Chapter V

TECHNICAL EFFICIENCY AND ECONOMIC PERFORMANCE

5.0 The preceding chapter explored the relationship between firm-size/ownership pattern and partial factor productivities of the spinning mills in Kerala. This chapter examines the relationship between firm-size/ownership and technical efficiency in production using a two factor frontier Cobb-Douglas production function to measure technical efficiency in six categories of spinning mills. Intersectoral differences in total factor productivity are also analysed with the help of dummy variables.

An investigation into the sources of technical efficiency differentials among firms in the sample is also done. The important explanatory variables selected are capacity utilization, wage rate and presence of well equipped research and development (R&D) department.

5.1 THE CONCEPTUAL FRAMEWORK

Neo-classical economics characterized by microeconomic theoretical systems assumes the working of a firm in a perfectly competitive and riskless environment and maximise profit. But in real practice, the efficiency varies greatly among firms as against neo-classical assumption. Micro-
economic studies usually distinguish between allocative efficiency, and technical efficiency. Technical inefficiency arises due to a firm's failure to maximise output from a given set of inputs.

Production, in the broadest sense may be defined as any activity the net result of which is to increase the degree of compliance between the quantity, quality and distribution of commodities and a given preference pattern (Heathfield and Soren, 1987). Production process is the means of transforming inputs into outputs. Production function is the set of possible efficient relations between inputs and outputs given the current state of technological knowledge.

\[ y = g (r_1, r_2, \ldots, r_m) \]

which states that 'Y' is the maximum amount of commodity Y which the firm can produce if it uses exactly \( r_1 \) units of inputs 1, \( r_2 \) units of inputs 2 etc. Knowledge of such a functional relationship presupposes that a set of optionality calculations has already been carried out, explicitly or implicitly, by the firm's engineers or production managers.

The existence of embodied technological progress has led to the introduction of frontier production functions. The
frontier production function represents the best technology, i.e., the most modern. It is called 'frontier' function because it represents the efficiency frontier of the industry. It is also called 'best practice' functions or 'ex-ante' production functions. The introduction of frontier production has inspired the studies of efficiency in an industry.

5.2 MEASUREMENT OF PRODUCTIVE EFFICIENCY

Best practice studies started with a study in 1948 by A.P. Groose on open hearth steel furnaces. In this and later works in Salter (1960) the term was reserved for a specific 'technique' rather than for whole production function. The first to use of a best practice function as an empirical concept was in 1957 by Farrell (Heathfield and Soren 1987). Most of the best practice, or frontier production studies are related to the analysis of productive efficiency/inefficiency. The concept of frontier and best practice relations are due respectively to Farrel and Salter. Farrel (1957) introduced the concept of technical efficiency along with that of frontier or best practice production function, which defines for a set of observations the maximum output attainable from a given vector of measured inputs.

Before the emergence of best practice concept, efficiency measurement by average productivity of labour or
capital or total factor productivity index was thought to be adequate. The former indices are simply the average products of labour or capital while total factor productivity, often referred to as the 'residual' or the 'index of technical progress' is defined as ratio of output to weighted sum of all factors. Symbolically these indices are:

Partial indices: (a) $AP_L = Q/L$,  
(b) $AP_K = Q/K$

Total productivity index: $A = Q/(aL + bK)$

where $Q$, $L$ and $K$ are respectively, the aggregate level of output, labour and capital inputs; 'a' and 'b' are some appropriate weights.

Keshrai and Thomas (1994) summarize the disadvantages of these measures:

1. An average productivity measure ignores the contribution of other factors in production.

2. Although an index of total factor productivity (TFP) can take into account all the factors of production, in construction of index one faces the usual index number problems while aggregating inputs.
3. Measures of TFP are deduced from explicitly or implicitly defined average production function but the production function by definition are frontier functions.

Thus the total factor productivity index should be constructed on the basis of a frontier production function: Farrel's measure of efficiency avoids the aforementioned problems - one which takes into account all inputs and yet avoids index number problems. The measure developed is applicable to any productive organization from a workshop to a whole economy.

Farrel has proposed two measures of technical efficiency. First measure is based on the ratio of best practice input usage to actual usage, holding the output constant. It is called input based measure. The second measure is based on ratio of actual output obtained from a given vector of inputs to maximum possible output achievable from the same input vector. Farrel's input based measure of productive efficiency can be illustrated with the help of a diagram.
Fig. 5.1 Measurement of Technical Efficiency

The point D in the diagram represents the inputs of the two factors, per unit of output, that the firm is observed to use. The isoquent AA denotes the frontier production function for various combinations of two factors to produce unit output. The crosses denote observable input coefficients of the firms in the industry. Each cross is a per unit of output coefficient.
Let C be a specific firm. It represents an efficient firm using the two factors in the same ratio as D. Firm C produces the same output as D using only OC/OD as much of each factor. Thus OC/OD is defined as the technical efficiency (TE) of firm D.

This ratio has the properties that a measure of efficiency obviously needs. It takes the value of 1 (or 100 per cent) for a perfectly efficient firm. Since AA has a negative slope, an increase in the input per unit of output of one factor implies lower technical efficiency ceteris paribus. The technical efficiency has the range 0 → 1.

