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ESTIMATING ALLOCATIVE EFFICIENCY AND ELASTICITIES OF SUBSTITUTION IN THE LARGE-SCALE MANUFACTURING SECTOR OF PAKISTAN

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This paper considers a generalised translog cost function, which takes care of distortions in factor markets due to the regulatory environment in Pakistan's large-scale manufacturing sector. The paper explores the nature of allocative inefficiencies and evaluates elasticities by employing pooled provincial time-series data of Sindh and Punjab from the CMI. The paper rejects the use of neo-classical assumption of perfect competition in input markets as a maintained hypothesis and argues that price and substitution elasticities produced by previous studies, without incorporating allocative inefficiencies, may be misleading.

I. Introduction

This paper is an attempt to estimate allocative efficiency and elasticities of substitution in the large-scale manufacturing sector of Pakistan. To put it simply, efficiency means the ratio of observed to maximum potential output obtainable from given factor inputs. Economic efficiency can be decomposed into technical and allocative efficiency. Technical efficiency refers to the ability of a production unit to avoid waste or to produce as much output as possible with the use of given factor inputs. Allocative or price efficiency refers to the ability of a production unit to combine inputs and outputs in optimal proportions in the light of prevailing prices.

Inefficiencies in resource allocation are quite common in developing countries mainly due to distortions in factor markets leading to inappropriate factor use.[1]

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[1] For such an evidence, see Lau and Yotopoulos [(1971) and (1972)], Yotopoulos and Lau (1973), and Moussa and Jones (1991). For evidence from India and Pakistan, see Burki, et al., (1997).

However, White (1978) recommends that due to an abundance of labor in these countries "labor intensive techniques in LDC manufacturing is feasible and would be efficient." Pakistan has an abundance of labor and less capital and industrial raw material. But Burki, et al., (1997) have shown that distortions in factor markets in the manufacturing sector of India and Pakistan do produce allocative inefficiencies, which lead to over- or under-utilization of factor inputs relative to their factor endowments. This finding greatly undermines the validity of estimates of elasticities of demand and substitution that are based on the classical assumption that factor markets are perfectly competitive in Pakistan.[2]

At the time of independence, Pakistan identified industrialization as a prerequisite for economic development and rapid economic growth. This was translated into the policy of import-substituting industrialization in the 1950s and the 1960s. Though this policy was successful in achieving high economic growth rates, it led to a pro capital and raw material bias [Islam (1970), Khan (1970)]. This bias was promoted through policies of low rates of interest, heavy protection in the guise of the infant industry argument, overvalued exchange rates, fiscal concessions, the import licensing system and agricultural raw material prices set below world market prices. Further, the capital-intensive technologies were also supplemented by the government guarantees regarding the supply of imported raw materials [Ahmed and Amjad (1984)].

Such policies resulted in a market bias in favor of capital-intensive, large scale, industries making excessive use of capital and imported raw material.[3] As a result, there was little expansion in the demand for labor. Public investment was never made on the criterion of relative factor endowments or employment generation [Ahmed and Amjad (1984)]. Other reasons for adopting capital-intensive technology were the policy maker's sense of being-up-to-date and that the most modern technologies required less administrative efforts in labor supervision [Little, et al., (1970)]. These policies are believed to have produced factor price distortions in Pakistan's large-scale manufacturing, which may have led to allocative inefficiencies. Whether or not this assertion is true is an emperical question.

In this backdrop, this study investigates the nature of allocative inefficiencies in Pakistan's large scale manufacturing sector by using a flexible translog cost function and pooled provincial annual time series data from 1969-70 to 1990-91. The study estimates own and cross price elasticities of demand, and Allen elasticities of substitution, which are also compared with earlier studies.

[2] For instance, studies by Kemal (1981) and (1982), Kazi, et al., (1976), Battese and Malik (1987) and (1988), Zahid, et al., (1992), Khan and Rafiq (1993), Mahmood (1989) and (1992), Ahmad and Idrees (1999), Khan and Burki (1999), and Chaudhary, et al., (1999), fall in this category.

[3] For further details, see Ahmed and Amjad (1984), and Burki, et al., (1997).

II. Model Specification

The above description of Pakistan's large scale manufacturing sector shows that the economic policies in Pakistan have signalled the use of production technologies that conflict with its factor endowments. These policies are likely to have created distortions for relative factor use. In such distorted factor markets, producers do not base their production decisions on market prices for inputs because doing so would lead to failure of the cost minimisation condition. Instead, unobservable shadow prices are used by producers to minimize their cost subject to the constraints imposed by the distorted factor markets. Following Atkinson and Halvorsen (1984), we specify a generalised translog cost function which takes care of the distortions in factor markets due to the prevailing regulatory environment.

