The Pakistan Development Review
30 : 1 (Spring 1991) pp. 83 – 88

The Energy Demand in the Industrial Sector of Pakistan

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The purpose of this study is to analyse the role of energy in the manufacturing sector of Pakistan. The translog cost function alongwith the input demand equations corresponding to energy, capital, and labour have been estimated, using Zellner's iterative procedure. Time trend has been included in the cost equation in view of the low Durbin-Watson statistics. The results justify the inclusion of energy as a separate factor of production. Price elasticities and Allen-Uzawa partial substitution elasticities have been estimated. Own price elasticities indicate a rather inelastic demand for inputs. Cross-price elasticities show that energy and labour, and capital and labour are substitutes. The partial substitution elasticities between energy and capital are negative; which implies that higher energy prices will adversely affect investment in capital goods. On the other hand, the positive substitution elasticity between energy and employment implies that higher energy prices would induce more labour absorption.

I. INTRODUCTION

Energy has been a serious constraint in the industrial growth of Pakistan.[1] As the energy intensity of production increases, the problem is likely to become more acute in the future. The purpose of this study is to examine the role of energy in the production process of the manufacturing sector of Pakistan. More specifically, in the framework of a translog production function, the extent of substitution possibilities between energy and non-energy inputs and the demand response to pricing policies has been estimated. Such a study may have important policy implications. For instance, if there are significant substitution possibilities between capital and energy, then energy-conserving investment policies may be useful. However, if the corresponding substitution elasticity is small, this would mean either that the technology in which such substitution is possible does not exist, or that our industrialists lack information or face other constraints. Similarly, if the substitution elasticity between energy and labour is high, then energy-conserving policies would have a favourable impact on employment.

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Authors' Note: We gratefully acknowledge the comments made by the anonymous referee of *The Pakistan Development Review*.

[1]A recent study has found that the load-shedding has led to a reduction in value-added by the industrial sector of Pakistan of about 6 percent, equivalent to a loss of over 4.5 billion rupees [Pasha, Ghaus and Malik (1989)].

Though there are numerous studies in which the role of energy as a factor input has been examined, there is hardly any study on Pakistan. Such a study may be useful to guide energy policy specially, because the demand management policies are set by the government.

In this paper, Section 2 describes the model. In Section 3 the results are reported, and finally, Section 4 contains the concluding remarks.

II. THE MODEL

A translog production function in three inputs, namely, capital, labour, and energy has been assumed. Invoking duality theory, this production function is equivalent to the following cost function:

$$\begin{aligned} lnC = {} & \alpha_o + \alpha_q * lnQ + \alpha_n * (lnP_n) + \alpha_k * (lnP_k) + \alpha_e * (lnP_e) \\ & + 1/2[\beta_{qq} * lnQ^2 + \beta nn * ln\,(Pn)^2 + \beta kk * ln\,(P_k)^2 + \beta ee * ln\,(Pe)^2] \\ & + \beta nk * (lnP_n)(lnP_k) + \beta ne * (lnP_n)(lnP_e) \\ & + \beta_{ke} * (lnP_k)(lnP_e) + \beta_{qn} * (lnP_n)(lnQ) \\ & + \beta_{qk} * (lnP_k)(lnQ) + \beta_{qe} * (lnP_e)(lnQ) \qquad \ldots \quad \ldots \quad (1) \end{aligned}$$

Where P_n, P_k, and P_e, are the wage rate, user cost of capital, and price of energy, respectively. Q is value-added. Partially differentiating (1) with respect to factor prices, invoking Shephard's lemma, imposing homogeneity, and adding up and symmetry conditions yield the following input demand equations:

$$S_n = \alpha_n + \beta_{nn} * lnP_n + \beta_{nk} * (lnP_k) + \beta_{ne} * (lnP_e) + \beta_{qn} * lnQ \quad \ldots \quad (2)$$

$$S_k = \alpha_k + \beta_{nk} * lnP_n + \beta_{kk} * (lnP_k) + \beta_{ke} * (lnP_e) + \beta_{qk} * lnQ \quad \ldots \quad (2a)$$

$$S_e = a_e + \beta_{ne} * lnP_n + \beta_{ke} * (lnP_k) + \beta_{ee} * (lnP_e) + \beta_{qe} * lnQ \quad \ldots \quad (2b)$$

Given (2), the Allen-Uzawa partial substitution elasticities are obtained by:

$$\sigma_{rk} = [\beta_{rk} + S_r S_k] / S_r S_k \text{ and} \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

$$\sigma_{rr} = [\beta_{rr} + S_r (S_{r-1})] / S_r^2 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

and the price elasticities by:

$$\tilde{n}_{rk} = \sigma_{rk} \,.\, S_k \text{ and} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

$$\bar{n}_{rr} = \sigma_{rr} \cdot S_r \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad (6)$$

III. DATA AND RESULTS

The model has been estimated for the manufacturing sector of Pakistan at the aggregate level with data corresponding to 1960 – 1980. All the data except for energy have been taken from Naqvi *et al.* (1983). The energy data for the corresponding years have been taken from the Energy Year Book.

