CHAPTER 4

Chapter 4

TRENDS AND STRUCTURE OF COSTS OF THE INDIAN AIRLINES

4.1 INTRODUCTION

The economic analysis of the behaviour of costs of a business is important, for it has a significant bearing on various policy issues. The behaviour of costs of a business can be empirically studied through cost function. The cost function describes the relationship between costs and factors affecting it.

Traditionally, the relationship between total cost and the output is established by assuming constant technology and competitive input markets (given input prices). These assumptions make the minimum cost of producing a commodity a function of the level of output only. However, with the advancement in techniques, it has become possible now to show the minimum total cost as not only a function of output but also a function of various factor prices and the technology. From such total cost function, one can derive various economic features of a business such as the extent of scale economies, substitution possibilities between different factors of production, elasticity of demand for these factors and the productivity growth over time

In the present chapter, therefore, an attempt is made to estimate a total cost function, along with the measures of economies of scale, elasticities of substitution between different factors, elasticities of demand for these factors and the productivity growth over time for the Indian Airlines. However, before these estimations, a theoretical background is provided in the following section. On the basis of this theoretical background, the estimation procedures with reference to present analysis are discussed. An attempt is then made to provide trends in some important variables related to cost of the Indian Airlines. Finally, the empirical findings of the analysis and their implications are discussed.

4.2 THEORETICAL BACKGROUND

In the present chapter, the duality relation between the neoclassical cost function and production function is utilised in specifying the Indian Airlines cost function. "This duality theory implies that if firms are input price takers, and if they minimise the cost of production, then the cost function (satisfying usual regularity conditions) contains sufficient information to characterise the production technology completely".[1] Therefore, in this study the cost function of the Indian Airlines is estimated to examine the structure of production technology of the same.

It would be pertinent to emphasise here that the cost function assumes level of output and input prices as exogenous variables, and input quantities and production costs as endogenous variables. In this context it is to be noted that in the Indian Airlines (in most of other regulated transport industries also), the government according to demand and other considerations decides the output level at a predetermined rate structure, rendering output as an exogenous variable. Also the

Indian Airlines is a price taker in the factor market, rendering factor prices also as exogenous variables. In such a situation, therefore, the Indian Airlines can aim at minimisation of the production cost by selecting the optimum combinations and the levels of factor inputs, and thus, these are the endogenous variables.

As the present analysis has made use of the duality relation between the production function and cost function, it would be useful to discuss technically how the cost function is dual to the production function. However, before the discussion of duality, it will be helpful to study the definitions and properties of the production function and cost function.[2]

4.2.1 Definition and Properties of Production Function

A production function, which describes a pure technical relationship between input and output, can be expressed as:

$$Y = f(x)$$

Where, Y = Output and x = Vector of inputs.

A production function possesses the following properties:

i) Monotonicity

The 'monotonicity' property of the production function implies that the marginal unit of any input can never lead to a decrease in the level of output. Mathematically,

$$\text{If, } x' \geq x, \text{ then } f(x') \geq f(x)$$

In other words, the marginal product of any input $\{\partial f(x) / \partial x_i\}$ must always be positive. In other words, this property assumes a rational behavior on the part of the producers.

ii) Convexity

The 'convexity' property of the production function implies the application of the law of diminishing marginal rate of technical substitution. Mathematically speaking, it assumes input requirement set (all input combinations capable of producing output level Y), $V(y) = \{x : f(x) \geq y\}$ to be convex. When input requirement set V(y) is convex, production function f(x) is quasi-concave. When f(x) is twice-continuously differentiable, diagonal elements of Hessian matrix $\{\partial^2 f(x) / \partial x^2_i\}$ are negative. In other words, it means that by keeping other factors constant, each additional application of input will produce less and less of additional output.

iii) Essentiality

The 'essentiality' property of the production function states that the inputs are essential for the production process. This implies that there cannot be a strictly positive output without the utilization of economically scarce resources.

iv) Input Requirement set V(y) is Non-Empty and Closed for Y > 0

The property of non-emptiness of V(y) implies that it is always possible to produce a positive level of output, whereas the 'closedness' property of the production function implies that there is no hole in the boundary of V(y). The hole in V(y) implies discontinuous changes from being able to produce Y to not being able to produce Y.

v) Another property of a production function is that it is finite, nonnegative, real valued and single valued for all nonnegative and finite X. Further; the f(x) is everywhere twice continuously differentiable.

4.2.2 Definition and Properties of Cost Function

"The cost function is the minimum cost of producing a given output level during a given time period expressed as a function of input prices (p_i) and output (Y)".[3] Mathematically, it can be defined as:

$$c(p,y) = \min \{p.x : x \in V(y)\} \text{ for } x \geq 0$$

Where, p = vector of positive input prices, $p.x = \sum_i p_i x_i$

In the above cost function it is assumed that the input prices are exogenous to the producer.

A production function satisfying all the properties mentioned earlier will have a cost function satisfying the following properties:

i) **Non-Negativity**

The 'essentiality' property of a production function and the assumption of 'positive input prices' make it impossible to produce a positive output at less than positive cost i.e., positive output can be produced only with positive cost. Mathematically,

$$c(p,y) \geq 0 \text{ for all } p \geq 0, \ \& \ Y \geq 0$$

ii) **Non-Decreasing in Input Prices 'P'**

With the increase in any input price, cost must also increase. Mathematically,

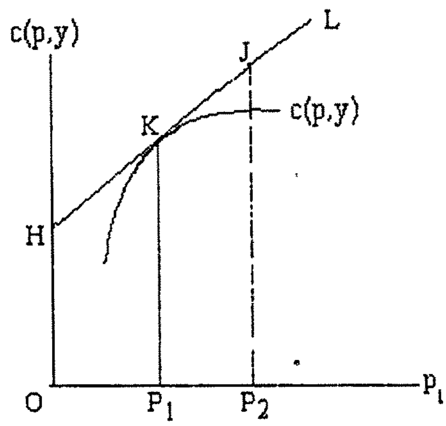
$$\text{If, } p' \geq p, \text{ then } c(p'\ y) \geq c(p\ y) \qquad \partial C / \partial p_i \geq o$$

iii) **Concave and Continuous**

A well-behaved cost function will be concave and continuous. Concavity can be understood from the following example:

Figure 4.1 depicts a relationship between cost and a single input price. Cost has been measured on Y-axis, while the input price has been measured on x-axis. The line HL shows the responsiveness of cost to the change in input price P, holding input vectors constant at x'.

Figure 4.1 : Concavity of c(p,y)



To begin with there is an optimal point k, with given p_1 & x'. With the increase in price from p_1 to p_2, total cost is increased from KP_1 to JP_2. The optimal response of the producer to the increase in price can never result in a cost higher than that associated with J, and thus, cost function c(p y) can never lie above the line segment HL. At worst cost function could be linear, ruling out the possibility of input substitution. Assuming that the substitution is possible, any increase in input price will substitute cheaper input for x' (cutting down the use of x). Therefore the rise in cost will be less than that associated with J. This justifies the cost function of being concave.

To avoid the jump in the cost function, a function must be continuous.

iv) Positive Linear Homogeneity

This property means that only relative price of input matters to optimal factor demand. If all input prices vary by a particular proportion, it will not change the optimal cost minimizing input choice, only cost will increase by the same proportion. Mathematically,

$$c(k\,p\,y) = k\,c(p\,y), \qquad k > 0$$

v) Non-Decreasing in Output

The 'Non-Decreasing in Output' property of the cost function implies that increasing output cannot decrease the cost.

$$\text{If, } Y \geq Y' \quad \text{then, } c(p\,y) \geq c(p\,y')$$

vi) Shephard's Lemma

This property states that if a cost function is continuous then there exists a unique vector of cost minimizing demands, which is equal to the gradient of c (p y), in P. Mathematically,

$$\partial\, c(p\,y) \,/\, \partial\, p_i = x_i(p\,y)$$

For the condition of Shephard's Lemma to apply, it is necessary that the input requirement set V(y) is convex.

