel data. Such a model is used for this study, as we use panel data of the Indian engineering industry to estimate the Translog stochastic production function for the period, 1990-2000. By using the time varying inefficiency model developed by Battese and Coelli (1995) we measure the technical efficiency scores for the i^{th} firm in the industry at t^{th} year. This model is equivalent to the Kumbhakar, Ghosh and McGukin (1991) specification, with the exceptions that allocative efficiency is imposed, the first-order profit maximizing conditions removed, and use of panel data is permitted. The Battese and Coelli (1995) model specification may be expressed as:

$$Y_{it} = x_{it}\beta + (V_{it} - U_{it}), \qquad i=1,...,N;\ t=1,...,T.$$

where Y_{it} is the production of the i^{th} firm in the t^{th} time period; x_{it} is a k×1 vector of input quantities of the i^{th} firm in the t^{th} time period; the V_{it} are random variables which are assumed to be iid, $N(0,\sigma_V^2)$, and independent of the U_{it} which are non-negative random variables, assumed to account for technical inefficiency in production and be independently distributed as truncations at zero of the $N(m_{it},\sigma_U^2)$ distribution; where $m_{it} = z_{it}\delta$, and z_{it} is a time trend. δ is an 1×p vector of parameters to be estimated. The computer program “FRONTIER 4.1” written by Coelli (1996) has been used to estimate the SFPF.

II.2 Modeling efficiency convergence among firms

To study convergence in technical efficiency, a simple model has been applied. The model is estimated for domestic firms. The growth rate of technical efficiency of a domestic firm in a year is taken as a function of the gap between the technical efficiency of the firm and the mean technical of foreign firms in the previous year. The model may be written as:

$$\Delta \ln (TE)_{it} = \alpha + \beta\, GAP_{i,\, t-1} + u$$

In this equation, TE_{it} is the technical efficiency of the i^{th} firm in year t, $GAP_{i,\, t-1}$ is the gap between technical efficiency of the i^{th} firm and the mean technical efficiency of foreign firms in the previous year, and u is the error term. The hypothesis is that the higher the gap, the higher would be the rate of increase in technical efficiency, i.e., β is positive. Evidently, a positive value of β implies that the efficiency levels of domestic firms tend to convergence over time to the efficiency levels of foreign firms. The higher the value of β, the faster is the pace of convergence. This convergence may be the result of spillovers from foreign firms and/or increase in competitive pressures in the industry due to foreign presence.

The above model has been estimated by applying the panel data estimation techniques (fixed-effects model and random-effects model). While estimating the parameters, corrections have been made for auto-correlation and heteroscedasticity.

II.3 Model for explaining inter-firm differences in technical efficiency

To explain differences in technical efficiency across firms, a multiple regression equation has been estimated using data for both foreign and domestically owned firms. The equation is specified as (*i* is the firm subscript):

$$TE_i = \beta_0 + \sum \beta_k Z_{ki} + \beta_F\, DFOR_i + \beta_P\, DPUB_i + u_i$$

In this equation, TE denotes technical efficiency and Z is a vector of explanatory variables representing firm characteristics, such as export intensity, import intensity and R&D intensity. DFOR is a dummy variable for foreign firms and DPUB is a dummy variable for public sector firms. These dummy variables help in assessing whether there is a significant difference in technical efficiency between domestic and foreign firms and between private sector and public sector firms, after controlling for other explanatory variables.

One problem in applying the above model is that the estimated technical efficiency of a firm may vary from year to year due to short-term factors such fluctuations in demand, and supply side bottlenecks. To overcome this inadequacy in the estimates of technical efficiency, averages of three or four years have been taken. Thus, the above model has been estimated for three cross-sections, relating to the periods: (a) 1990-91 to 1992-93, (b) 1993-94 to 1996-97, and (c) 1997-98 to 1999-2000. For each firm, the average value of technical efficiency is computed for the period 1990-91 to 1992-93, and this is then regressed on the values of explanatory variables for 1990-91. Similarly, the average values of technical efficiency for the period 1993-94 to 1996-97 and 1997-98 to 1999-2000 have been regressed on the values of explanatory variables for 1996-97 and 1999-2000 respectively. The purpose in estimating the model for the three cross-sections is to find out if the influence of explanatory factors have changed over time. Given that the economic environment changed considerably during the 1990s due to the reforms undertaken, the determinants of efficiency could undergo significant changes, and an analysis of these changes would obviously be useful. Chow test has been carried out to ascertain whether there are significant differences in the estimated equations for the three time periods.