However, point C does not represent the most profitable factor combination eventhough it is technically efficient. Both firm C and A₀ represent 100 per cent technical efficiency, but firm C is not resorting to optimal method of production. Since PP has a slope equal to the ratio of the prices of the two factors of the firm, A₀ is restoring to optimal method of production. Thus firm D has also a price inefficiency. The price efficiency (PE) of firm D is OB/OC.

Further, if the observed firms were to change the proportions of its inputs until they were the same as those represented by A₀, while keeping its TE constant, its cost
would be reduced by a factor $OB/OC$, so long as factor prices did not change. If the observed firms were perfectly efficient both technically and in respect of prices, its cost would be a fraction of $OB/OD$ of what they in fact were. Farrel defined this as the overall efficiency (OE) of the firm. Thus $OE = TE \times PE = OB/OD$.

Farrel's efficiency measures are relative in the sense the performance of the individual firms are compared with the best performer in a peer group. Farrel also proposed an output-based measure of technical efficiency that could be derived by estimating a frontier production function with a specific functional form. A frontier production function is defined as the locus of output achievable from the given input vectors.

Technical efficiency is the ratio of actual output to the corresponding level of output shown by the production frontier, i.e. ratio of actual to maximum potential output. Technical inefficiency is defined as the amount by which the actual output falls short of the maximum possible output on the frontier. It measures the extent to which a firm fails to obtain the maximum output from its inputs, as judged by how far its output-input ratio falls short of the most efficient of the firms in the sample that use factors in the same proportions as they do.
"The TFP differential between actual and potential (or best practice) output is defined conventionally as technical inefficiency" (Little et al., 1987). The concept of technical efficiency is closely related to that of total factor productivity (TFP). Nishimizu and Page (1982) rightly pointed out that the amount by which actual output is less than potential output is formally equivalent to the difference between total factor productivity based on best practice and that based on actual practice. Since differences in technical efficiency between firms are equivalent to the differences in TFP, the production frontier provides a useful tool for analyzing the relative productive efficiency of individual economic units. Deviations from best practice are ascribed to technical inefficiency.

Farrel did not follow up his own suggestion of estimating a frontier production function. Non-parametric approaches for the estimation of the efficiency frontier were popular after Farrel's work. However, techniques have been developed to estimate a parametric frontier by imposing a functional form. Early efforts at specifying frontiers were done by Aigner and Chu (1968), Timmer (1971), Afriat (1972), Richmond (1974) and Schmidt (1976). Beginning with the pioneering work of Aigner and Chu (1968), substantial econometric effort has been focused on developing frontier
production functions. They specified a homogeneous Cobb-Douglas production frontier and required all observations to be on or beneath the frontier. Their model may be written

\[ \ln Y = \ln f(x) - u \]

\[ = \alpha + \sum_{i=1}^{n} \alpha_i \ln x_i - u, \quad u \geq 0 \]  

(5.1)

where the one-sided error term forces \( y \leq f(x) \).

Aigner and Chu suggested the estimation by mathematical programming methods. The parameters may be estimated by linear programming, i.e. minimizing the sum of the absolute values of the residuals, subject to the constraint that each residual be non-positive (i.e. negative). They suggest the minimization of

\[ \sum_{i=1}^{n} [y_j - \ln f(x_j)] \]

subject to \( y_j \leq \ln f(x_j) \) where \( x_j \) is a vector of \( n \) inputs used by the \( j \)th firm.

It can also be estimated by quadratic programming, i.e. minimizing the sum of the squared residuals, subject to the same constraint. The technical efficiency of each
observation can be computed directly from the vector of residuals, since 'u' represents technical inefficiency. That is, the ratio of observed output of a firm to its efficiency frontier output provides the TE index.

The most important problem of this approach is that it does not allow for random shocks in the production process which are outside the firms' control. Two alternative approaches to the specification of the frontier have come into prominence, namely deterministic and stochastic.

5.3 DETERMINISTIC STATISTICAL FRONTIER

The frontier is called deterministic if all observations must lie on or below the frontier. A deterministic frontier production function envisages a deterministic optimal relationship between inputs and output, unaffected by random events and statistical noise such as measurement errors. Thus the actual level of output of a firm lies below the frontier only due to the existence of technical inefficiency in the production process. This implies the assumption that all random factors are under the control of the firm. Model in (5.1) can be written as

\[ y = f(x)e^{-u} \]  

(5.2)
Taking logarithms to the base $e$ it may be written as

$$\ln y = \ln[f(x)] - u \quad (5.3)$$

where $u \geq 0$ (and thus $0 \leq e^{-u} \leq 1$) and where $\ln[f(x)]$ is linear in the Cobb Douglas case in (5.1). The assumption is that the observations on 'u' are independently and identically distributed (iid) and that $x$ is exogenous (independent of $u$). For a deterministic frontier production function model, there are choices regarding the assumptions to be made about probability distribution of the error terms. Error terms may be assumed to follow any of gamma, exponential or half normal distribution. There do not appear to be good a priori arguments for any particular distribution.