Assuming that the shadow price for input j, P^{*}_{j}, is approximated by

$$P^{*}_{j} = k_{j}, P_{j} \tag{1}$$

where k_j is the factor of proportionality, which is input specific. It can be regarded as effective normalised prices of factors because in such situations firms equate marginal product of each factor to a proportion of the factor prices. Using this shadow price approach and assuming a translog shadow cost function, Atkinson and Halvorsen (1984) have derived an empirical form of actual cost function and share equations, which make it possible to minimize costs subject to shadow and market prices. This empirical total actual cost function for translog specifications is written as:

$$\ln C^{A} = \alpha_0 + \alpha_Q \ln Q + \frac{1}{2} \gamma_{QQ} \ln Q^2 + \textit{sumfromi}\ \gamma_{iQ} \ln Q \ln(k_i P_i) +$$

$$\sum_i \alpha_i \ln(+ \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln(k_i P_i) \ln(k_j P_j) + \ln[\sum_i k^{-1}_{i} (\alpha_i + \sum_j \gamma_{ij} \ln(k_j \tag{2}$$

where C^A is the actual total cost, Q is manufacturing output and P_i is price of input i. Note that if all k's are equal to one, the total actual cost function in equation (2) reduces to a simple translog cost function.

Holding output as constant, total actual cost should increase proportionally when prices increase proportionally. Symbolically, linear homogeneity in prices imposes the following restrictions on the parameters:

$$\sum_i \alpha_i = 1 \sum_i \gamma_{iQ} = 0$$

$$\sum_i \gamma_{ij} = \sum_j \gamma_{ji} = \sum_i \sum_j \gamma_{ij} = 0 \tag{3}$$

The symmetry condition requires that $\gamma_{ij} = \gamma_{ji}$. The associated cost share equation for this form of the translog cost function is written as:

$$M^A_i = \frac{[\alpha_i + \sum_j \gamma_{ij} \ln(k_j P_j) + \gamma_{iQ} \ln(Q)] k^{-1}_i}{\sum_i [\alpha_i + \sum_j \gamma_{ij} \ln(k_j P_j) + \gamma_{iQ} \ln(Q)] k^{-1}_i} \quad (4)$$

Equations (2) and (4) will be estimated by appending a classical error term to each equation to reflect errors in cost minimizing behavior.

The flexible cost function does not satisfy *a priori* the properties of monotonicity and concavity in factor prices and thus they need to be tested. Monotonicity in prices holds *if and only if* cost shares are positive. Similarly, monotonicity in output requires that the partial derivative of the total cost function with respect to output is positive. We can translate this condition for the translog cost function as:

$$\frac{\partial \ln C}{\partial \ln Q} = \gamma_Q + \gamma_{QQ} \ln(Q) + \sum_i \gamma_{iQ} \ln(P_i k_i) > 0 \quad (5)$$

The monotonicity conditions in prices and output may or may not hold in our data set. If these conditions do not hold then we will impose them. The curvature condition for the cost function requires that the Hessian matrix of the second order partial derivatives with respect to factor prices should be negative semi-definite. We will test the curvature conditions for the cost function.

a) Parametric Efficiency Tests

Economists usually define relative price efficiency when the marginal rate of technical substitution equals the ratio of factor prices while absolute price efficiency is defined as a state where the value of the marginal product of each factor/input is equal to its market price. The existence of relative price efficiency with respect to all pairs of inputs indicates that the cost is being minimized in the production process whereas the attainment of absolute price efficiency indicates not only cost minimization but also efficient levels of production.