III Data and Variables

The sample consists of 63 firms in the engineering industries, and data for these firms have been taken for 10 years, 1990-91 to 1999-2000. Domestic firms are 51 (of which 12 are public sector firms) and foreign firms are 12. All these 63 firms selected are large firms having an annual sales turnover of Rs. 50 crore (US $ 11.5 million at 1999 exchange rate) and above during the period 1990-91 to 1999-2000. The data collection commenced with 100 such firms. As continuous time series data were unavailable for 37 firms, the number of sample firms was reduced to 63.

The basic data for the analysis have been drawn from the Prowess Database, 2001 version, of the Centre for Monitoring Indian Economy (CMIE). It contains information for about 7000 companies. The coverage includes Public, Private, Co-operative and Joint Sector companies, listed or otherwise. Approximately, the coverage of this database is seventy percent of the economic activities of the country. Information available includes data from the companies' profit and loss accounts, balance sheets and also fund flow accounts. Key variables on which data were collected for this study include Gross Fixed Assets, Salary and Wages, and Gross Valued Added. Other variables are Sales (Net), Exports, Imports, R&D current expenditure, Value of import of raw materials, Total purchase of raw materials, Profit before tax, Excise duty, Gross output and Foreign equity.

Variables for the estimation of technical efficiency

As discussed above, a two-input frontier production function framework is used to estimate technical efficiency. This requires, for each firm, data on output, labour input and capital input.

Deflated gross value added has been taken as the measure of output. For this purpose, the products of each company were matched with the Wholesale Price Indices (WPI) classification, and the best available price series was chosen for deflation. The base of the wholesale price indices was shifted to 1990-91 before deflation.

Total number of employees directly or indirectly connected to the production has been taken as the measure of labour input for each firm in the sample. The CMIE Prowess database does not contain data on employees in the firms. Instead, data on salary and wages are provided. From the data on salary and wages, an estimate of employment was derived in the following way. In the first step, data on total emoluments and total employees were taken from the Annual Survey of Industries[1] (ASI) for various three-digit industries belonging to engineering. Using these data, emoluments per employee was computed for the period 1990-91 to 1997-98 for those three-digit industries. The series were extended to 1998-99 and 1999-2000 by fitting a trend line to the computed emoluments per employee series for the period 1990-91 to 1997-98.[2] In the next step, the engineering firms in the samples were matched into the three-digit industrial classification of ASI considering the products of the firms. Then, for each firm, the series on salaries and wages obtained from the CMIE database was divided by the computed series on emoluments per employee for the corresponding three-digit ASI industry. This yielded an estimate of employment in the firm.

This method of estimation of employment has a shortcoming that it assumes a uniform wage/earning rate among all firms belonging to an industry. This is unlikely to be true for foreign firms. Empirical studies on differences in wages between foreign and domestic firm indicate clearly that foreign owned firms pay more to their employees. A study for Indonesia (Lipsey and Sjoholm, 1999), for example, finds that wages in foreign own plants for blue collars workers is 12 percent higher and that for while collar workers is 20 percent higher than in domestically owned plants. To account for this factor, the emolument per employee in foreign owned firms has been taken as 10 percent higher than the industry average (obtained from the ASI) and the estimation of employment in such firms has been done with this adjustment.

Gross fixed capital stock at constant prices has been taken as the measure of capital input. The time-series on gross fixed capital stock has been constructed by the perpetual inventory method. This is done in two steps. In the first step, a benchmark estimate of gross fixed capital stock is obtained for each firm for the year 1990-91 (end). Then, to this figure, annual deflated gross investment is fixed assets is added to derive the time-series on gross fixed capital stock.

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1 *Annual Survey of Industries*, Central Statistical Organization, Government of India.

2 At the time these computations were made, ASI results for 1998-99 and 1999-2000 were not available.

Proper estimation of benchmark capital stock requires detailed information on the age structure of capital assets existing at the end of the benchmark year. Since this information was not available, a crude estimate the replacement value of fixed capital stock existing at the end of 1990-91 in each firm has been made by applying a rule of thumb. The 63 firms in the sample have been divided into three groups: new, old and very old. Companies have been classified according to the date of incorporation.

a) Companies incorporated 1965 & before are classified as very old companies (44 companies)
b) Companies incorporated after 1965 through 1980 are classified as old companies (12 companies)
c) Companies incorporated after 1980 are classified as new companies (7 companies)

To get the replacement value of fixed assets, Gross Fixed Assets (GFA) of the companies in 1990-91 (end) has been multiplying by 3 for very old companies, by 2 for old companies and by 1.5 for new companies.