Figure 4.2 : Cost Minimisation with V(y) strictly convex

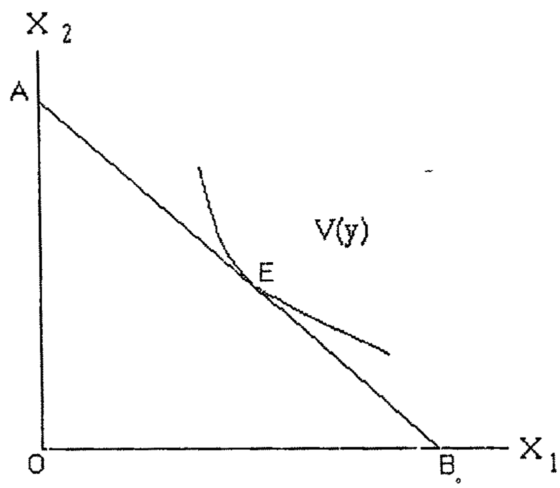
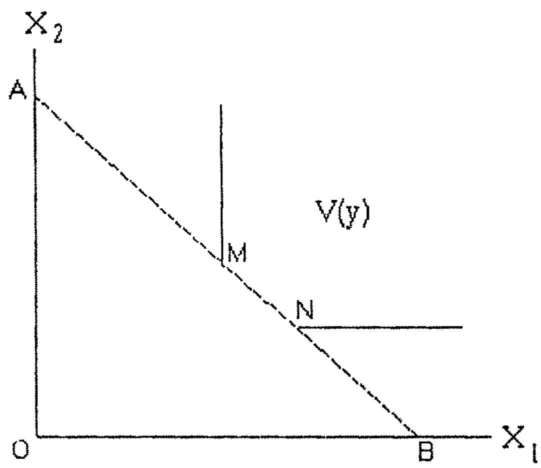


Figure 4.3 : Violation of Shephard's Lemma



When V(y) is convex, as can be seen in Figure 4.2, with two input X_1 and X_2, a unique cost minimizing bundle will appear at point E, where the cost minimizing condition (marginal rate of technical substitution is equal to the negative of the ratio of input prices) is well satisfied. If, however, V(y) is not strictly convex, as shown in the Figure 4.3, there are infinite number of input combinations between the points MN where the cost minimizing condition is satisfied, and hence no unique combination of inputs.

4.2.3 Duality between Production Function and Cost Function

The duality is an attempt to use the cost function to describe the technology, as the specification of a well-behaved cost function is equivalent to the estimation of a well-behaved production function. In production function, technological restrictions are manifested in the economic behaviour of optimising agents, whereas in the cost function economic phenomenon are used to reconstruct and study the properties of the technology.[4]

Shephard (1953) was the first to systematically describe the technology from the cost function. Uzawa (1962) using Shephard's results, showed how the cost function could be used to reconstruct the input requirement set from which it was generated.

Minkowski's theorem is useful in deriving the technology from the cost function (duality). According to this theorem 'every closed convex set in R' can be characterized by the intersection of its supporting half spaces. A half space H (m k) is defined as:

$$H(m, k) = \{x : m \cdot x \leq k\},$$

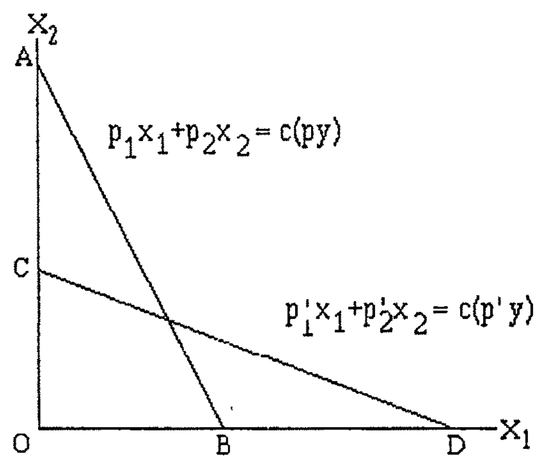
Where, $m \in R^n$ & $k \in R$

A cost function with a particular Y, p and c (p y), can define a half space by:

$$N(p\ y) = \{x : P\ x \leq c(p\ y)\},$$

Since c(p y) is the minimum cost of producing Y, no $x \in n(p\ y)$ can represent a strictly cheaper way of producing Y than c(p y).

Figure 4.4 : Minkowski's theorem: Duality between Production and Costs



In Figure 4.4, the line AB represents $c(p_1, p_2, y) = p_1x_1 + p_2x_2$. The cost-minimizing bundle associated with p_1, p_2 and y cannot lie below the line AB. Thus, the half space above the hyperplane must contain V(y). However, at least one point on AB must be able to produce y, where V(y) and AB share a point in common.

Now, considering the other half space, defined by:

$$N(p'\ y) = \{x : p' . x \leq c(p'\ y)\}, \quad p \neq p'$$

The line CD represents $c(p' y) = c(p'_1, p'_2, y) = p'_1x_1 + p'_2x_2$

By the similar logic, it can be argued that the cost-minimizing bundle cannot exist below the line CD. If it does, it will imply that there is a cheaper way of producing y than $c(p'_1, p'_2, y)$, which means that $c(p' y)$ is not cost minimizing. Thus, the area above the line CD must contain V(y), CD sharing at least one point in common with V(y). At the same time V(y) must lie above both the line CD and AB. To exactly locate where this V(y) exists, this procedure has to be followed for all the possible input price vectors. Ultimately, the lower boundary of the intersection of these half spaces will start taking a shape similar to the neoclassical isoquant, which is V(y).

4.2.4 Specification of the Cost Function

A flexible translog has been selected for estimating the neoclassical cost function. The main advantage of the translog cost function is that "it places no a *priori* restrictions on substitution possibilities among the factors of production. Equally important, it allows scale economies to vary with the level of output".[5]

"The non-homothetic translog cost function can be envisaged as a second order Taylor's series approximation in logarithms to an arbitrary cost function".[6] The following is the general form of a non-homothetic translog cost function with input prices and output as independent variables:

$$\ln (TC) = \beta_0 + \beta_y \ln y + \Sigma_i \beta_i \ln p_i + \frac{1}{2} \beta_{yy} (\ln y)^2 + \frac{1}{2} \Sigma_i \Sigma_j \beta_i \beta_j \ln p_i \ln p_j + \Sigma_i \beta_{iy} \ln p_i \ln y$$

Where, $\beta_i\beta_j = \beta_j\beta_i$, TC = Total Cost, β_0 = Constant Term, y = output, P_i = Vector of Input Prices.

It is argued that the efficiency of the parameters' estimate of the above cost function can be improved if it is estimated with cost share equations.[7] The cost share equation can be arrived at by differentiating logarithmically the above cost function with respect to input prices. The following is the general form of the estimated share equation:

$$S_i = \beta_i + \Sigma_{i=1} \beta_{ij} \ln p_j + \beta_{iy} \ln y$$

Where, $S_i = P_i X_i / TC$ = share equation of the i_{th} input.

However, there are problems associated with the estimation of the above share equations As the shares always sum to unity, the disturbances across the equations are always zero. This implies that the disturbance covariance matrix is singular and non-diagonal. Further, the ordinary least square (OLS) method to solve these equations step by step results into non-diagonal and singular residual cross product matrix To overcome the problem of singularity a common procedure is to drop arbitrarily one of these share equations and estimate the remaining share equations by the Maximum Likelihood (ML) technique, with the restrictions imposed to make the cost function homogeneous of degree one in input prices.[8] The following restrictions make a cost function homogeneous of degree one:

$$\Sigma\beta_i=1,\ \Sigma\beta_{ki}=0,\ \Sigma\beta_{li}=0,\ \Sigma\beta_{mi}=0,\ \Sigma\beta_{ei}=0.$$

4.2.5 Structure of the Cost Function

As was mentioned earlier, the main advantage of the translog cost function is that it does not impose restrictions either on the structure of cost function or on the elasticities of substitution. One can go on imposing several alternative restrictions on the well-behaved non-homothetic translog cost model and test the validity of these restrictions statistically with the help of Likelihood Ratio Test (LRT).[9] For a cost function to be homothetic, it is necessary that $\beta_{iyn} = 0\ \forall\ i=1\ldots n$. A cost function would become homogeneous of a constant degree in output if in addition to the condition $\beta_{iy} = 0\ \forall\ i = 1\ldots n$., it also satisfies the condition that $\beta yy = 0$ Imposing one more restriction $\beta_y = 1$ yields a constant returns to scale cost function. A Cobb-Douglas cost function would emerge if, in addition to the above restrictions, all the second order coefficients are dropped from the model. Likelihood Ratio Test is used to test the validity of different restrictions imposed on the parameters in a model. Denoting the determinants of the unrestricted and restricted estimates of the disturbance covariance matrix by $|\Omega_u|$ and $|\Omega_R|$ respectively, the Likelihood Ratio (λ) can be written as:[10]

$$\lambda = (|\Omega_R| / |\Omega_U|)^{-T/2}$$

Where, T = number of observations.

4.2.6 Economies of Scale

A measure of economies of scale can be derived from the cost function. The extent of economies of scale can be measured from a relative change in total cost as a result of a small proportional change in the level of output i.e., from the elasticity of cost with respect to output. Following Christensen and Greene[11] the economies of scale has been defined as unity minus the elasticity of cost with respect to output Symbolically,

$$SCE = 1 - (\partial \ln TC / \partial \ln Y)$$

Where, SCE = Economies of Scale, TC= Total cost and Y= output.