Richmand (1974) suggested a method of estimation based on ordinary least square results called corrected ordinary least square (COLS) method. Richmand assumed 'u' has a gamma distribution. Let $\mu$ be the means of $u$, then equation (5.3) may be rewritten as

$$\ln y = (\alpha_o - \mu) + \sum \alpha_i \ln x_i - (u - \mu)$$

where the new error term has a zero mean and satisfies all the usual ideal condition except normality. Therefore, the above
equation can be estimated by OLS technique to obtain best linear unbiased estimate of \((\alpha_0 - \mu)\) and of the \(\alpha_1\). It can be shown that since \(u\) has been assumed to follow a gamma distribution, an estimate of \(\mu\) is given by the variance of OLS residuals and this estimate can be used to 'correct' the OLS constant term, which is a consistent estimate of \((\alpha_0 - \mu)\). COLS thus provides consistent estimates of all the parameters of frontier.

A problem with COLS method is that even after correcting the constant term, some of the residuals may still have the 'wrong' sign so that some firms will lie above the frontier. That is, some firms show the efficiency index more than 100 per cent because their observed output is more than potential output. They can be assumed to be 100 per cent efficient (Golder and Agarwal, 1992). Another way to resolve this problem is to correct the constant term not as above, but by shifting it up until no residual is positive and one is zero. This method was followed by Greene (1980). Greene had shown that regardless of the distribution of error term one may obtain a consistent estimate of the intercept term by adding to it the largest error term in the sample.\(^1\)

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\(^1\) Golder and Agarwal (1992) modified this approach and had taken the average of five largest error terms as the correction factor. They claimed that this method is consistent and better than the Green's method in the sense that correction factor is based on five largest error terms.
5.4 STOCHASTIC FRONTIERS

The stochastic frontier approach accommodates exogenous shocks like power shortages, raw material supply breakdowns, machine and equipment failure, in addition to measurement errors by decomposing the deviation from the frontier into two components, the first of which is distributed symmetrically with zero mean reflecting randomness found in any relationship and the other is assumed to be distributed asymmetrically reflecting technical inefficiency. To lump the effects of exogenous shocks with the effects of measurement error and inefficiency into a single one-sided error term is questionable. This involves the specification of the error term as being made up of two components, one normal and the other from a one-sided distribution. Aigner, Lovel and Schmidt (1977) and Meesen and van den Broeck (1977) suggested stochastic error specification (composed error) models. They introduced two separate disturbance terms. A stochastic production model may be written as

\[ y = f(x) \exp(v-u). \]

The disturbance 'v' represents the influence of factors outside the control of the firm, while 'u' represents technical errors of the firm. Technical inefficiency relative to the stochastic production frontier is given by 'u' per cent.
The model can be estimated either by maximum likelihood or COILS methods. In either case the distribution of 'u' must be specified. Stochastic frontier is considered superior because it gives less biased measure of efficiency. The main disadvantage of the model is that the frontier being stochastic, it is not possible to obtain estimates of efficiency for each observation or each firm. The best that one can do is to obtain an estimate of mean inefficiency over the sample (Forsund et al., 1980). The choice between deterministic and stochastic frontier mainly depends on the purpose of study besides information about the quality of data, and how data are generated.

There are two competing paradigms on how to construct frontiers viz.

1. Mathematical programming
2. Econometric techniques.

The main advantage of mathematical programming or 'Data Envelopment Analysis' (DEA) is that it does not impose any explicit functional form (such as Cobb-Douglas etc.) on production function to be estimated. But the calculated frontier may be warped if the data are contaminated by
statistical noise. It can estimate only deterministic frontier and it produces 'estimates' which have no statistical properties such as standard errors or 't' ratios.

The econometric approach can handle statistical noise, but it imposes an explicit, and possibly overly restrictive, functional form for technology. This approach is capable of estimating deterministic as well as stochastic frontier and provides estimates with statistical properties. Researchers prefer econometric approach because of these advantages.

5.5 THE MODEL: PRESENT STUDY

Econometric estimation of frontier production function has been done to estimate efficiency of a firm or industry. Majority of the studies¹ have estimated the relative technical efficiency using deterministic frontier. Following them the present study also adopts a deterministic frontier frame-work.

Composed error model is considered to be more sophisticated approach to the analysis of technical efficiency. Jondrow et al., Greene and Mayes (1991) recommended the use of a composite error term stochastic

frontier production function. These models require the estimation method of maximum likelihood when the assumed distribution of inefficiency component of error term is truncated at a point other than the mode. Olson et al. (1980) and Jondrow et al. (1982) had used mode as the truncation point and thus applied half normal distribution to the inefficiency error component. They had derived the average technical efficiency and firm level technical efficiency based on the moments of composite error term. The efficiency index so obtained is found upward biased on account of the assumption of mode being the truncation point. On the basis of these arguments Goldar and Agarwal (1992) applied deterministic frontier production function.