The difference in book value of GFA of every company, year to year, is considered as nominal investment (I_1=GFA_1 – GFA_0). Nominal Investment so obtained is deflated using the Wholesale Price Indices for 'machinery and machine tools'. Computed real gross Investments are then successively added from the second year to the Benchmark Capital value (K_0) to arrive at real capital stock series.

As explained above, the data on output, labour input and capital input for different firms for different years during 1990-91 to 1999-2000 are used for estimating technical efficiency. Estimates of technical efficiency are obtained for each firm for each year of the period studied. Using these estimates, growth rate of technical efficiency has been computed for each firm for each year. Comparing the technical efficiency of a domestic firm with the average technical efficiency of foreign owned firms, the technical efficiency gap variable has been constructed. The growth rate of technical efficiency and the gap between technical efficiency of domestically owned firms and foreign owned firms have been used for estimating the efficiency convergence model.

Variables for explaining inter-firm differences in technical efficiency

The explanatory variables used in the regression equation estimated to explain inter-firm differences in technical efficiency are listed below along with the measure used and the expected relationship.

Export Intensity (XI): Export intensity is measured by the total value of a firm's exports as a ratio of its sales. With the liberalization of the Indian economy, more and more companies have turned towards foreign markets to sell their goods. The depreciation of real effective exchange rate during the first half of the 1990s must have made exports more rewarding. Thus, export-oriented firms must have gained significantly from the depreciation of the exchange rate during this period, which is likely to be reflected in value added and hence in the technical efficiency estimates of such firms.

Since cost competitiveness is important for selling in international markets, a positive relationship is expected between export intensity and technical efficiency. Another link between export intensity and technical efficiency (measured) may operate through customs duty concessions. Under certain schemes operating in the 1990s, firms could import capital goods with customs duty concessions if they made commitments for exports. Inasmuch as the export intensity of firms may reflect in part the export obligations, this is likely to be associated with customs duty concession for purchase of capital assets from abroad, which in turn should show up as higher technical efficiency.

Import Intensity (MI): Import intensity is measured as a ratio of value of imports to the value of sales. The removal of quantitative restrictions on imports and lowering of customs duties should have improved access of Indian engineering firms to imported raw materials (such as non-ferrous metals), stores and spares, and capital goods. Imports of machinery and materials embodying latest technologies should improve the technical efficiency of the firms. Thus, the relationship of this ratio with the dependent variable is expected to be positive.

Vertical Integration (VI): The degree of vertical integration of a firm is measured by the ratio of gross value added to total value of output, as several earlier studies have done. Vertical integration can have both positive and negative effects on technical efficiency of firms. The negative effects emanate from loss of efficiency because the firm supplies its own inputs rather than buying them from competitive markets. The positive effects of vertical integration may emerge from various benefits of integration, including assured supply of inputs, better monitoring of up-stream/ down-stream activities, and lower transactions cost. The observed relationship between vertical integration and technical efficiency in an empirical research would depend on the relative strength these two opposing effects.

It may be argued that the efficiency loss due to integration is likely to more when the economy is well integrated with the world economy than when the trade is restricted. This is so because a highly integrated firm will not be able to take advantage of availability of quality inputs in international markets. Accordingly, one would expect the effect of vertical integration on efficiency to turn adverse towards the end of the 1990s as compared in the early years of reform.

R & D Intensity (RDI): R & D intensity is defined as the ratio of R&D expenditure (current) to sales of firms. Although R&D expenditure in Indian firms is low judged by international standards, there are reasons to expect expenditures on R&D to be favorably related to efficiency of production. First, adoption of imported technology to the local conditions, assimilation of the technology and its further development needs some amount of in-house research. Secondly, R&D is helpful for the search and selection of technology to import, which needless to say is quite important for getting the best out of technology imports.

Advertisement Intensity (ADI): This is defined as the ratio of advertisement expenditure to sales. This variable may be taken as a proxy for product differentiation. Impact of this variable on technical efficiency is unpredictable.