Relative efficiency in our model holds if $k_i = k_j$ while absolute price efficiency in the use of factor i is achieved when $k_i = 1$. In the model specified above, total actual cost and cost shares are homogenous of degree zero in k's, which limits our ability to use the generalized cost function for testing absolute price efficiency. Therefore, the generalized cost function is normalized to conduct a test of relative price efficiency, as suggested by Atkinson and Halvorsen (1984).

b) Input Demand Elasticities

To explore the consequences of changes in factor prices, we estimate price responsiveness and substitution possibilities. We analyze price responsiveness by own price and cross price elasticities of demand. The own price elasticity of demand for input i with respect to its market price can be calculated as $E_{ii} = [S_i (S_i - 1) + \gamma_{ii}] / S_i$. The cross price elasticity of demand is defined as $E_{ij} = [S_i S_j + \gamma_{ij}] / S_i$ for all $i \neq j$. Our assumption in Allen partial elasticity of substitution is that other input prices are held constant. The Allen partial elasticities of substitution are defined as[4] $AES = \sigma_{ij} = 1 + [\gamma_{ij} / S_i S_j]$ for all $i \neq j$. Due to nonlinear estimators, the standard errors and t-values are not easy to obtain for our input demand elasticities and elasticities of substitution. For our purposes, we make use of the Taylor series expansions to obtain the necessary standard errors [see, Kmenta (1986) for further details].

III. Data and Construction of Variables

The primary data source for Pakistan's large-scale manufacturing sector is the Census of Manufacturing Industries (CMI), which has been published irregularly for the years 1969-70, 1970-71, 1975-76 to 1987-88 and 1990-91. In other words, we have only 16 annual observations to work with. However, the number of observations are increased to 16 (1+3) = 64, because we have a translog cost function along with three share equations, which are to be estimated in a system of equations. To gain further degrees of freedom, we use pooled provincial level data of Sindh and Punjab, which represents more than 80 per cent of total manufacturing industries of Pakistan that increases the number of observations to 32 (1+3) = 128. While pooling provincial data, we implicitly assume that firms in both provinces are characterized by similar production technologies.[5]

Data on prices and quantities of energy, capital, labor, and raw material are used to obtain total cost of production. We use the Divisia quantity and price indices, where aggregation was needed, due to its desirable properties [Nguyen (1987)]. We calculate the energy price index by aggregating various energy sources used in manufacturing industries. The measurement scale for the variety of energy sources have always posed difficulty for researchers to bring them on a common scale. The construction of British Thermal Unit (BTU) is also a step in that direction. However, it has been found that the Divisia energy index is superior due to some obvious problems in using the BTU index [Nguyen (1987)].

[4] For further details on own price and Allen partial elasticities of substitution, see Binswanger (1970).

[5] Battese and Malik (1987) have justified and supported the use of pooled provincial data, which has also been used by Ahmad and Idrees (1999), Chaudhary, et al., (1999), and Khan and Burki (1999).

The stock of capital is calculated by the perpetual inventory method while the user cost of capital is calculated as $P_K = P_M(r + \delta - \pi_M)$, where P_K is the user cost of capital, P_M is the price index of capital goods, r is the real rate of interest, δ is the depreciation rate and π_M is the rate of growth in the price index of capital. The user cost of capital is an increasing function of the price of capital, real rate of interest and the depreciation rate, and a decreasing function of the appreciation in the value of capital.

The capital stock series is calculated from a gross investment series by using a perpetual inventory method, and a constant rate of depreciation. To illustrate, let GI be the gross investment, K_t be the capital stock in time period t, and δ be the rate of depreciation. Then the series for capital stock is computed as $K_t = (1-\delta)\, K_{t-1} + GI_{t-1}$. We use the value of fixed assets at the beginning of the year 1969-70 as the benchmark value for calculation of the capital stock series. Price of labour is calculated by dividing total employment cost by average number of daily employed workers, which in turn is converted into an index. Data on raw material cost is directly available in CMI. The raw material cost includes cost on indigenous and imported raw material. The raw material price is taken from the Economic Survey and converted into an index . We compute real output by dividing the value of production by the wholesale price index of manufacturing goods.

Total cost (TC) is obtained by summing up the value of energy (V_1), the value of capital stock (V_2), total employment cost (V_3), and the value of raw material (V_4). Input shares are obtained by dividing the cost of each input with the total cost (TC).

IV. Empirical Results

The system of equations in Equations (2) and (4) are estimated by imposing symmetry, and linear homogeneity in prices given in equation (3). We use the Iterative Zellner Efficient (IZEF) method to estimate the system of equations. To avoid the problem of singularity we drop the share equation for raw material, but recover its parameters with the help of adding-up restrictions. Since the IZEF estimates converge to maximum likelihood estimates that are unique, they are invariant to which equation is dropped. Since the share equations in our model are nonlinear in parameters, the likelihood function may or may not have achieved a global maximum. To make sure that our likelihood function is single peaked or has achieved the same maximum, the model is, therefore, estimated four times, by dropping a different share equation each time. As expected, we find that the parameter estimates and the values of likelihood function remain the same no matter which equation was dropped. In other words, these results confirm the attainment of a global maximum.