The frontier production function for the present analysis has been specified as deterministic since the main objective of the study is to measure inter-firm differences in efficiency. It is assumed that the technology of the spinning mills is represented by a Cobb-Douglas value added function. Hence the model specified is a homogeneous Cobb-Douglas production frontier and all observations are required to be on or beneath the frontier.

The model takes the following form:

\[ Y = AL^a K^b e^{-u} \] (1)
where \( u \geq 0 \) and thus \( 0 \leq e^{-u} \leq 1 \)

where \( y = \) Gross value added  
\[ L = \text{Labour} \]  
\[ K = \text{Capital} \]  
\[ A = \text{Efficiency parameter} \]  
\[ a = \text{Coefficient of labour} \]  
\[ b = \text{Coefficient of capital}. \]

A random disturbance term is added to account for the various factors that result in less than maximum production. For the interpretation of the function to remain that of maximum output, one requires that the disturbance takes only negative values. Thus the condition \( u \geq 0 \) ensures that all observations lie on or beneath the production frontier.

The model further assumes that the observations on 'u' are independently identically distributed (iid) and that L and K are exogeneous (independent of 'u'). If a firm is on the production frontier 'u' is equal to zero, so that \( e^{-u} \) takes on the value unity. \( e^{-u} \) is the measure of technical efficiency. The parameters 'a' and 'b' represent elasticities of value added with respect to labour and capital respectively and their sum gives a measure of returns to scale.
The logarithm of both the sides of the equation is taken to convert the equation in linear form. The log transformation is specified as,

\[ \ln y = \ln A + a \ln L + b \ln k - u \]  \hspace{1cm} (2)

\[ u \geq 0 \]

The model is expanded introducing time element (T) and converted as follows:

\[ \ln y = \ln A + a \ln L + b \ln k + gT - u \]  \hspace{1cm} (3)

\[ u \geq 0 \]

The model now allows exponential technological change at a constant annual rate of 'g'. The parameters of the model are A, a, b and g. The model is estimated using corrected ordinary least square (COLS) method pooling cross section and time-series data (panel data). The error term is assumed to follow Gamma distribution.

Then, an estimate of the parameters may be obtained from the OLS residuals. The OLS residual of each mill is obtained as,

\[ e_{it} = \ln y_{it} - \ln \hat{y}_{it} \]
where $e_{it}$ is the difference between the actual and estimated value of $\ln y$ for firm $i$ in year $t$. Then the constant term of the estimated production function is corrected by using the term $m$, where $m$ is the variance of the OLS residuals. The corrected constant term is $\ln A + m$.

Let $e_{it}$ be the OLS residuals for firm $i$ then an estimate of technical efficiency (TE) of firm $i$ in year $t$ is computed as,

$$\exp (e_{it} - m) = e_{it}^{-m}$$

The average efficiency level of each mill is computed using the efficiency indices computed for that mill in different years. In this approach, a few firms have efficiency index more than 100 per cent and they are assumed to be 100 per cent efficient and TE index is taken as one. Then the firms are grouped ownership-wise and size-wise to compute average efficiency level of each group.

Sources of variations in technical efficiency are examined by using a multiple regression framework. The dependent variable is the firm-specific index of technical efficiency. The relationship is assumed log-linear.
Inter-sectoral difference in efficiency are also analysed with the help of dummy variable. The model takes the given form

\[
\log y = \beta_0 + \beta_1 \log L + \beta_2 \log K + r D_1 + \delta D_2 \\
+ \zeta D_3 + \alpha_1 S_2 + u_i
\]

(4)

where,

\[\beta_0', \beta_1', \beta_2, \gamma, \delta, \zeta \text{ and } \alpha_1\] are the parameters to be estimated.

\[
D_1 = 1 \text{ if the mill is a co-operative one} \\
0 \text{ otherwise}
\]

\[
D_2 = 1 \text{ if the mill is a KSTC mill} \\
0 \text{ otherwise}
\]

\[
D_3 = 1 \text{ if the mill is an NTC mill} \\
0 \text{ otherwise}
\]

\[
S_1 = 1 \text{ if spindles } \leq .26,000 \\
0 \text{ otherwise}
\]

5.6 THE MEASUREMENT AND INTERPRETATION OF TECHNICAL EFFICIENCY: REGRESSION RESULTS

The present study has selected total factor productivity as the index of technical efficiency. The estimated parameters of Cobb-Douglas frontier production function give the following best fitted equation.\(^1\)

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1. Equation is estimated after adjusting for serial correlation by the Prais-Winston method.
\[ \log y = -3.2496 + 0.8405 \log L + 0.3542 \log K + 0.0378 \]
\[ (3.26) \quad (2.97) \quad (2.88) \]

\[ R^2 = 0.551 \]
\[ D.W. = 1.98 \]

Figures in parentheses below the regression coefficient denote their t-values. The magnitudes of the coefficients are reasonable. The estimated coefficients are significant at the 5 per cent level. The \( R^2 \) obtained is not so high. In cross-section data it is customary to get low \( R^2 \)'s. This is particularly so while using an abstract production function in an aggregate form. In the present panel data set weightage of cross-section is high. As a first approximation to the problem of technical efficiency, the estimated production function is acceptable.\(^1\)

Elasticities of output with respect to labour capital are found as 0.84 and 0.35 respectively. A linear test for the null hypothesis \( \alpha + \beta = 1 \) was undertaken with the OLS estimates and found the null hypothesis could not be rejected.