Liquidity Ratio (LR): This is defined in this study as the ratio of current assets of a company minus inventories to current liabilities. It shows the ability of a firm to meet its financial liabilities in a short run of one year. A financially constrained firm may find it difficult to operate efficiently. Therefore, a positive relationship between liquidity ratio and technical efficiency is expected.

Central Excise Duty paid (CED): This is measured as the ratio of central excise duty paid by a firm to its value of output. A high effective rate of excise should have an adverse effect on value added in the firm unless the producer is able to shift the tax burden to consumers completely. A high rate of excise will also lower the incentives of the producers in raising production, say through better capacity utilization. Hence, a negative relationship is expected between excise duty rate a firm is subject to and its level of technical efficiency.

Dummy variables for foreign (DFOR) and public sector (DPUB) firms. To capture the effect of foreign ownership on efficiency, a dummy variable for foreign firms has been used. The criterion applied is that the foreign equity share should be more than 20 percent. Based on this criterion, 12 firms in the sample are foreign firms.[3] Another dummy variable is used for public sector firms. There are 12 public sector firm among the 63 firms included in the sample.

IV Technical Efficiency Estimates

Table 1 shows the means of estimated technical efficiency for the foreign owned firms, domestically owned private sector firms and public sector firms for different years during the period, 1990-91 to 1999-2000. The last two columns of the table give t-statistics for testing equality of mean between foreign owned and domestic owned firms and between domestically owned private sector firms and public sector firms.

[3] In seven companies, the foreign equity share is over 50 percent and in four others it is between 30 and 50 percent. Thus, in only one company, the foreign equity share is less than 30 percent, but above 20 percent. Among the12 foreign firms, five are manufacturing auto parts and two-wheelers, four belong to electrical engineering and three belong to general engineering.

Table 1: Mean Technical Efficiency in Indian Engineering Firms, 1990-91 to 1999-2000, by ownership category

Year	Mean technical efficiency				t-ratio for testing equality of means	
	Foreign owned firms (12 firms)	Domestically owned firms			Foreign owned versus domestically owned firms	Domestically owned private sector firms versus public sector firms
		Private sector (39 Firms)	Public sector (12 firms)	All (51 firms)		
1990-91	0.773	0.704	0.667	0.696	2.80 #	0.83
1991-92	0.785	0.718	0.657	0.704	2.63 #	0.99
1992-93	0.786	0.704	0.664	0.695	2.66 #	0.67
1993-94	0.789	0.720	0.659	0.706	1.84 @	1.07
1994-95	0.829	0.747	0.656	0.726	2.39 @	1.37
1995-96	0.834	0.767	0.654	0.740	2.17 @	1.61 @
1996-97	0.832	0.756	0.678	0.738	2.31 @	1.16
1997-98	0.807	0.731	0.688	0.721	1.79 @	0.64
1998-99	0.764	0.708	0.659	0.697	1.11	0.74
1999-00	0.743	0.714	0.679	0.706	0.56	0.51
1990-91 to 1999-2000	0.794	0.727	0.666	0.713		

Note: the t-ratios are for testing of equality of means done under the assumption of unequal variance.

Statistically significant at one percent level (one-tail test)
@ Statistically significant at five percent level (one tail test)

It is evident from the comparison presented in Table 1 that the mean technical efficiency of foreign firms was higher than that of domestically owned private sector firms and public sector firms in each year of the period under study. For the ten-year period, 1990-91 to 1999-2000, the average technical efficiency of foreign firms was 0.794, higher than the average technical efficiency of domestically owned firms (0.713). The difference between the mean technical efficiency of foreign owned firms and that of domestically owned firms is statistically significant at one percent level (one-tail test) for the first three years under study, and statistically significant at five percent level (one-tail test) in the next five years. It is in the last two years that the difference in mean technical efficiency between the foreign and domestically owned firms is not statistically significant. This is clearly indicative of higher efficiency of foreign owned firms compared to domestically owned firms in Indian engineering industry. The advantage of foreign firms in technical efficiency seems to have declined in the late 1990s.

The difference in mean technical efficiency between domestically owned private sector firms and public sector firms is relatively small. The difference is found to be consistently positive, but it is statistically significant for only one year out of the 10 years studied. Thus, on the basis of these results, it cannot be concluded that public sector engineering firms are relatively less efficient as compared to the domestically owned private sector firms in engineering.