If SCE is positive, it implies economies of scale whereas a negative value of the same implies diseconomies of scale in the production. A zero value of SCE indicates that there is neither economies nor diseconomies of scale in the production process.

The sign and the value of scale economies enable one to determine the optimum size of the plant. When there are economies of scale, there lies scope for further expansion of the plant, and the existence of more than one firm is not justified so long as these entire economies are not reaped by the existing firm. If there are diseconomies of scale in the production, it suggests contraction in the size of the given plant, and the existence of more than one firm would be better from the welfare point of view. When there is neither economies nor diseconomies of scale, then, the decision with regard to one or more than one firm would depend upon the shape of the average cost curve. If the situation of neither economies nor diseconomies persists at all levels of output then, the other qualitative factors like quality of the service, quality of management decision, etc., of the existing firm in relation to its potential competitors, may be taken into account for deciding the existence of one or more than one firm.

The positive values of the elasticity of cost with respect to output and marginal cost at each observation ensures the satisfaction of the assumptions about non-decreasing cost in output and the rationality of the producer.[12]

4.2.7 Elasticities of Substitution

From the analysis of the cost function one can also derive the information about the nature of technology employed by estimating the elasticities of substitution from the cost function directly. In this context it may be recalled that the translog cost function does not impose restrictions on the elasticities of substitution.

In the two input case the original definition of elasticity of substitution (σ) is given as:

$$\sigma = \% \text{ Change in Factor Ratio} / \% \text{ Change in MRTS}$$

Where, MRTS = Marginal Rate of Technical Substitution

Symbolically,

$$\sigma = d \ln (x_2 / x_1) / d \ln (f_1 / f_2)$$

Since in equilibrium position marginal rate of technical substitution (MRTS) is equal to the ratio of factor prices, MRTS in the above formula can be replaced by the factor prices, and thus it becomes:

$$\sigma = \text{\% Change in Factor Ratio / \% Change in the Ratio of Factor Prices}$$

Symbolically,

$$\sigma = d \ln (X_2 / X_1) / d \ln (W_1 / W_2)$$

Thus, the elasticity of substitution is the "elasticity of an input ratio with respect to an output ratio".[13] In other words, it is the responsiveness of the relative input use to the change in relative input prices. As the Allen elasticity of substitution[14] has been estimated in most of the cost function studies, the same is estimated in this study also. Uzawa (1962) derived Allen partial elasticity of substitution, between the inputs 'i' and 'j' for a general dual cost function C, having n inputs as:[15]

$$\sigma_{ij} = CC_{ij} / C_i C_j$$

Where, $C_i = \delta C / \delta P_i$, $C_{ij} = \delta^2 C / \delta P_i P_j$ and $\sigma_{ij} = \sigma_{ji}$

If the value of elasticity of substitution σij is positive, it suggests that the two inputs 'i' and 'j' are substitutes. Conversely a negative value of the same would imply complementarily between inputs 'i' and 'j'.

4.2.8 Price Elasticities of Demand

Price elasticities of demand ($\in_{ij}$) for factors of production is defined as:

$$\in_{ij} = \delta \ln x_i / \delta \ln P_j$$

Assuming other factors such as output and prices of other inputs constant, price elasticity of demand is related to the Allen elasticity of substitution in the following way:[16]

$$\in_{ij} = S_j \sigma_{ij}$$

For a cost function to be well behaved it should be concave in input prices and input demand function should be strictly positive. While the concavity of a cost function requires Hessian matrix to be negative semi-definite, positivity condition is satisfied if all the fitted cost shares are positive at each observation.

4.2.9 Time Trend Variable

In order to assess the effect of technical change over time, a time trend variable 't' can also been incorporated in the translog total cost function. With this incorporation, the cost function would become:

$$C = c(p, y, t)$$

Where, p = vector of input prices, y = output, and t = time trend variable.

Technical change (ρ_t) reflected by the shift in cost function can be estimated by:

$$\rho_t = \delta \ln TC / \delta t$$

While a negative estimated value of technical change ρ_t implies a technical progress, positive value of the same indicates an obsolescence technology. If, however, ρ_t is zero, it would imply that no technical change has taken place.

With the above theoretical background, in the following section the sets of methodology adopted for various estimates with reference to the present analysis are discussed.

4.3 METHODOLOGY

On the basis of the theoretical background, in the present section an attempt is made to specify the methodology adopted for the estimations of cost function, structure of cost function, economies of scale, elasticities of substitution, price elasticities of demand and technical progress in context to the present analysis.

4.3.1 Specification of the Cost Function

The following form of translog total cost function and the share equations are estimated:

$$\ln (TC/p_m) = \beta_0 + \beta_y \ln y + \Sigma_i \beta_i \ln (p_i / p_m) + \beta_t t + \tfrac{1}{2} \beta_{yy} (\ln y)^2 + \tfrac{1}{2} \Sigma_i \Sigma_j \beta_i\beta_j [\ln(p_i / p_m) . \ln(pj / p_m)] + \tfrac{1}{2} \beta_{tt} t^2 + \Sigma_i \beta_{iy} \ln (p_i / p_m).\ln y + \Sigma_i \beta_{it} \ln(pi / p_m).t + \beta_{yt} \ln y.t$$

$$S_i = \beta_i + \beta_{ii} \ln (P_i / P_m) + \Sigma_j\beta_{ij} \ln (p_j / p_m) + \beta_{iy} \ln y + \beta_{it} t$$

Where, $\beta_i \beta_j = \beta_j \beta_i$, TC = Total Cost, β_0 = Constant Term, y = available ton kilometre for model I and revenue ton kilometre for model II, P_i = Vector of Input Prices (P_l = price of labour, P_k = price of capital, P_e = price of energy and P_m = price of materials), t = time trend variable (t = 1,2...30) and S_i = Share Equation of i_{th} input (i = labour, capital, energy and materials).

The above cost function and the factor share equations are simultaneously estimated by applying the Maximums Likelihood (ML) technique. To overcome the problem of singularity the materials' share equation was arbitrarily dropped from the model. Further, while estimating the full system, restrictions were imposed to make the cost function homogenous of degree one in input prices.

Two alternative translog cost function models have been estimated; model I with the available ton kilometre (producer related measure of output) and model II with the revenue to kilometre (user related measure of output) as measures of output. The rationale of estimating two models is that the interpretation of the two results will have different implications. In each translog cost models, the input prices are normalized. Further, a trend variable T has also been added to incorporate a measure of technical change in both the models.

4.3.2 Structure of the Cost Function

Denoting the determinants of the unrestricted and restricted estimates of the disturbance covariance matrix by $|\Omega_u|$ and $|\Omega_R|$ respectively, the Likelihood Ratio has been calculated with the help of the following formula:

$$\lambda = (|\Omega_R| / |\Omega_u|)^{-T/2}$$

Where, T = number of observations.

Likelihood Ratio Test has been used to test the validity of different restrictions imposed on the parametres in both the alternative models. Assuming $-2 \ln \lambda$ is distributed asymptotically as chi-squared, hypotheses are tested with the degrees of freedom equal to the number of independent restrictions being imposed.

4.3.3 Economies of Scale

From the specified cost function, the economies of scale (η_c) has been calculated as:

$$\eta_c = 1 - [\beta_y + \beta_{yy} \ln y + \beta_{ky} \ln (P_k / P_m) + \beta_{ly} \ln (P_l / P_m) + \beta_{ey} \ln (P_e / P_m) + \beta_{yt} T]$$

4.3.4 Elasticities of Substitution

From the translog cost function the Allen partial elasticity of substitution has been computed as:

$$\sigma_{ij} = (\gamma_{ij} + S_i S_j) / S_i S_j \qquad i, j = 1......n, \qquad \text{but, } i \neq j$$

$$\sigma_{ii} = (\gamma_{ii} + S_i^2 - S_i) / S_i^2 \qquad i = 1......n$$

4.3.5 Price Elasticities of Demand

In terms of translog, the own price elasticities of demand has been calculated as:

$$\in_{ii} = (\gamma_{ii} + S_i^2 - S_i) / S_i \qquad i = 1,......n$$

For a cost function to be well behaved it should be concave in input prices and input demand function should be strictly positive. While the concavity of a cost function requires Hessian matrix to be negative semi-definite, positivity condition is satisfied if all the fitted cost shares are positive at each observation.

4.3.6 Time Trend Variable

In order to assess the effect of technical change over time, a time trend variable 't' has also been incorporated in the models. In terms of the translog cost function estimated in present study, shift in the cost function brought about by the technical change (ρ_t) can be estimated by:

$$\rho_t = \beta_t + \beta_{tt}\, t + \beta_{tk} \ln (P_k / P_m) + \beta_{tl} \ln (P_l / P_m) + \beta_{te} \ln (P_e / P_m) + \beta_{ty} \ln y$$

4.4 VARIABLES USED FOR REGRESSION ANALYSIS : RATIONALE AND PROCEDURE

The rationale and the procedure for including variables in the model are discussed below.