\(^{1}\) A more general production function with different types of capital and different types of labour such as:
\[ Q = A, k_1, k_2, \ldots, k_n, L_1, L_2, \ldots, L_m, u \]
would have yielded better \( R^2 \). Hence, low \( R^2 \) can be attributed to the inability to distinguish differential impacts of different types of capital and labour. The results point towards the formulation of new questions and hypotheses which require further research.
The sum of labour and capital coefficients (returns to scale) is not significantly different from one. Hence, it can be concluded that the production technology is characterized by constant returns to scale. The evidence revealed the relevance of estimating Cobb-Douglas production function parameters. However, interpreting the sum of labour and capital coefficients as a measure of returns to scale is not quite accurate (Goldar, 1981). Elasticity of substitution is sensitive to specification, method of estimation, data and time period (Nerlove, 1967).

Another reason for selecting Cobb-Douglas production function is its simplicity, comparability and general credibility. Time trend variable introduced in regression allows for exponential technological change at a constant annual rate of 3.78 per cent per annum. The coefficient of time is statistically significant at the 5 per cent level.

Estimates of indices of technical efficiency by ownership and by firm-size are presented in Table 5.1. The analysis suggests variations in technical efficiency among different sectors. The technical efficiency of private sector is the highest (88%) among ownership categories. The least efficient is the co-operative sector with mean technical
efficiency of 51%. Among size-categories, the medium-sized mills are technically more efficient than small-sized mills.

Table 5.1

Technical Efficiency Indices of Spinning Mills in Kerala by ownership and by firm-size

<table>
<thead>
<tr>
<th>Ownership/size</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private</td>
<td>0.88</td>
<td>0.49</td>
<td>100</td>
</tr>
<tr>
<td>NTC</td>
<td>0.81</td>
<td>0.23</td>
<td>40</td>
</tr>
<tr>
<td>Co-operative</td>
<td>0.51</td>
<td>0.21</td>
<td>30</td>
</tr>
<tr>
<td>KSTC</td>
<td>0.76</td>
<td>0.28</td>
<td>40</td>
</tr>
<tr>
<td>Spindle ≤ 26,000</td>
<td>0.78</td>
<td>0.31</td>
<td>150</td>
</tr>
<tr>
<td>26,000 ≤ 50,000</td>
<td>0.80</td>
<td>0.22</td>
<td>60</td>
</tr>
<tr>
<td>All units</td>
<td>0.79</td>
<td>0.36</td>
<td>210</td>
</tr>
</tbody>
</table>

The estimates are based on the assumption that 'u' follows a gamma distribution. The intercept term is corrected by adding the variance of error terms 'u'. If a different assumption of exponential distribution is followed, the relative position of mills will remain the same even though technical efficiency index varies (Goldar, 1985). The study by
Ramaswamy (1993) also substantiated this argument. Ramaswamy tried four different methods of measuring technical efficiency and found that the relative position of firms remained the same.¹

Estimates of technical efficiency clearly indicate that private sector mills are relatively more efficient when compared to its public sector counterparts. To test statistical significance, pair-wise Z-test was applied between private and its public counterparts and between small-size class and medium-size class. The results are presented in Table 5.2.

**Table 5.2**

Estimates of pair-wise Z-tests of indices of technical efficiency

<table>
<thead>
<tr>
<th>Groups</th>
<th>Computed Z-value</th>
<th>Significant at 5%</th>
<th>Significant at 10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private - NTC</td>
<td>1.14</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Private - Co-op.</td>
<td>5.946</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Private - KSTC</td>
<td>1.548</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Small - Medium</td>
<td>0.52</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

¹. An alternative method of converting the intercept term of OLS estimate by adding to it the largest error term was also tried. This also led to different estimates of technical efficiency. But the relative position of different mills and different categories remained the same. Hence, the results are not reported here.
The results reveal that there is no statistically significant variation of efficiency with firm-size. There is a statistically significant difference between the mean technical efficiency in the private sector and that for the cooperative sector. Among other ownership categories, the difference between mean technical efficiency of private and KSTC is significant at the 10 per cent level.

There is statistically no significant difference between the mean values of private and NTC sectors. The graphical illustration of technical efficiency is charted out in Fig.6 in Appendix B.

The firm specific technical efficiency indices are given in Table 5.3.