The mean technical efficiency estimates presented in Table 1 reveal an upward trend in technically efficiency in foreign firms and domestically owned private sector firms in the first half of the 1990s and a downward trend in technical efficiency in the second half of the 1990s. The upward trend in technical efficiency in the first half of the 1990s is possibly a result of the economic reforms. The downward trend in the later half of the 1990s could have been caused by the recession Indian industry experienced in that period. It should be pointed out that the fall in the technical efficiency level among foreign firms was more marked than that among domestically owned private sector firms. In contrast, the public sector firms did not gain much in technical efficiency (on an average) during the first half of the 1990s nor lost in the second half.

V Results of Econometric Analysis

V.1 Convergence in technical efficiency

The results of the model estimated to examine convergence in technical efficiency among engineering firms are presented in Table 2. As mentioned earlier, the model is estimated using data for domestic firms, belonging to both private and public sector. The model has been estimated separately for the periods 1990-91 to 1995-96 and 1996-97 to 1999-2000, and for the entire period 1990-91 to 1999-2000.

Table 2: Results of the Technical Efficiency Convergence Model, Indian Engineering Industry, 1990-91 to 1999-2000

Period	Method of estimation	Constant	Coefficient of GAP_{-1}	Lagrange multiplier/ Hausman Statistics
1990-91 to 1999-00	FE		1.589 (11.0)	LM=10.29 HS=35.30
	RE	-0.106 (-2.7)	1.151(9.3)	
1990-91 to 1995-96	FE		2.723 (3.2)	LM=16.80 HS=2.01
	RE	-0.127 (-2.3)	1.566 (6.6)	
1996-97 to 1999-00	FE		1.462 (1.7)	LM=8.54 HS=1.11
	RE	-0.066 (-1.6)	0.569 (3.4)	

FE= fixed-effects model; RE= random-effects model; LM = Lagrange multiplier;
HS= Hausman Statistics; GAP_{-1} = gap in technical efficiency (lagged one year).
Note: t-ratios in parentheses. Parameter estimates are corrected for auto-correlation and heteroscadasticity.
Total number of observations = 567.

The results of the Lagrange multiplier test indicate that the parameter estimates obtained by the Fixed-effects/Random-effects models are to be preferred to the estimates obtained by the Ordinary Least Squares (OLS) method. The OLS estimates are therefore not reported in the table. The Hausman statistics indicate that the fixed-effects model is to be preferred over the random-effects model for the estimates for the entire period, but the random-effects model is to be preferred for the estimates for the sub-periods. It may be mentioned in this context that a test has been carried out for testing for a structural break in mid 1990s. The test statistic is found to be statistically significant, rejecting the null hypothesis that the parameters in the two sub-periods were the same. Thus, there are indications of a structural change in the relationship between growth in technical efficiency and the gap.

The coefficient of GAP is found to be positive and statistically significant at one percent level in the estimates for the entire period, and also in the estimates for the sub-periods obtained by the random-effects model, which is the preferred estimation method on the basis of Hausman statistics. Thus, the results presented in Table 2 clearly indicate that there was a process of convergence in technical efficiency among Indian engineering firms during the 1990s – the domestically owned firms tending to catch up with the foreign firms. Also, it appears form the results (note the marked fall in the coefficient of GAP in the period 1996-97 to 1999-00 as compared to the period 1990-91 to 1995-96) that this process of convergence weakened in the second half of the 1990s. This perhaps indicates a reduction in the positive spillover effects from foreign firm.[4]

The finding from the econometric analysis that the process of efficiency convergence in Indian engineering became weaker in the second half of the 1990s may appear conflicting with the tests of equality of mean efficiency presented in Table 1 above. One would note that there were significant differences in the average technical efficiency between foreign owned and domestically owned engineering firms in the initial years of the 1990, and this gap narrowed and turned statistically insignificant in the last two years of the 1990s. One might argue that if the process of convergence had turned weaker in the second half of the 1990s, the difference in mean technical efficiency between foreign and domestically owned firms should not have declined. A closer examination of the data reveals, however, that the reduction in the gap in mean technical efficiency level is not due to an increase in the efficiency of the domestically owned firm, but due to a fall in the mean technical efficiency of foreign owned firms. It may be pointed out in this context that in 1990-91 there were three foreign owned firms and two domestically owned private sector firms on the frontier (technical efficiency more than 0.9). In 1999-2000, by contrast, there were two foreign owned firms, two domestically owned private sector firms and two public sector firms on the frontier.