4.4.1 Dependent Variables

The following are the dependent variables used for the regressions:

i) Total Cost

The total cost was arrived at by aggregating the expenses incurred on four factors: labour (L), capital (K), fuel (E) and materials (M). Symbolically,

$$TC = P_l \cdot Q_l + P_k \cdot Q_k + P_e \cdot Q_e + P_m \cdot Q_m$$

Where, TC = total cost, P_l, P_k, P_e and P_m = prices of labour, capital, energy and materials respectively, Q_l, Q_k, Q_e and Q_m = quantities of labour, capital, energy and materials respectively.

ii) Factor Shares

The shares of the four factors in total cost have been calculated as:

$$S_i = P_i \cdot Q_i \;/\; TC$$

Where, S_i = share of 'i'$_{th}$ input in total cost, Pi = price of 'i'$_{th}$ input, Qi = quantity of 'i'$_{th}$ input, and TC = Total cost.

4.4.2 Independent Variables

The following independent variables have been used in the present analysis:

I) Output

The two alternative measures of output; available ton kilometre (ATK) and revenue ton kilometre (RTK) have been used to estimate model I and model II respectively. When available ton kilometre is used as a measure of output, it gives an estimation of total cost (TC) with respect to service provided, as it is a producer related measure of output. This measure of output enables one to find out if provision of an extra ton kilometer is subject to increasing, constant or decreasing economies of scale. That is, it provides a measure of scale economy with respect to service provision. The main advantage of using available ton kilometre rather than revenue ton kilometre, as measure of output is that former is more closely related with costs and input prices.

There are some industries, which are characterized by lower output utilization than what is produced. Chief among such industries is airline sector where the actual utilization falls short of the output produced. In such cases, even if there are scale economies with respect to service provision, increase of scale may not be suggested if there are scale diseconomies with respect to revenue output. This being so, from economics point of view it will be useful, if one estimates a cost function with revenue output in actual utilization terms also. This will help in estimating a relationship between cost and the revenue output rather than total output produced.

The various attributes of output also have their effects on total cost. In present context, main attributes of output may include the load factor and the average distance flown per flight. It can be noted that larger load factor may affect the total cost positively. On the other hand, larger is the distance flown per flight smaller would be the addition to the total cost. These two attributes of output, however, could not be incorporated in the models. This is because the inclusion of load factor in the models led to the problem of multicollenearity, whereas the data on average distance per flight was not available.

II) Prices of Inputs

Inputs in present study are: labour (L), Capital (K), Energy (E), and Materials (M). The method of arriving at the individual price each input is discussed below.

i) Price of Labour

The price of labour (P_L) was arrived at by dividing the total expenses on account of labour / employees (TE_L) by the total number of labour / employees (L). Symbolically,

$$P_L = TE_L / L$$

The total expense on labour has been calculated by aggregating the expenses incurred on different types of labour in a year. Total number of employees at the end of the year is being taken as the quantity of labour employed.

ii) Price of Capital

The price of capital (P_k) was arrived at by dividing the opportunity cost of capital (C_K) by the stock of capital (K) in a given year. Symbolically,

$$P_k = C_K / K$$

An attempt has been made to arrive at the price of capital, which is related to the opportunity cost of the same. Following Jorgenson and Griliches[17] the price of a rupee worth of capital services is defined as $r_t + d_t$, where r_t is the rate of interest on log term government bonds and d_t is the rate of depreciation in that industry. Therefore, the total cost of capital service for a year was arrived at by adding the return on capital (capital here stands for the net depreciated block of planes at the end of the year) to the depreciation of capital during that year. The return on capital has been calculated by applying the long term lending rate of the Industrial Development Bank of India (IDBI) for respective years. Thus, the opportunity cost of capital service for a given year was arrived at with the help of the following formula:

$$C_k = D + R_C$$

Where, C_k = Opportunity Cost of Capital, D= Depreciation, R_C = Return on Capital.

Capital stock in terms of the size of fleet was not reasoned to be appropriate, as different sizes of planes cannot be added. Further, over the years new models of planes have been introduced and the old discarded during different years and thereby, rendering the measurement of the size of capital in terms of fleet incomparable. For example, if two 50 seated aircraft move out of the fleet and one 278 seated aircraft is added to the fleet, then it will indicate a reduction in the stock of capital, which is not the case. In view of this problem, stock of capital has been measured in terms of Available seat at the end of the year, assuming a positive relationship between the available seat and the capital expenses. Thus, the Pk, in the present analysis, stands for the price of an aircraft seat for a year.

iii) Price of Materials

Since the wide varieties of materials are utilised, it will be difficult to arrive at a single price for the materials use. Therefore, to overcome this problem the wholesale price deflator is used as a proxy for the price of material inputs.[18]

iv) Price of Energy

Energy in present study refers to the consumption of fuel and oil. Price of energy is measured in rupees per kilolitre.

III) Time Trend Variable

In this study, t =1, 2, ...30, is used for thirty years time period, from 1964-65 - 1993-94.

4.5 TRENDS IN DATA USED FOR PRESENT ANALYSIS

4.5.1 Trend in Total Cost

Table 4 1 shows an ever-increasing trend of total cost over the period studied. Between the years 1964-65 and 1993-94, the total expenses incurred by the Indian Airlines increased by a whopping 9905 per cent. It can be noted that the increase in expenses was somewhat gradual until 1988-89. However, after 1988-89, the total expenses have been increasing at a faster speed, mainly due to the inductions of expensive A-320 aircraft in the fleet. The index of total expense (with base year 1964-65) was only 4011 in the year 1988-89, which became 10005 in the year 1993-94.

4.5.2 Trend in Factor Shares

The trends in shares of the four factors are shown in Table 4.1 and Table 4.2. The share of labour expenses in total expenses shows a declining trend. The share of labour was 34 per cent in the year 1964-65, which declined to 12 per cent by the year 1993-94; a decline of 65 per cent over the period. This declining share of labour can be mainly attributed to the increasing share of materials and capital in the total expenses.

The share of capital in the total expenses was about 19 per cent in the year 1964-65, which kept hovering around 20 per cent for most of the years, before finally increasing to 29 per cent by the year 1993-94. Over the study period, thus, share of capital in total expenses shows an increase of 55 per cent.

The share of energy in the total expenses has been fluctuating widely. The share of energy in total expenses, which was 27.09 per cent in the year 1964-65, increased to 41 per cent in the year 1974-75 but it declined to 27.88 per cent in the year 1978-79. By the year 1986-87 the share again increased and finally, it again came down to 27.80 per cent in 1993-94. Thus, the share of energy in total expense has increased just by 3 per cent over the study period. The increasing share of fuel in total expenses can be mainly attributed to the increasing price of air turbine fuel whereas the decline in the share of the same can be mainly attributed to the inductions of better fuel-efficient aircraft.

The share of materials in total expenses between the years 1964-65 and 1993-94 has increased by 57 per cent. It was 20 per cent in the year 1964-65, which went up to 31 per cent by the year 1993-94. Increasing share of material, among other things, can be attributed to larger maintenance expenses and better quality of services now being provided by the Indian Airlines.

Table 4.1 : Total Expenses and Shares of Labour and Capital in Total Expenses of Indian Airlines

Year	TE (Rs. in ml)	Index	Sl (%)	Index	Sk (%)	Index
1964-65	217.69	100.00	34.29	100.00	18.66	100.00
1965-66	242.35	111.32	36.70	107.05	18.31	98.13
1966-67	310.30	142.54	37.38	109.02	16.23	86.98
1967-68	351.61	161.52	36.17	105.49	20.21	108.31
1968-69	385.08	176.89	36.04	105.12	16.87	90.37
1969-70	445.05	204.44	36.21	105.59	16.21	86.85
1970-71	499.18	229.30	34.99	102.05	21.39	114.58
1971-72	581.15	266.96	36.79	107.31	20.68	110.80
1972-73	700.22	321.66	34.16	99.61	22.13	118.58
1973-74	677.96	311.43	32.92	96.01	19.79	106.05
1974-75	960.47	441.21	24.12	70.35	17.24	92.36
1975-76	1025.60	471.12	26.28	76.63	16.04	85.94
1976-77	1167.71	536.40	23.64	68.95	21.38	114.53
1977-78	1396.70	641.59	20.65	60.21	21.73	116.40
1978-79	1718.28	789.31	21.50	62.71	22.25	119.22
1979-80	2074.39	952.90	20.05	58.46	19.52	104.59
1980-81	3015.77	1385.33	15.46	45.10	21.64	115.94
1981-82	3613.29	1659.81	15.52	45.26	19.80	106.08
1982-83	4305.13	1977.62	15.30	44.61	22.04	118.09
1983-84	4865.41	2234.99	15.29	44.59	20.31	108.84
1984-85	5380.17	2471.45	14.34	41.81	17.81	95.45
1985-86	6427.42	2952.52	13.99	40.81	14.94	80.06
1986-87	7425.16	3410.85	13.83	40.32	14.05	75.30
1987-88	8239.59	3784.97	14.37	41.90	12.16	65.13
1988-89	8729.66	4010.09	16.07	46.87	11.18	59.87
1989-90	11057.38	5079.36	13.74	40.06	24.49	131.19
1990-91	12335.54	5666.50	14.73	42.97	26.02	139.42
1991-92	16218.06	7449.99	13.12	38.25	27.38	146.69
1992-93	18134.44	8330.30	13.25	38.64	29.40	157.54
1993-94	21780.00	10004.93	12.09	35.27	28.87	154.67

Source Derived from various Annual Reports of the Indian Airlines, New Delhi.