The efficiency index is found 100% in the case of Sri Bhagawathi, Asok Textiles, GTN Textiles and Madras Spinners—all private mills. Some other firms of which efficiency index is found above 90% are Kathayee Cotton Mill, Vanaja Textiles, Prabhum, Kottayam Textiles and Cannanore Spinning and Weaving Mills. Among the private mills the efficiency index is lowest in the case of Euro Spinners (68%). Trivandrum
Table 5.3
Technical efficiency index of individual spinning mills in Kerala

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of the mill</th>
<th>Technical efficiency index</th>
<th>Ownership</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sri Bhagavathi Textiles</td>
<td>1.00</td>
<td>P</td>
<td>S</td>
</tr>
<tr>
<td>2</td>
<td>Asoka</td>
<td>1.00</td>
<td>P</td>
<td>S</td>
</tr>
<tr>
<td>3</td>
<td>Kathai Cotton Mills</td>
<td>0.92</td>
<td>P</td>
<td>S</td>
</tr>
<tr>
<td>4</td>
<td>Raj Gopal Textiles</td>
<td>0.58</td>
<td>P</td>
<td>S</td>
</tr>
<tr>
<td>5</td>
<td>Vanaja</td>
<td>0.99</td>
<td>P</td>
<td>S</td>
</tr>
<tr>
<td>6</td>
<td>Trichur Cotton Mills</td>
<td>0.89</td>
<td>P</td>
<td>S</td>
</tr>
<tr>
<td>7</td>
<td>GTN Textiles</td>
<td>1.00</td>
<td>P</td>
<td>M</td>
</tr>
<tr>
<td>8</td>
<td>Madras Spinners</td>
<td>1.00</td>
<td>P</td>
<td>M</td>
</tr>
<tr>
<td>9</td>
<td>Euro Spinners</td>
<td>0.68</td>
<td>P</td>
<td>S</td>
</tr>
<tr>
<td>10</td>
<td>Thruvepathy Mills</td>
<td>0.69</td>
<td>P</td>
<td>S</td>
</tr>
<tr>
<td>11</td>
<td>Quilon Co-op.</td>
<td>0.51</td>
<td>C</td>
<td>S</td>
</tr>
<tr>
<td>12</td>
<td>Malappuram Co-op.</td>
<td>0.49</td>
<td>C</td>
<td>S</td>
</tr>
<tr>
<td>13</td>
<td>Cannanore Co-op.</td>
<td>0.53</td>
<td>C</td>
<td>M</td>
</tr>
<tr>
<td>14</td>
<td>Trivandrum Spinning Mills</td>
<td>0.59</td>
<td>K</td>
<td>S</td>
</tr>
<tr>
<td>15</td>
<td>Prabthuram Mills</td>
<td>0.94</td>
<td>K</td>
<td>S</td>
</tr>
<tr>
<td>16</td>
<td>Kottayam Textiles</td>
<td>0.90</td>
<td>K</td>
<td>S</td>
</tr>
<tr>
<td>17</td>
<td>Malabar Spinning and Weaving Mills</td>
<td>0.62</td>
<td>K</td>
<td>S</td>
</tr>
<tr>
<td>18</td>
<td>Vijaya Mohini Mills</td>
<td>0.79</td>
<td>N</td>
<td>M</td>
</tr>
<tr>
<td>19</td>
<td>Kerala Lakshmi Mills</td>
<td>0.78</td>
<td>N</td>
<td>M</td>
</tr>
<tr>
<td>20</td>
<td>Alagappa</td>
<td>0.68</td>
<td>N</td>
<td>M</td>
</tr>
<tr>
<td>21</td>
<td>Cannanore Spinning and Weaving Mills</td>
<td>0.98</td>
<td>N</td>
<td>S</td>
</tr>
</tbody>
</table>

All units 0.79

Note: (1) The very low observed levels of efficiency of mill numbers 11 and 12 can be attributed to its infant industry problems faced during the first half of the period of study.
(2) P - Private, C - Co-operative, K - KSTC, N - NTC, S - Small, M - Medium.
spinning mills with 59% efficiency is the least efficient KSTC mill. Malappuram Co-operative (49%) and Algappa Textiles (68%) are least efficient among cooperative and NTC sectors respectively. There are two 100% technically efficient mills both in small and medium sector. The firm-level survey and investigations conducted give ample proof that the estimated levels of technical efficiency are plausible even though measurement error and data difficulties necessitate qualification in interpreting empirical results.

5.7 SOURCES OF TECHNICAL EFFICIENCY: EMPIRICAL RESULTS

The data set collected provides substantial information on a number of enterprise characteristics which might be related to the level of technical efficiency. Table 5.4 reports the results of attempts to explain variations in relative technical efficiency in terms of qualitative and quantitative variables.¹

<table>
<thead>
<tr>
<th>Explanatory variables</th>
<th>Regression coefficient</th>
<th>Computed t-value</th>
<th>Significant at 5%</th>
<th>Significant at 10%</th>
<th>Sign of regression Expected</th>
<th>Sign of regression Obtained</th>
</tr>
</thead>
<tbody>
<tr>
<td>X₁</td>
<td>-0.36401</td>
<td>-2.88</td>
<td>YES</td>
<td>YES</td>
<td>-ve</td>
<td>-ve</td>
</tr>
<tr>
<td>X₂</td>
<td>0.630297</td>
<td>3.97</td>
<td>YES</td>
<td>YES</td>
<td>+ve</td>
<td>+ve</td>
</tr>
<tr>
<td>X₃</td>
<td>0.391436</td>
<td>2.71</td>
<td>YES</td>
<td>YES</td>
<td>+ve</td>
<td>+ve</td>
</tr>
<tr>
<td>R²</td>
<td>0.60</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D.W.</td>
<td>1.914</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