The cost function corresponds to a well behaved production function only if it is monotonically increasing in prices and is concave. This condition is satisfied for each observation in our data set. However, the concavity condition in input prices is partially satisfied as the principal minors of the Hessian matrix do not alternate in signs.[6] The failure of the cost function to be concave in input prices can be interpreted as violation of the cost minimizing assumption underlying the development of the cost function model.[7] The estimated parameters along with their asymptotic t-statistics are reported in Table 1.

TABLE 1

Results with Allocative Efficiency

Parameter	Estimate	Asymptotic t-statistics
α_0	60.102	5.13*
α_E	0.121	1.58
γ_{EE}	-0.009	-1.37
γ_{EK}	-0.001	-0.04
γ_{EL}	0.027	1.82**
γ_{EM}	-0.018	-1.27
α_K	1.093	2.35*
γ_{KK}	-0.163	-2.10*
γ_{KL}	0.112	2.31*
γ_{KM}	0.051	0.93
α_L	1.648	2.71*
γ_{LL}	0.057	1.83**
γ_{LM}	-0.196	-2.44*
α_M	-1.861	-1.81**
γ_{MM}	0.162	1.72**
γ_Q	-5.811	-4.28*
γ_{QQ}	0.384	4.88*
γ_{EQ}	-0.008	-1.50
γ_{KQ}	-0.070	-2.48*
γ_{LQ}	-0.080	-2.30*
γ_{MQ}	0.157	2.54*
k_E	0.173	2.37*
k_K	0.224	3.22*
k_L	1.000	–
k_M	0.504	1.37
χ^2	332.710	–
N	32	–

Note: *indicates significant at the 5 per cent and **indicates significant at the 10 per cent level. To estimate standard deviations, we use the Taylor series expansions.

[6] The evaluated principal minors of the Hessian matrix are, H_{11} = 8.015, H_{22} = -0.173, H_{33} = 0, and H_{44} = -1.50.

[7] For further details, see Capalbo and Antle (1988).

a) Relative Price Efficiency

Relative price efficiency with respect to all inputs is attained if and only if all k's are equal, i.e., $k_E = k_K = k_L = k_M$. The actual cost and cost shares are homogeneous of degree zero in k's, therefore, we cannot estimate the values of k for each input. Estimation of their relative values require that the value of the k's be normalized. The estimated relative values of k's, and all other parameters are invariant to the choice of which k_i is normalized and the value chosen for it.[8] We normalize the value of k_L to equal one, or $k_L = 1$. With this normalization, the restriction of relative price efficiency with respect to all inputs becomes $k_E = k_K = k_M = 1$. We test the hypothesis of relative price efficiency and reject it because the computed value of the χ^2 test statistic is 12.326, which is greater than the critical value of the χ^2 (11.34) at the one per cent level of significance.[9] It implies that the manufacturing sector of Pakistan does not minimize costs subject to market prices and there is evidence of allocative inefficiency. In other words, it is inappropriate to make the assumption that relative price efficiency is attained in the manufacturing sector of Pakistan.

It can be seen from Table 1 that the estimated values of k's statistically differ from zero. To investigate it further, we test the relative price efficiency between each pair of inputs using the hypothesis that $k_i = k_j$, where i, j = E, K, L, M. The hypotheses tests of pair wise relative price efficiency are presented in Table 2, which show that $k_E - k_j$ and $k_K - k_L$, while all the other inputs are relatively equally price inefficient. Our results also indicate that relative to labor, energy is the most inefficiently utilized factor of production, followed by capital and raw material.

TABLE 2

Relative Efficiency Test for each pair of Inputs

Hypothesis	Ratio of Relative Efficiency	t-statistics
$k_E = k_K$	0.775	0.759
$k_L = k_K$	4.471	11.172
$k_L = k_E$	5.764	11.276
$k_K = k_M$	0.444	0.784
$k_E = k_M$	0.344	0.896
$k_L = k_M$	1.985	1.342

8 For further details, see Atkinson and Halvorsen (1984).

9 Relative price efficiency with respect to all inputs was also rejected by Atkinson and Halvorsen [(1980] and (1984)], and Burki, et al., (1997).