Notes: a) TE = Total Expenses, b) Sl = share of labour, c) Sk = share of capital.

Table 4.2 : Shares of Energy and Materials in Total Expenses of Indian Airlines

Year	Se (%)	Index	Sm (%)	Index
1964-65	27.09	100.00	19.96	100.00
1965-66	26.32	97.17	18.66	93.48
1966-67	25.08	92.61	21.30	106.71
1967-68	25.14	92.81	18.48	92.56
1968-69	26.44	97.62	20.65	103.44
1969-70	26.69	98.54	20.89	104.66
1970-71	22.50	83.08	21.12	105.80
1971-72	22.90	84.53	19.63	98.34
1972-73	22.73	83.91	20.99	105.14
1973-74	26.07	96.26	21.21	106.27
1974-75	40.96	151.22	17.68	88.57
1975-76	38.21	141.06	19.48	97.58
1976-77	32.50	120.00	22.48	112.61
1977-78	29.64	109.43	27.99	140.20
1978-79	27.88	102.95	28.36	142.08
1979-80	32.14	118.66	28.29	141.74
1980-81	38.58	142.45	24.31	121.80
1981-82	42.20	155.81	22.48	112.62
1982-83	41.01	151.40	21.66	108.48
1983-84	39.97	147.55	24.43	122.39
1984-85	40.49	149.48	27.36	137.07
1985-86	42.80	158.01	28.27	141.61
1986-87	43.90	162.09	28.22	141.35
1987-88	43.33	159.96	30.15	151.03
1988-89	39.29	145.05	33.47	167.65
1989-90	31.33	115.69	30.44	152.51
1990-91	31.79	117.37	27.46	137.54
1991-92	33.04	122.00	26.46	132.55
1992-93	30.03	110.86	27.32	136.86
1993-94	27.80	102.63	31.24	156.50

Source Derived from various Annual Reports of the Indian Airlines, New Delhi.

Notes a) Se = share of energy, b) Sm = share of materials.

4.5.3 Trends in Output

The trends in output in terms of available ton kilometre (ATK) and revenue ton kilometre (RTK) are discussed in chapter 2 with reference to Table 2.4.

4.5.4 Trends in Inputs Prices

The trends in the prices of the four inputs: labour, capital, energy and materials are discussed below.

i) Trends in Price of Labour

The trend in the price of labour (Pl) is depicted in Table 4.3. Over the study period the price of labour exhibited an increase of 1653 per cent. The increase in price of labour has been more or less gradual till the year 1989-90. From the year 1990-91 onward, however, increase in price of labour has become more pronounced as a result of the rising competition with the private airlines for limited skilled labour.

ii) Trends in Price of Capital

Amongst all the prices of factors, Price of capital (Pk) has increased the largest by 3550 per cent between 1964-65 and 1993-94. In Table 4.3 it can also be seen that the price of capital started increasing sharply with the induction of A-320 aircraft. The price index of capital (with 1964-65 =100), which had increased only to 774 by the year 1988-89, became 3650 by the year 1993-94.

iii) Trends in Price of Energy

As can be seen in Table 4.4 that for most of the years the price of energy (Pe) has shown a stepwise pattern of increase. The total increase in price of energy over the study period is of 2364 per cent. During the year 1973-74 to 1974-75 there are sudden increases in the price of energy. Other sharp increases are noticeable in the year 1979-80 and 1980-81. From the year 1989-90 the price of energy has shown a constant increase.

iv) Trends in Price of Materials

As the wholesale price index of all commodities is taken the proxy for price of materials (Pm), it does not show wide fluctuations, as can be observed in Table 4.4. There have been a gradual increases in this variable over the period studied. Over the study period the price of materials increased by about 933 per cent.

Using the methodology discussed earlier and incorporating the data in various equations, the findings are discussed below.

Table 4.3 : Prices of Labour and Capital of Indian Airlines

(Rs. in thousand)

Year	Pl	Index	Pk	Index
1964-65	6.76	100.00	17.98	100.00
1965-66	7.50	110.90	19.27	107.20
1966-67	9.39	138.91	20.33	113.08
1967-68	9.92	146.73	24.87	138.33
1968-69	10.53	155.77	22.25	123.77
1969-70	11.89	175.91	23.61	131.31
1970-71	12.34	182.55	29.38	163.40
1971-72	14.37	212.48	35.43	197.08
1972-73	15.29	226.13	48.46	269.54
1973-74	14.15	209.27	44.19	245.77
1974-75	15.19	224.64	51.17	284.61
1975-76	18.05	266.89	51.07	284.07
1976-77	18.49	273.49	63.89	355.37
1977-78	19.08	282.11	73.10	406.62
1978-79	23.04	340.67	84.54	470.21
1979-80	24.64	364.40	90.20	501.74
1980-81	26.02	384.76	117.67	654.51
1981-82	30.22	446.95	125.28	696.87
1982-83	34.32	507.61	140.36	780.74
1983-84	38.52	569.60	147.17	818.61
1984-85	39.23	580.14	142.71	793.80
1985-86	44.54	658.66	143.00	795.44
1986-87	48.83	722.10	150.52	837.25
1987-88	57.03	843.40	146.33	813.96
1988-89	66.61	985.06	139.19	774.20
1989-90	69.88	1033.44	311.67	1733.59
1990-91	82.31	1217.22	344.59	1916.73
1991-92	96.21	1422.81	490.27	2727.06
1992-93	106.93	1581.41	567.69	3157.67
1993-94	118.55	1753.20	656.15	3649.75

Source. Derived from various Annual Reports of the Indian Airlines, New Delhi.

Note a) Pl = yearly price of a labour, b) Pk = yearly price of a seat.

Table 4.4 : Prices of Energy and Materials of Indian Airlines

(in Rs.)

Year	Pe per Kilolitre	Index	Pm per unit	Index
1964-65	477.04	100.00	26.23	100.00
1965-66	501.00	105.02	28.25	107.70
1966-67	515.37	108.03	32.18	122.68
1967-68	562.87	117.99	35.91	136.90
1968-69	588.82	123.43	35.48	135.26
1969-70	630.74	132.22	36.84	140.45
1970-71	686.22	143.85	38.87	148.19
1971-72	831.93	174.39	41.04	156.46
1972-73	860.68	180.42	45.20	172.32
1973-74	1193.61	250.21	54.29	206.98
1974-75	1979.23	414.90	67.98	259.17
1975-76	2034.72	426.53	67.24	256.35
1976-77	2038.71	427.37	68.64	261.69
1977-78	2043.50	428.37	72.21	275.30
1978-79	2124.54	445.36	72.25	275.45
1979-80	2962.46	621.01	84.57	322.42
1980-81	3992.00	836.83	100.00	381.24
1981-82	4046.29	848.21	109.33	416.81
1982-83	4072.24	853.65	112.20	427.75
1983-84	4072.24	853.65	122.81	468.20
1984-85	4125.33	864.78	131.52	501.41
1985-86	4727.73	991.06	139.06	530.16
1986-87	4726.93	990.89	146.44	558.29
1987-88	4740.90	993.82	157.56	600.69
1988-89	4742.10	994.07	168.79	643.50
1989-90	5704.97	1195.91	181.16	690.66
1990-91	7837.49	1642.94	199.74	761.49
1991-92	9993.97	2095.00	227.18	866.11
1992-93	11271.81	2362.86	250.03	953.22
1993-94	11754.84	2464.12	270.91	1032.83

Source Derived from various Annual Reports of the Indian Airlines, New Delhi.

Notes. a) Pe = Price of energy, b) Pm = wholesale price index of all commodities.