X₁: Dummy variable = 1 for firms having no modern well equipped Research and Development (R&D) Department

X₂: Capacity utilization

X₃: Wage rate

1. The equation is linear and was estimated by OLS. The dependent variable is the firm specific index of technical efficiency derived from Cobb-Douglas production function.
The regressions are relatively successful in explaining variations in technical efficiency. To test the importance of Research and Development (R&D) as determinants of technical efficiency, mills in the sample were classified into two groups, those with well equipped R & D facility and those with poor or no R & D facility. A dummy variable, assigned the value of one for those in the latter group was introduced into the regression with the prior expectation that lack of R & D facility would be negatively correlated with the level of technical efficiency. The coefficient obtained is of expected sign and significant at the 5 per cent level.

The level of capacity utilization was included in the analysis to test the influence of spindle utilization. The expectation was that the sign of the regression coefficient would be positive. The result obtained shows that capacity utilization is positively correlated with technical efficiency and statistically significant at the 5 per cent level.

Wage rate was the third explanatory variable used to test its influence on technical efficiency. It had been computed by dividing total wage bill by total number of employees. It is assumed that higher the wage rate more will be the efficiency in the utilization of labour and other factors of production. It is seen from the estimated result
that regression coefficient is positive as expected and statistically significant at the 5 per cent level.

More variables were regressed to measure the sources of technical inefficiency. But the results revealed weak relationship and statistically insignificant.¹

5.8 DUMMY VARIABLE ANALYSIS

Inter-sectoral differences in total factor productivity (TFP) are analysed with the help of dummy variables using Cobb-Douglas Production function. The estimates of parameters are presented in Table 5.5.

Table 5.5
Least squares estimates of the Cobb-Douglas Production Function with dummy variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Regression Coefficient</th>
<th>Computed t-value</th>
<th>Significant at 5%</th>
<th>Significant at 10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-3.218</td>
<td>-4.356</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Log K</td>
<td>0.828</td>
<td>3.037</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Log L</td>
<td>0.382</td>
<td>2.450</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Dummy Co-CP</td>
<td>-0.561</td>
<td>-3.973</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Dummy KSTC</td>
<td>-0.183</td>
<td>-1.855</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Dummy NTC</td>
<td>-0.220</td>
<td>-1.965</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Dummy small</td>
<td>-0.134</td>
<td>-1.230</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.575</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D.W.</td>
<td>1.868</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cases</td>
<td>210</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹. Some such explanatory variables tested were capital intensity and assets per spindle. These variables were subsequently dropped from the equation.
The coefficients of sectoral dummy variables give the level of efficiency vis-a-vis the excluded category, co-operative sector is 56% less efficient than private sector (excluded category): KSTC 18% and NTC 22% less efficient than private sector. The coefficient of small sector is -0.134 which shows that small mills are 13.4% less efficient than medium mills (excluded category).

5.9 CHARACTERISTICS OF FRONTIER FIRMS (BEST PRACTICE FIRMS)

Firm-specific efficiency index of four firms is 1 obtained by the ratio of its observed output to the maximum producible output. These firms are termed as frontier firms or best practice firms. Table 5.6 provides some descriptive.

Table 5.6

Characteristics of Best Practice Firms: Pooled Cross-Section and Time-Series Data: 1982-83 to 1991-92

<table>
<thead>
<tr>
<th>Type of firm</th>
<th>LP₁</th>
<th>LP₂</th>
<th>KP</th>
<th>KL</th>
<th>GPM</th>
<th>CU(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best practice firms</td>
<td>0.301</td>
<td>2.910</td>
<td>0.304</td>
<td>1.38</td>
<td>15.02</td>
<td>87.74</td>
</tr>
<tr>
<td>Private</td>
<td>0.271</td>
<td>2.691</td>
<td>0.291</td>
<td>0.98</td>
<td>8.86</td>
<td>77.06</td>
</tr>
<tr>
<td>NTC</td>
<td>0.204</td>
<td>1.756</td>
<td>0.359</td>
<td>0.61</td>
<td>6.21</td>
<td>80.78</td>
</tr>
<tr>
<td>Co-operative</td>
<td>0.127</td>
<td>1.981</td>
<td>0.194</td>
<td>0.80</td>
<td>5.09</td>
<td>56.78</td>
</tr>
<tr>
<td>KSTC</td>
<td>0.169</td>
<td>1.517</td>
<td>0.331</td>
<td>0.55</td>
<td>0.13</td>
<td>64.76</td>
</tr>
<tr>
<td>Spindle ≤ 26,000</td>
<td>0.206</td>
<td>2.191</td>
<td>0.290</td>
<td>0.80</td>
<td>5.06</td>
<td>69.46</td>
</tr>
<tr>
<td>26,000 ≤ 50,000</td>
<td>0.247</td>
<td>2.181</td>
<td>0.318</td>
<td>0.81</td>
<td>8.91</td>
<td>80.16</td>
</tr>
</tbody>
</table>
The firm-characteristics reveal that the best practice firms are ahead of all other groups in terms of all efficiency indices presented except in capital productivity. The capital productivity though not very low, we would however realize that it is not sufficient when compared to gross profit margin earned by these groups. This may be the result of high capital intensity or due to errors in measurement of capital.