[4] Some of the studies show that the convergence or spillovers may be lower if the productivity gap is too large between domestic and foreign firms, since the absorptive capacity of domestic firms is low if the gap is too large. A dummy variable was introduced to capture the effect of very large gap (above 60%). However, the coefficient of this variable was not found to be significant though it had a negative sign.

V.2 Inter-firm variations in technical efficiency

Table 3 presents the multiple regression equations estimated to explain variations in technical efficiency among engineering firm in the early, mid and late 1990s. Three regression equations are presented: one for the period 1990-91 to 1992-93, another for the period 1993-94 to 1996-97 and the third for the period 1997-98 to 1999-00. The Chow test indicates that the parameters of the model cannot be assumed to be the same for the three time periods and there is justification for estimating three separate regressions rather than estimating one common regression equation after pooling data for the three time periods.

Table 3: Inter-firm variations in technical efficiency, Regression Results

Dependent variable: technical efficiency No. of observations = 63

Explanatory variables	Regression equation for the period		
	1990-91 to 1992-93	1993-94 to 1996-97	1997-98 to 1999-00
Export intensity	0.0857 (0.5)	0.3084 (2.3)**	0.1126 (0.8)
Import intensity	-0.2495 (-1.4)	0.2580 (2.7)***	0.6492 (2.7)***
Vertical integration	0.4455 (2.6)**	0.3750 (2.0)*	-0.0366 (-1.4)
R&D intensity	-2.6711 (-0.7)	0.3638 (0.2)	2.2776 (1.5)
Adv. Intensity	1.8532 (1.1)	5.3131 (3.2)***	4.2361 (2.4)**
Liquidity ratio	0.0114 (0.6)	0.0110 (0.9)	0.0380 (4.2)***
Excise duty rate	0.3021 (2.0)*	0.3620 (1.7)*	0.3150 (1.3)
Foreign firm	0.0625 (1.9)*	0.0862 (2.3)**	0.0691 (2.3)**
Public sector firm	-0.1566 (-0.4)	-0.0294 (-0.6)	-0.0437 (-0.8)
Constant	0.5684 (8.8)	0.4929 (6.5)	0.5083 (9.5)
R-squared [F-ratio]	0.258 [2.06]	0.367 [3.41]	0.463 [5.09]
Chow Test Statistic	5.58		

t-ratios in parentheses.
* Statistically significant at 10 percent level
** Statistically significant at 5 percent level
*** Statistically significant at 1 percent level

The regression results clearly indicate that technical efficiency of foreign firms is significantly higher than that of domestic firms. The coefficient of the foreign firm dummy variable is positive and statistically significant in all the three estimated equations. This is consistent with the results of t-tests for equality of means reported in Table 1 above.

As regards the difference in technical efficiency between domestically owned private sector and public sector firms, no statistically significant difference is indicated by the regression results. The coefficient of the dummy variable for public sector firms is negative, but it is not statistically significant in any of the equations estimated. This is in line with the results of t-tests for equality of means reported in Table 1.

The coefficient of export intensity is positive as hypothesized. The estimated coefficient for the period 1993-94 to 1996-97 is statistically significant at five percent level. However, in the estimated equation for the later period, the coefficient is smaller in numerical value and statistically insignificant. The explanation possibly lies in the fact that there was a rapid growth in India's engineering exports during 1993-94 to 1996-97 which may have benefited firms with greater export orientation, but these benefits disappeared or became small later, as the growth of engineering export turned sluggish during 1997-98 to 1999-2000. [5]

Import intensity is found to be a significant variable in explaining technical efficiency during 1993-94 to 1996-97 and 1997-98 to 1999-00.[6] The sign of the coefficient is positive as expected. It is statistically significant at one percent level. It may be inferred accordingly that the liberalization of imports enhanced access of firms to

[5] Engineering exports in US dollars increased from 3,038 million US dollars in 1993-94 to 4,962 million US dollars in 1996-97. The annual rate of growth was 26 per cent per annum between. In 1999-00, engineering exports in US dollars was 5,152 million US dollars. The growth rate between 1996-97 and 1999-00 was 5.5 per cent per annum.