4.5.5 Trends in Inputs Use

i) Trends in Labour Use

During the period under consideration the labour use (Ql) has not increased much as can be seen in Table 4.5. It increased by only 101 per cent between 1964-65 and 1993-94. Relatively slower growth of labour has resulted in a declining share of labour expenses in the total expenses. From the year 1990-91 onward the labour use has almost remained constant. In the year 1990-91 labour use was 22082, which increased to 22470 in the year 1992-93 before finally falling to 22220 in the year 1993-94.

ii) Trends in Capital Use

Table 4.5 also depicts the trend in the use of capital (Qk) over the present study period. Unlike the labour use the capital use shows a larger increase 324 per cent over the study period. The various inductions of capacity oriented planes have resulted jumps in capital use in the respective years. The jump in capital use in the year 1967-68 can be attributed to the induction of aircraft HS-748, in 1970-71 to the induction of aircraft B-737, in 1976-77 to the induction of aircraft A-300 and finally in 1988-89 to the induction of the aircraft A-320. It can be noted that the capital use during 1982-83 to 1988-89 does not show much change because of lack of induction of new planes in this period. In later years, however, with the exception of the year 1991-92, capital use has increased due to induction of more planes in the fleet from time to time. In the year 1991-92, the capital use fell due to the total withdrawal of HS-748 from the fleet.

iii) Trends in Energy Use

The trend in energy use (Qe) over the study period is shown in Table 4.6. Over the study period energy use registered an increase of 317 per cent. It can be noted that up to the year 1979-80, the energy use has been fluctuating within a small range. These fluctuations in the energy use can be attributed to many factors. It is directly related to the production of output on the one hand and the kind of technology of newer planes on the other hand. In between the years 1980-81 and 1987-88 the energy use is continuously increasing. However, from the year 1988-89 onward the total fuel consumption has been falling sharply due to the declining trend in output coupled with the use of better fuel-efficient aircraft.

iv) Trends in Materials Use

To get materials input in physical units expenses on materials are deflated by the Wholesale Price Index. Out of all factors the material use (Qm) has increased the largest by 1416 per cent over the study period. It can be noticed from Table 4.6 that up to the year 1975-76 the material use has been fluctuating within a smail range. With the induction of A-300 aircraft in the year 1976-77, materials consumption started increasing faster. Similarly in the year 1989-90, the material use increased when A-320 aircraft were brought into the operation. But when the entire fleet of A-320 aircraft was withdrawn in the year 1990-91, use of materials fell sharply. It can also be noted that the materials use during the last few years has been increasing in spite of declining trend of output. Thus, the increasing share of materials consumption can be mainly attributed to the use of better technology and the quality of the services provided.

Table 4.5 : Labour and Capital Employed in Indian Airlines

Year	Ql	Index	QK	Index
1964-65	11039	100.00	2260	100.00
1965-66	11862	107.46	2303	101.90
1966-67	12349	111.87	2478	109.65
1967-68	12819	116.12	2858	126.46
1968-69	13178	119.38	2919	129.16
1969-70	13547	122.72	3056	135.22
1970-71	14151	128.19	3634	160.80
1971-72	14883	134.82	3392	150.09
1972-73	15641	141.69	3198	141.50
1973-74	15772	142.88	3037	134.38
1974-75	15253	138.17	3236	143.19
1975-76	14933	135.27	3221	142.52
1976-77	14928	135.23	3907	172.88
1977-78	15117	136.94	4151	183.67
1978-79	16039	145.29	4523	200.13
1979-80	16877	152.89	4489	198.63
1980-81	17925	162.38	5546	245.40
1981-82	18554	168.08	5710	252.65
1982-83	19186	173.80	6760	299.12
1983-84	19312	174.94	6716	297.17
1984-85	19662	178.11	6716	297.17
1985-86	20192	182.92	6716	297.17
1986-87	21026	190.47	6933	306.77
1987-88	20758	188.04	6845	302.88
1988-89	21062	190.80	7009	310.13
1989-90	21737	196.91	8687	384.38
1990-91	22082	200.04	9315	412.17
1991-92	22112	200.31	9057	400.75
1992-93	22470	203.55	9393	415.62
1993-94	22220	201.29	9582	423.98

Source Compiled and Derived from various Annual Reports of the Indian Airlines, New Delhi.

Note. a) Ql = total employees in a year, b) Qk = Total Available Seats in a year.

Table 4.6 : Energy and Materials Employed in Indian Airlines

Year	Qe (Kilolitre in 000)	Index	QM (Unit in 000)	Index
1964-65	123.60	100.00	1656.72	100.00
1965-66	127.32	103.00	1600.84	96.63
1966-67	151.02	122.18	2054.01	123.98
1967-68	157.03	127.05	1809.09	109.20
1968-69	172.91	139.89	2241.15	135.28
1969-70	188.33	152.37	2523.88	152.34
1970-71	163.69	132.43	2712.26	163.71
1971-72	159.94	129.40	2779.75	167.79
1972-73	184.89	149.59	3251.33	196.25
1973-74	148.09	119.81	2649.21	159.91
1974-75	198.76	160.81	2498.03	150.78
1975-76	192.57	155.80	2971.15	179.34
1976-77	186.17	150.62	3824.28	230.84
1977-78	202.59	163.90	5413.42	326.76
1978-79	225.51	182.45	6745.38	407.15
1979-80	225.04	182.07	6940.32	418.92
1980-81	291.47	235.82	7332.70	442.60
1981-82	376.86	304.90	7429.85	448.47
1982-83	433.54	350.75	8309.19	501.55
1983-84	477.50	386.32	9679.37	584.25
1984-85	528.04	427.21	11192.91	675.61
1985-86	581.84	470.74	13065.93	788.66
1986-87	689.62	557.94	14307.33	863.60
1987-88	753.01	609.23	15766.59	951.68
1988-89	723.25	585.15	17308.33	1044.74
1989-90	607.32	491.36	18581.50	1121.59
1990-91	500.33	404.80	16956.32	1023.49
1991-92	536.22	433.83	18889.71	1140.19
1992-93	483.08	390.84	19814.48	1196.01
1993-94	515.05	416.70	25116.59	1516.05

Source Derived from various Annual Reports of the Indian Airlines, New Delhi.

Notes a) Qe = total fuel consumption in a year, b) Qm = total materials consumption in a year

4.6 THE EMPIRICAL FINDINGS

The findings of cost analysis are discussed below under different headings.

4.6.1 Coefficients of the Translog Cost Function

Table 4.1 shows the estimated coefficients of the translog cost function. For simplicity they are explained under the following two heads:

i) First Order Coefficients

- Coefficients of output and time are not significant in both the two models.
- Among the coefficients of factor prices, the coefficients associated with the price of labour are the largest, in both the models.

ii) Second Order Coefficients

- The coefficients associated with the interaction of trend variable 't' with other variables are mostly not significant, in the two models.
- The coefficients associated with the interaction of output with capital, output and time were also not found to be significant statistically.

Table 4.7 : Parameters' Estimate : Translog Cost Function

Coefficients	Y=ATK (Model I)	Y= RTK (Model II)
βo	3.8728*	14.77
βk (Capital)	0.20396	0.21268
βl (Labour)	1.0478	1.1323
βe (Energy)	-0.026557	-0.030009
βm(Materials)	-0.225203	-0.314971
βy (Output)	2 2819*	-2.2573*
βt (Time)	-0 12349*	0.17125*
βkk	-0.20357	0.19412
βkl	-0.13216	-0.13758
βke	-0.01072	-0.0090264
βkt	0.001734*	-0.0023411*
βll	0.15921	0.12872
βle	-0.0096882	-0.0093085
βee	0.0091383	0.0071288
βkm	-0.06069	-0.04751
βlm	-0.01736	0.018169
βem	0.01127	0.011206
βmm	0.066782	0.018139
βlt	-0.0060648	-0.0037275*
βky	-0.011475*	-0.014563*
βly	-0.053663	-0.076272
βey	0.0064617	0.007719
βyy	-0.46218*	.4946*
βet	-0.00015239*	-0.000056967*
βyt	0.036367*	-0.030323*
βmt	0.00417841	0.00132943
βmy	0.058676	0.083116
βtt	-0.0035035*	0.0024672*

Note *Indicates not significant at the 5 per cent level of significance.

4.6.2 The Structure of the Cost Function of the Indian Airlines

The result of Likelihood Ratio Test (LRT) is depicted in Table 4.8. The validity of different restrictions on a well-behaved cost function has been tested using likelihood ratio test at the 10 per cent significance level for both the alternative measures of output. It did not matter much, however, which of the measures of output was used for the structure of the cost function. LRT statistics did not turn out to be much different for both the models. In the light of the result homothetic and homogeneous structure of the cost function have been rejected. The constant returns to scale (CRTS) hypothesis, however, was not rejected strongly, which is apparent from the results. The Cobb-Douglas model was, however, strongly rejected. Thus, the Likelihood Ratio Test statistics at 10 per cent significance level made it possible to prefer a non-homothetic translog form to some other restrictive versions of the translog cost function.