The columns for the ratio of relative efficiency illustrate the direction of relative allocative inefficiency of factor use because we know that $(F_L/F_K) = (k_L P_L / k_K P_k)$. To illustrate when $(k_L/k_K) = 4.47$, it implies that $(F_L/F_K) = (P_L/P_K)$, i.e., the marginal rate of technical substitution is greater than the ratio of input prices. In other words, capital is over-utilised relative to labor. Tests of pairwise efficiency suggest that the input mix inefficiency takes the form of over-utilization of energy, capital and raw material as compared with labor. The results also indicate that energy is over-utilised as compared with capital and raw material, while in the case of capital and raw material, capital is more over-utilised than raw material.[10] Our results indicate that energy is the most over-utilised factor while labor is the most under-utilized factor of production.

The effects of relative price inefficiency on cost of production can be evaluated by comparing actual total cost with the cost when relative price efficiency holds. The efficient level of cost is estimated by imposing restrictions $k_E = k_K = k_L = k_M = 1$. A comparison with the fitted total actual cost indicates that over the period of our analysis, relative price inefficiency increases total cost by 0.21 per cent per annum, which may appear quite limited. But when we visualize that the cost of production is also decreasing on account of technological progress this increase may not be trivial.[11] It implies that allocative inefficiency increases the cost of production or reduces the profitability of production units beneath their full potential.

In sum, the above discussion shows that the hypothesis of relative price efficiency is rejected, which implies that it is inappropriate to assume relative price efficiency as a maintained hypothesis. The rejection of allocative efficiency as a maintained hypothesis also implies variation in the estimates of elasticities of demand and substitution in studies which do not take this aspect into account.

b) Elasticities of Demand and Substitution

The estimates of own and cross price elasticities of demand as the mean of the data, and Allen elasticities of substitution are reported in Table 3, separately for models (a) when relative price efficiency is not imposed, and (b) when relative price efficiency is imposed. A central point to show in these Tables is the bias contained in estimates of elasticities on account of allocative inefficiencies. One can notice significant differences in the magnitudes of own/cross price and substitution elasticities in the two tables. Another purpose here is to interpret our elasticities and compare them with earlier studies.

[10] Burki, et al., (1977) found that capital and raw material are over utilized as compared to labor. Raw material is also over-utilized as compared to energy.

[11] For instance, in an earlier study we show that "due to disembodied technological progress cost of production decreases at the rate of 0.76 per cent per annum," [Khan and Burki (1999)].

TABLE 3

Matrix of Own and Cross Price Elasticities of Input Demand

Variables	When Relative Price Efficiency is not Imposed				When Relative Price Efficiency is Imposed			
	Energy	Capital	Labour	Raw Material	Energy	Capital	Labour	Raw Material
Energy	-1.52 (-0.56)	0.08 (0.14)	1.81 (0.24)	-0.37 (-0.07)	-1.37 (57.57)*	0.65 (1.63)**	0.367 (3.27)*	0.35 (0.65)
Capital	0.01 (0.11)	-2.53 (-1.72)**	1.29 (1.05)	1.22 (0.74)	0.14 (1.68)**	-1.89 (-28.10)*	0.32 (5.07)*	1.43 (3.61)*
Labour	0.17 (0.96)	0.74 (1.88)**	-0.50 (-11.80)*	-0.41 (-0.75)	0.20 (3.28)*	0.80 (4.70)*	-0.60 (-142.90)*	-0.41 (-1.86)**
Raw Material	-0.01 (-0.09)	0.17 (1.15)	-0.10 (-0.35)	-0.06 (-0.09)	0.02 (0.65)	0.45 (3.97)*	-0.05 (-1.89)*	-0.42 (-36.88)*

Notes: a) Figures in parentheses are asymptotic *t*- values.
b) *indicates significant at the 5 per cent, and **indicates significant at the 10 per cent level.
c) Standard deviations are estimated by using Taylor series expansions.

All the own price elasticities are of the correct sign where own price elasticities of capital and energy show an elastic response, while labor and raw material depict inelastic demand patterns. To illustrate, the own price elasticity for capital at −2.53 and −1.89, indicates that a 10 per cent increase in the price of capital leads to a decrease in the demand for capital from 25.3 to 18.9 per cent. However, a similar increase in the price of labor leads to between 5 to 6 per cent fall in its demand. All cross price elasticities are found to be statistically equivalent to zero, which is quite surprising.