In five of the high profit mills selected for study, four firms were having technical efficiency equal to one. Another feature noticed is that the least efficient category (co-operative) is having very low capacity utilization percentage. Another noticeable feature is that even though KSTC is more efficient than NTC mills (Dummy variable analysis) the gross profit margin is relatively very low in KSTC group of mills. This can be considered as evidence of substantial X-inefficiency. A well equipped research and development department is found as another characteristic of all best practice firms. In many of the mills in Kerala, traditional method of quality testing is another most unsatisfactory feature. These firms are having comparatively low technical efficiency (eg. Raj-Gopal and Thiruvepathy mills).
High technical inefficiency has important implications for policy framework. Increased output gains can be realised through increase in technical efficiency for firms operating below 'best practice' spinning mills. As suggested by the results if public sector units tend to be less efficient, direct government measures should be undertaken to improve its technical efficiency. Since the estimates indicate substantially lower inter-firm variation in majority of the cases measures to shift the frontier itself through modernization and technological upgradation is highly warranted.

5.10 PRODUCTIVITY DEPRESSING FACTORS

The overall effects of technical change in spinning mills cannot be estimated since data over time were not available. Firm level interview conducted helped to elicit important factors retarding production as a result of slow technical change.

Majority of the spinning mills in Kerala have adopted an intermediate technology—a mix of semi-modern with modern technology, while a very few mills have started shifting from modern technology to best practice technology of international
Technology of international standard is by and large absent in Kerala.¹

Three important operating characteristics which shift production function downward were empirically analysed by Pack (1987). He described the functional relation in the form of an equation:

\[ Q = \frac{R}{T} e \]

The output per spindle hour of a given count of yarn, \( Q \), depends on the speed, \( R \), at which spindle rotates per minute, the number of twists, \( T \), inserted per inch, and the hourly rate of spindle utilization, `e′, i.e., machine or spindle efficiency.

Information gathered from firms reveals the position of spinning mills in Kerala. The important productivity depressing factors are detailed below.

Speed

The speed at which spindle rotates is lower in almost all mills surveyed. For each mill, the speed in revolutions

¹ For a detailed discussion of traditional and modern technology see Pickett and Robson (1981). Details of emerging trends in spinning machinery of international standard are explained by Doraiswamy and Chellamani (1992).
per minute for different counts of yarn is compared with the desirable speed fixed by SITRA. The rpm of 40s count is as low as 10,000 in certain mills while SITRA standard is 14,400 (SITRA standard in Appendix C-2).

The speed is found lower mainly because of inadequate maintenance, greater yarn breakage and objection from workers. Improper plant lay-out, lack of good humidification plant, technological obsolescence, poor raw material quality are the main reasons of increased breakage.

The lower speed can be mainly attributed to technical and managerial inefficiency (x - inefficiency). No mill surveyed is found reducing speed to economize electricity. Mills are not resorting to scientific study regarding the relationship between speed, breakage rate, output and electricity consumption given the vintage and design of firm level plants. They are found simply relying SITRA standard evolved on the basis of vintage and design of best-practice plants.

**Twist Per Inch (TPI)**

Higher than normal twists are found inserted in most of the plants simply to compensate poor quality in cotton. The increase in twist per inch is also due to deficient
blending and back process. In some mills, the tpi of 40s carded count is as high as 28.76 while SITRA specification is only 26.56. This increases cost of production, reduces output and adversely affects the profitability position.

Some plants are found increasing tpi due to stiff objection from workers as a result of increased breakage. The customers in the local market are not specifying tpi, while customers in the international market specify required tpi of each count. This creates problem to catch international market for plants deviating from best-practice standards.

A major defect of SITRA standards is that it is solely based on production per spindle shift and not on value added or economic efficiency. The loss in quantity due to reduction in spindle speed and maintaining tpi as per customer requirements can be well compensated by high quality and increased value addition.

Spindle Efficiency

Machine or spindle efficiency indicates the percentage of each hour during which spindle works without interruption. Frequent interruptions are found in most of the mills due to a variety of reasons. Hence, idle spindle is observed in many units mainly due to following reasons.
1. Spindle tape
2. Ring defect
3. Top roll short
4. Apron cut
5. Roving bobbin runout
6. Separators

In addition to this, spindle utilization may be affected by time taken to repair broken end, for doffing, replacing bobbins and other usual factory interruptions, and labour inefficiency. Idle spindle percentage is fixed as 0.1% by SITRA. But it goes upto 5% or even more in very poor performing firms.

Frequent alteration of machine setting due to change in counts spun is common in public sector mills. This significantly affects productivity. The remedy is to limit production to certain specified counts which can be spun economically. Increased product diversity will result only in increased cost.

Among many other reasons, one of the main reasons for low spindle speed, high twist per inch and low spindle efficiency is due to deviation from best-practice technology.