[6] The coefficient of import intensity is incorrectly signed and statistically insignificant in the regression equation estimated for 1990-91 to 1992-93. The absence of a significant positive effect of import intensity could be due to high tariffs and the devaluation of the Rupee in 1991 making imported inputs costly.

imported inputs and capital goods, and thus contributed considerably to increases in efficiency of engineering firms.

The coefficient of vertical integration is positive and statistically significant in the estimates for 1990-91 to 1992-93 and 1993-94 to 1996-97. This indicates that vertically integrated firms had an advantage in efficiency compared to firms less vertically integrated. However, the coefficient of this variable is negative and statistically insignificant for the estimated for 1997-98 to 1999-00. It appears that, with increased availability of imported inputs, the advantages of vertical integration were cancelled by the costs associated with it (in not being able to use better quality inputs purchased from international markets).

Although a positive relationship is expected between R&D activity and efficiency, the coefficient of R&D intensity is found to be negative in the regression equation estimated for 1990-91 to 1992-93. It is positive in the regression equations estimated for 1993-94 to 1996-97 and 1997-98 to 1999-00, but not statistically significant. The numerical value of the coefficient is higher in the estimate for 1997-98 to 1999-00 than that for 1993-94 to 1996-97. Also, the t-ratio falls short of the tabulated value at 10 percent level of significance only by a small margin. It appears from the results therefore that as the Indian economy became more and more liberalized, the favorable effects of R&D on efficiency of engineering firms grew stronger.

The results indicate a positive relationship between advertisement intensity and technical efficiency. The coefficient is positive for all the three regressions. It is statistically significant in the regressions estimated for the periods 1993-94 to 1996-97 and 1997-98 to 1999-00. Since advertisement intensity may be taken as a proxy for product differentiation, one possible interpretation of the results is that the firm producing differentiated products could attain higher value addition for a given amount of labour and capital than a firm producing a homogeneous product.[7]

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7 Companies manufacturing capital goods may incur heavy advertisement expenditure towards global supply. Inasmuch as this make the company more export oriented, a favorable effect on efficiency is expected.

Another possibility to consider in this context is that advertise intensity would generally be more for firms producing consumer goods than for firms producing producer goods. Since most consumer goods remained under protection till the end of the 1990s while their intermediate inputs became more easily available, the effective protection of consumer goods was higher than that of producer goods. This may be reflected in the estimates of technical efficiency.

Liquidity ratio is found to have had a significant positive effect on efficiency in the period 1997-98 to 1999-00. The coefficient is positive but not statistically significant in the regression equations estimated for the periods 1990-91 to 1992-93 and 1993-94 to 1996-97. Given that Indian industry faced considerable demand problems in the late 1990s, liquidity must have been an important factor for smooth operations of production facilities. This appears to be reflected in the finding of a significant positive coefficient of liquidity in the regression estimated for 1997-98 to 1999-00.

The positive coefficient of the excise duty variable in the estimated regression equations comes as a surprise – a negative relationship is expected. It is interesting to note that the numerical value of the coefficient is quite stable across the equation, and the coefficient is statistically significant at 10 per cent level in the equations estimated for 1990-91 to 1992-93 and 1993-94 to 1996-97. The results suggest that a firm subject to higher rates of excise duty often has a higher level of technical efficiency (other things remaining the same). It seems firms try to compensate for the higher burden of excise by being more economical in the use of resources.

VI Conclusion

The analysis presented above clearly indicates that foreign firms in Indian engineering industry have higher technical efficiency than domestically owned firms. No significant difference in technical efficiency is found between private sector and public sector firms among the domestically owned firms.

There are indications of a process of efficiency convergence – the domestically owned firms tending to catch up with foreign owned firms in terms of technical efficiency. This process of convergence seems to have weakened in the second half of the 1990s. The gap in mean technical efficiency level between foreign owned and domestically owned firms has fallen towards the end of the 1990s. But, this not due to an increase in the efficiency of the domestically owned firm, but due to a fall in the mean technical efficiency of foreign owned firms.

The results show a positive relationship between international trade orientation of a firm and its level of technical efficiency. The effect of import intensity is found to be particularly strong, which signifies the efficiency raising effects of import liberalization; the improved access to imported inputs enabling firms reach higher levels of technical efficiency.

From the results, it appears that in the first half of the 1990s there were significant positive productivity spillover effects from foreign owned firms to domestically owned firms. This effect became relatively less important in the second half of the 1990s when access to imported inputs became an increasingly more important source of efficiency of engineering firms in India.

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