Since Allen elasticities are equal to ratios of cross price elasticities with their cost shares, they take the same sign as cross price elasticities because cost shares are always positive. The Allen elasticities of substitution estimated at the mean of the data are reported in Table 4. These results show that energy/raw material and labor/raw material are complements while all other pairs are substitutes. As expected energy/labor and capital/labor are good substitutes to each other. Similarly, we find that the energy/capital pair is also a substitute to each other. It implies that there is no possibility of energy/capital complementarity from our data set. The same is the case of labor and raw material.

TABLE 4

Allen Elasticities of Substitution

Elasticities	When Relative Price Efficiency is not imposed		When Relative Price Efficiency is Imposed	
	Estimates	Asymptotic t-statistics	Estimates	Asymptotic t-statistics
σ_{EK}	0.80	0.15	3.13	1.67**
σ_{EL}	10.39	0.24	4.46	3.27*
σ_{EM}	-0.52	-0.06	0.52	0.65
σ_{KL}	7.42	0.93	3.83	5.07*
σ_{KM}	1.73	1.24	2.16	3.42*
σ_{LM}	-0.58	-0.37	-0.61	-1.89**

Notes: a) *indicates significant at the 5 per cent, and **indicates significant at the 10 per cent level.
b) Standard deviations are estimated by using Taylor series expansions.

c) Comparison with other Studies

There have been a number of studies of substitution elasticities in Pakistan's large-scale manufacturing sector, but the vast majority of them use non-flexible functional forms and they are also restricted to only two inputs namely, capital and labor. More recently, some studies have extended the input set by combining energy or raw material or both with labor and capital. In particular, Khan (1989), and Khan and Rafiq (1993) have estimated the nested CES production function approach to calculate the elasticities of substitution while Chishti and Mahmud (1991), Mahmood (1992) and Khan and Burki (1999) have used the translog cost function to estimate the elasticities of substitution. Ahmad and Idrees (1999) have, however, found that the Generalized Leontief cost function performs better on their data set while Chaudhary, et al., (1999) have estimated a flexible translog profit function to obtain price and substitution elasticities.

The estimates of elasticities of substitution tend to be quite high for capital-labor in Mahmood (1989), which are quite comparable with our estimates of 3.83 when relative price efficiency is imposed. This evidence of capital labor substitution is also corroborated by Ahmad and Idrees (1999), Khan and Burki (1999), and Chaudhary, et al., (1999). Two studies which report changing patterns of substitution elasticities are those of Mahmood (1992) and Ahmad and Idrees (1999). Both these studies find that energy-capital were complements till the mid to late seventies before becoming substitutes in the subsequent period. For instance, Ahmad and Idrees (1999) find that the complementary relation between energy-capital was found till 1979-80, which not only turned into substitutability in the later period but has been rising ever since. This result broadly supports our finding that energy and capital are good substitutes at the mean of the data point. A similar pattern of Allen elasticities of substitution is reported by Ahmad and Idrees (1999) between labor and energy which were found to be close complements until 1975-76 before turning into close substitutes and jumping to substitution elasticity of 3.2 in 1990-91, which is very similar to our estimate of 4.46.

It appears from the above, that due to changes observed by the large-scale manufacturing sector of Pakistan, it has become easier to substitute energy with both labor and capital and vice-versa, which is also supported by our findings.

V. Conclusions

This study attempts to investigate the nature of allocative inefficiencies in Pakistan's large scale manufacturing sector by using pooled provincial time series data and the translog cost function. We have explored the nature of allocative inefficiencies by employing the parametric approach. The relative price efficiency between each pair of input provides the evidence that energy, capital, and raw materials are over-utilised as compared to labor while capital is over-utilised relative to raw material. The distortion parameter in our model suggests that energy is the most inefficiently utilized factor followed by capital and raw material relative to labor.

A major finding of this paper is that the use of the conventional neo-classical cost function, which imposes cost minimisation as a maintained hypothesis, is inappropriate in the case of Pakistan's large-scale manufacturing sector. Estimates of elasticities produced by previous studies without taking allocative inefficiency into account may have produced erroneous results.

The estimates of own price elasticities reveal that capital and energy have elastic behavior, while labor and raw material have inelastic patterns of demand. The Allen elasticities of substitution reveal that energy/labor and capital/energy are good-substitutes to each others. The finding of under-utilization of labor is also pronounced from its low elasticity in Pakistan's large scale manufacturing sector. Therefore, steps should be taken to rule out price distortions in the factor market and an appropriate change in relative prices is recommended to reduce capital-intensity in the large scale manufacturing sector. This is also the appeal of measures aimed at reducing poverty in Pakistan.

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