Table 4.8 : Estimates of the Likelihood Ratio Test (LRT) statistics with Restrictions on the model.

Cost Function	Degrees of Freedom	LRT Statistics (Y=ATK)	LRT Statistics (Y=RTK)	χ^2 at 0.100 level
Homothetic	4	22.335	36.563	7.779
Homogeneous	5	25.825	36.496	9.236
CRTS	6	12.478	10.928	10.6446
Cobb-Douglas	16	252.410	250.860	23.542

4.6.3 Scale Economies in the Indian Airlines

From the result of economies of scale with respect to service provision - available ton kilometre - one finds that there is a slight scale economies in the Indian Airlines. It should be noted that from the year 1990-91 onwards, output elasticity of cost has become greater than one because of falling trend of output from this year. The output of the Indian Airlines shows a declining trend from this year due to the entrance of private operators in the market.

The output elasticity of cost from the year 1990-91 has become greater than one also because of the fact that the declining trend of output has not been accompanied by reductions in the costs of the Indian Airlines. Even at smaller levels of output, there could have been economies of scale, had the costs been reduced with the reductions in the level of output. In view of the results, therefore, it is suggested that the Indian Airlines should exercise some control over costs, which can help it to enjoy the economies of scale again.

With revenue ton kilometre (RTK) as a measure of output, Table 4.9 shows slight diseconomies of scale in the Indian Airlines. In other words the proportionate increase in cost has been greater than the proportionate increase in revenue output with larger revenue ton kilometre output. During the last few years the degree of diseconomies of scale has been declining as a result of contraction of revenue output resulted by entry of private airlines. It can further be observed that the degree of diseconomies of scale is more pronounced during the year 1975-76 to

1987-88 This can be attributed to increasing short-haul services in this period. Short haul services are not economical for the following two main reasons:

i) Short haul services are technically uneconomical as most of the planes meet their break-even only after an adequate length of service, depending upon the type of planes.

ii) Most of the short-haul services tend to have poor load factor. This is because on such routes usually the travel-time difference between the air and the other modes of transport is not much. A study by the Planning Commission[19] noted that load factor on some of these short-haul services was not even 50 per cent. It observed that during 1984-85 only one of such routes (Srinagar - Leh) up to 300 kilometres was making profit; and this increased to only three with stage length increasing up to 500 kilometres. It was only after the stage length of 500 kilometers that the number of routes making profit increased substantially.

Consistent efforts by the Indian Airlines in terms of increasing the long-haul services (including the addition to foreign flights), gradual cut of some loss making short-haul routes and overall reduction in revenue ton kilometre output have helped the Indian Airlines in reducing the degree of diseconomies of scale in the last few years of the present study period. However, there is still a room for converting diseconomies of scale into economies of scale by reducing short-haul loss making routes further and introducing cost control measures on costs resulting from increasing the revenue output.

Table 4.9 : Cost Elasticities with Respect to Output and Economies of Scale

Year	δlnC/δlnY	δlnC/δlnY	1-δlnC/δlnY	1-δlnC/δlnY
	(Y=ATK)	(Y=RTK)	(Y=ATK)	(Y=RTK)
1964-65	0.982	1.035	0.018	-0.035
1965-66	1.022	0.996	-0.022	0.004
1966-67	1.025	1.006	-0.025	-0.006
1967-68	0.961	1.044	0.039	-0.044
1968-69	0.989	1.073	0.011	-0.073
1969-70	0.988	1.094	0.012	-0.094
1970-71	1.058	1.028	-0.058	-0.028
1971-72	0.982	1.040	0.018	-0.040
1972-73	0.916	1.102	0.084	-0.102
1973-74	1.057	1.019	-0.057	-0.019
1974-75	1.040	1.077	-0.040	-0.077
1975-76	1.007	1.113	-0.007	-0.113
1976-77	0.990	1.135	0.010	-0.135
1977-78	0.936	1.191	0.064	-0.191
1978-79	0.895	1.246	0.105	-0.246
1979-80	0.915	1.232	0.085	-0.232
1980-81	0.901	1.237	0.099	-0.237
1981-82	0.880	1.275	0.120	-0.275
1982-83	0.859	1.286	0.141	-0.286
1983-84	0.873	1.320	0.127	-0.320
1984-85	0.871	1.358	0.129	-0.358
1985-86	0.869	1.366	0.131	-0.366
1986-87	0.867	1 371	0.133	-0.371
1987-88	0.885	1.376	0.115	-0.376
1988-89	0.934	1.328	0.066	-0.328
1989-90	0.950	1.267	0.050	-0.267
1990-91	1 079	1.128	-0.079	-0.128
1991-92	1.034	1.136	-0.034	-0.136
1992-93	1.133	1.045	-0.133	-0.045
1993-94	1.173	0.973	-0.173	0.027

Notes: a) C = total cost, b) Y = output, c) ATK = available ton kilometre, d) RTK = revenue ton kilometre.

4.6.4 Elasticities of Substitution

With the use of available ton kilometer as a measure of output, the 'positivity' condition was not satisfied. The fitted share of capital turned out to be negative for most of the observations. In view of the violation of the 'positivity' condition, the elasticities of substitution with this measure of output have not been estimated.

Revenue ton kilometer as a measure of output, however, has satisfied the 'positivity' condition in all cases for each observation. The condition of 'concavity' was checked at the average value of the study period, which also turned out to be satisfactory with revenue ton kilometre as a measure of output.

Referring to Table 4.10 and Table 4.11, depicting the estimates of the elasticities of substitution, the following observations can be made:

i) The result suggests complementarity between capital and labour. There is not much significant change in the degree of relationship over the years. This complementarity can be understood from the fact that the Indian Airlines employees are Government employees who have job security and thus cannot be sacked even when they are not required. In this context it can be noted that as compared to the Jet Airway, which employed only 210 employees per aircraft, the Indian Airlines employed 404 employees per aircraft in May 1998.[20]

ii) The estimates also reveal a complementarity between capital and energy, though this complementarity is weak. This essentially suggests that the overall employment of aircraft of the Indian Airlines has not been fuel-efficient. This does not mean, however, that the new aircraft are not fuel-efficient; but this only implies that the old aircraft still in operation are fuel-inefficient. In this context, it can be noted that the average age of the aircraft in the Indian Airlines was 11 years against only 3.5 years of the Jet Airways in May 1998.[21]

iii) As expected, labour and energy turned out to be complementary for all the observations.

iv) Yet another complementarity that emerged from the result was between capital and materials. The complementarity between capital and materials is not difficult to be explained. As mentioned earlier, some of the aircrafts of the Indian Airlines are overaged and thus, they require more and more maintenance. This again suggests a need to replace the old aircraft with the new ones.

It can be noted from the result that from the year 1989-90, the degree of complementarity between capital and materials is showing a declining trend as a consequent of some strong maintenance drives initiated by the Indian

Airlines; and also due to the inductions of some new aircraft from time to time.

v) There emerged a relatively good degree of substitutability between energy and materials, which has been gradually increasing over the years. It suggests that a strong maintenance drive would be furthermore fuel-efficient and thus be cost saving to a great extent.

vi) A further substitute relationship can be noticed between materials and labour. Obviously, an increase of materials does increase the labour productivity and hence the need for smaller number of labours.

Table 4.10 : Estimates of Elasticities of Substitution between the Factors Employed in Indian Airlines

Year	Skk	Sll	See	Smm	Skl
1964-65	0.072	-0.048	0.0010	-0.053	-0.153
1965-66	0.077	-0.047	0.0015	-0.053	-0.190
1966-67	0.101	-0.040	0.0018	-0.065	-0.419
1967-68	0.084	-0.058	0.0013	-0.070	-0.258
1968-69	0.111	-0.053	-0.0002	-0.084	-0.561
1969-70	0.120	-0.056	-0.0003	-0.093	-0.726
1970-71	0.094	-0.067	0.0014	-0.084	-0.357
1971-72	0.088	-0.076	0.0017	-0.089	-0.308
1972-73	0.058	-0.095	0.0025	-0.093	-0.122
1973-74	0.071	-0.091	-0.0022	-0.092	-0.193
1974-75	0.072	-0.100	-0.0072	-0.105	-0.206
1975-76	0.093	-0.098	-0.0069	-0.117	-0.361
1976-77	0.067	-0.108	-0.0057	-0.117	-0.189
1977-78	0.057	-0.114	-0.0059	-0.124	-0.149
1978-79	0.059	-0.116	-0.0046	-0.133	-0.162
1979-80	0.066	-0.117	-0.0075	-0.137	-0.195
1980-81	0.046	-0.121	-0.0089	-0.138	-0.122
1981-82	0.057	-0.121	-0.0090	-0.146	-0.164
1982-83	0.057	-0.121	-0.0079	-0.150	-0.167
1983-84	0.067	-0.121	-0.0082	-0.157	-0.211
1984-85	0.079	-0.121	-0.0099	-0.164	-0.267
1985-86	0.097	-0.121	-0.0108	-0.171	-0.387
1986-87	0.104	-0.121	-0.0106	-0.175	-0.442
1987-88	0.132	-0.121	-0.0108	-0.181	-0.817
1988-89	0.166	-0.119	-0.0106	-0.184	-2.268
1989-90	0.052	-0.118	-0.0049	-0.168	-0.158
1990-91	0.058	-0.120	-0.0045	-0.164	-0.180
1991-92	0.036	-0.115	-0.0037	-0.163	-0.117
1992-93	0.032	-0.115	-0.0025	-0.158	-0.107
1993-94	0.027	-0.114	-0.0008	-0.154	-0.096

Notes a) The Revenue Ton Kilometre (RTK) is used as a measure of output (Y) in the estimation, b) Skk, Sll, See and Smm are the own elasticities of substitution, c) Skl = elasticity of substitution between capital and labour.