Zellner's iterative procedure has been used to estimate the model consisting of the cost Equation (1) along with the input demand Equations (2). This procedure is initialized with some starting values of the parameters. In order to ensure that the procedure converges to the same likelihood and the corresponding parameters are invariant to the share equation dropped, the model has been estimated three times dropping one share equation at a time. The invariance indicates that the procedure has converged to a global maximum. Initial results showed a low value of the Durbin-Watson Statistic. Therefore, a term corresponding to the trend has been included in the cost equation. The results of the estimated parameters are presented in Table 1.

Fifteen out of the nineteen coefficients are significant at the 5 percent level. On the basis of these coefficients, the own and cross elasticities are computed and presented in Table 2. All the own price elasticities have the correct signs and are significant at the 1 percent level. However, the magnitudes of the elasticities indicate that the demand for factor inputs is rather inelastic. The most inelastic demand is for capital input. The demand for energy seems to be relatively more elastic to price.

The cross-price elasticities between employment and energy, and between employment and capital, although small in size, are significant at the 1 percent level. This implies that energy and employment and capital and employment are substitutes to some extent. However, cross-price elasticity between energy and capital is rather small.

In Table 3, Allen-Uzawa partial substitution elasticities are presented. Again, it shows that the substitution possibilities between employment and capital in Pakistan's manufacturing sector are limited, while between energy and employment are somewhat better.

These results are comparable to those in similar studies, most of which find high elasticity of substitution between energy and employment.

The substitution elasticity between capital and energy is negative. There has been a long controversy about the energy capital complementarity which started with Berndt and Wood (1975), who found this elasticity for U. S. manufacturing to be –3.2. Some inter-country and cross-sectional studies find energy and capital to be substitutes [Griffin and Gregory (1976)]. Most of the studies which have used annual time series data and also included materials along with capital, labour, and energy as factor inputs in the production function have found complementarity between energy and capital [Berndt and Wood (1975); Fuss (1977); Hudson and Jorgenson (1974) and Magnus

Table 1

Parameter Estimates

α_o	−11.95 (−2.293)	β_{NK}	−0.0911 (−2.59)
α_q	3.824 (3.056)	β_{NE}	0.0339 (2.24)
α_{qq}	−0.2614 (−1.58)	β_{KE}	−0.0569 (−4.55)
α_n	0.237 (0.908)	β_{qn}	−0.07945 (−2.204)
α_k	0.814 (3.30)	β_{qe}	−0.0458 (−4.83)
α_e	−0.05146 (−0.72)	β_{qk}	0.1253 (3.70)
β_{NN}	0.05719 (1.48)	α_t	−0.0993 (−3.88)
β_{KK}	0.1480 (4.38)	β_{tn}	0.01056 (3.84)
β_{EE}	0.02297 (1.121)	β_{tk}	−0.01412 (−5.41)
DW_n	1.78	β_{te}	0.00356 (3.53)
DW_e	1.64	DW_e	1.12

Table 2

Own and Cross Price Elasticities

	Elasticity	*t*-Ratio
ENN	–.41437	–5.0111
EEE	–.63852	–2.5742
EKK	–.21934	–2.9455
ENE	.87425	4.6690
EEN	.15579	4.8232
EKE	–.042545	–1.5465
EEK	–.23573	3.4237
ENK	.25858	3.4237
EKN	.26189	3.3713

Table 3

Elasticities of Substitution

	Elasticity	*t*-Ratio
SNE	1.8933	4.6936
SKE	–.51703	–1.5464
SNK	.56714	3.3987

(1979)]. However, later it was shown that the inclusion of materials as a fourth factor input is not of any empirical significance in resolving the controversy [Griffin (1981)]. Another explanation is given in terms of the time horizon for which the production relation is estimated. It is claimed that in the short run, if other inputs can be substituted against the capital energy aggregate, capital and energy can be complements; but in the long run, when energy input per unit of output can be adjusted, they are likely to be substitutes [Griffin and Gregory (1976) and Berndt and Wood (1975)]. This seems to be a more plausible explanation in our case as the period covered for the study might not have been long enough to make such adjustments fully effective. Subject to the condition of availability of appropriate data the issue needs to be explored carefully.

IV. CONCLUDING REMARKS

The purpose of the study is to estimate price and substitution elasticities between energy and non-energy inputs. Our results are similar to those of the earlier studies in this vein. As shown here, energy interacts differently with capital and labour. First, it justifies the inclusion of energy as a separate factor of production. Secondly, our results imply that higher energy prices will adversely affect investment in capital goods but will have some positive impact on labour absorption.

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