Table 4.11 : Estimates of Elasticities of Substitution between the Factors Employed in Indian Airlines

Year	Ske	Skm	Sem	Slm	Sle
1964-65	-0.0004	-0.020	0.145	0.008	-0.000036
1965-66	-0.0003	-0.021	0.160	0.008	-0.000036
1966-67	-0.0004	-0.033	0.198	0.010	-0.000035
1967-68	-0.0004	-0.027	0.196	0.012	-0.000038
1968-69	-0.0007	-0.046	0.189	0.016	-0.000036
1969-70	-0.0008	-0.059	0.208	0.019	-0.000036
1970-71	-0.0004	-0.035	0.237	0.016	-0.000040
1971-72	-0.0004	-0.033	0.269	0.018	-0.000041
1972-73	-0.0002	-0.021	0.322	0.020	-0.000044
1973-74	-0.0005	-0.026	0.166	0.019	-0.000042
1974-75	-0.0007	-0.027	0.131	0.025	0.000003
1975-76	-0.0009	-0.041	0.153	0.030	0.000000
1976-77	-0.0006	-0.025	0.165	0.031	-0.000028
1977-78	-0.0006	-0.020	0.174	0.035	-0.000036
1978-79	-0.0005	-0.020	0.209	0.040	-0.000053
1979-80	-0.0007	-0.023	0.182	0.043	-0.000024
1980-81	-0.0005	-0.013	0.170	0.044	-0.000022
1981-82	-0.0006	-0.017	0.184	0.050	-0.000021
1982-83	-0.0006	-0.016	0.203	0.053	-0.000043
1983-84	-0.0007	-0.021	0.214	0.059	-0.000040
1984-85	-0.0009	-0.028	0.213	0.066	-0.000017
1985-86	-0.0012	-0.047	0.219	0.073	0.000004
1986-87	-0.0013	-0.056	0.229	0.077	-0.000002
1987-88	-0.0022	-0.122	0.243	0.085	0.000011
1988-89	-0.0052	-0.375	0.255	0.089	0.000020
1989-90	-0.0005	-0.007	0.289	0.071	-0.000107
1990-91	-0.0005	-0.013	0.284	0.066	-0.000100
1991-92	-0.0004	-0.001	0.301	0.067	-0.000123
1992-93	-0.0003	-0.001	0.317	0.062	-0.000122
1993-94	-0.0003	-0.001	0.359	0.058	-0.000115

Notes a) The Revenue Ton Kilometre (RTK) is used as a measure of output (Y) in the estimation. b) Ske = elasticity of substitution between capital and energy, c) Skm = elasticity of substitution between capital and materials, d) Sem = elasticity of substitution between energy and materials, e) Slm = elasticity of substitution between labour and materials, and f) Sle = elasticity of substitution between labour and energy.

4.6.5 Price Elasticities of Demand for Factors in Indian Airlines

In view of the violation of 'positivity' condition with available ton kilometre as a measure of output, like the substitution elasticities, the own price elasticities of demand for factors are also estimated with revenue ton kilometre output only. Table 4.12 shows the estimates of the own price elasticities of demand for the four factors, viz., labour, capital, energy and materials. There is a relatively low price elasticity of demand for labour. This is not unexpected due to the reasons like existence of trade unions, contractual agreements with the employees etc. In spite of excess employment in the Indian Airlines, there has been no worthwhile and sustained effort to reduce its staff strength. In fact it is argued that the "Indian Airlines would be better off with just half that number of personnel".[22] In short, there lies a tremendous scope of trimming down the staff capacity and thus improving the productivity of labour.

Considering the price elasticity of demand for energy, it can be noticed that demand for this factor is also inelastic. This is again not unexpected due to the government's responsibility of providing the target service, which is not much sensitive to the changes in price of any factor.

The own price elasticity of demand for Capital turned out to be positive, which is inconsistent with the economic reasoning. This is often found in the Indian public enterprises, which have relatively less competition. Such firms do not respond quickly to the changing prices of capital, for one or the other reason, which clearly speaks of inefficiency in the management. This inefficiency fails them to select the cost-minimizing bundle of inputs through substitution of factors.

The price elasticity of demand for materials input is relatively less inelastic. As materials input comprise of many items, demand for such input is less insensitive to the change in its own price.

4.6.6 The Nature of Technical change

As the coefficients associated with the trend variable 'T' are mostly not significant statistically, the analysis of the nature of technical change has not been undertaken.

The foregoing discussions have provided various policy implications relating to economies of scale, elasticities of cost with respect to output, elasticities of substitution between different factors and price elasticities of demand for these factors It was noted that there is scale economies in the production of services, but scale diseconomies in the utilisation of the same. Therefore, it suggests that there is a scope of converting scale diseconomies into scale economies by reducing the short haul services. The analysis of elasticity of substitution indicated a need for reduction of number of employees and also a need to replace old aircrafts with the new fuel efficient ones. It also indicated that increase in material expenses would be fuel as well as labour saving. Relatively less price elasticities of demand for labour, fuel and materials indicate a scope of being more sensitive to the changes in prices of these factors. Positive price elasticity of capital indicates inefficiency in employment of capital.

Having analysed the various aspects of revenue and cost of the Indian Airlines, in previous and present chapters respectively, an attempt is made in the next chapter to discuss the over all performance of the Indian Airlines in financial and physical terms. Attempt will also be made to identify some main determinants of profitability and estimate a quantitative relationship between profitability and these determinants, which would help in focusing light on various implications.

Table 4.12 : Estimates of the own Price Elasticities of Demand for Factors Employed in Indian Airlines

Year	ε_{kk}	ε_{ll}	ε_{ee}	ε_{mm}
1964-65	0.509	-0.062	0.161	-0.687
1965-66	0.572	-0.061	0.274	-0.688
1966-67	0.966	-0.051	0.329	-0.710
1967-68	0.671	-0.077	0.222	-0.716
1968-69	1.205	-0.070	-0.028	-0.728
1969-70	1.501	-0.074	-0.038	-0.730
1970-71	0.834	-0.092	0.234	-0.728
1971-72	0.736	-0.106	0.324	-0.729
1972-73	0.357	-0.143	0.533	-0.730
1973-74	0.497	-0.136	-0.232	-0.730
1974-75	0.505	-0.154	-0.497	-0.730
1975-76	0.816	-0.150	-0.484	-0.726
1976-77	0.450	-0.177	-0.439	-0.726
1977-78	0.347	-0.195	-0.448	-0.723
1978-79	0.367	-0.204	-0.385	-0.717
1979-80	0.436	-0.207	-0.505	-0.713
1980-81	0.251	-0.228	-0.546	-0.713
1981-82	0.345	-0.229	-0.549	-0.705
1982-83	0.348	-0.235	-0.516	-0.701
1983-84	0.453	-0.236	-0.527	-0.694
1984-85	0.592	-0.238	-0.571	-0.684
1985-86	0.896	-0.235	-0.592	-0.675
1986-87	1.041	-0.237	-0.588	-0.670
1987-88	1.999	-0.229	-0.592	-0.660
1988-89	1.617	-0.216	-0.586	-0.654
1989-90	0.299	-0.266	-0.404	-0.679
1990-91	0.361	-0.261	-0.384	-0.685
1991-92	0.183	-0.274	-0.337	-0.686
1992-93	0.154	-0.274	-0.255	-0.692
1993-94	0.125	-0.275	-0.098	-0.697

Notes. a) The Revenue Ton Kilometre (RTK) is used as a measure of output (Y) in the estimation.
b) ε_{kk} ε_{ll} ε_{ee} ε_{mm} are the own price elasticities of capital, labour energy and materials respectively.

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