7 Energy Demand in the Manufacturing Establishment

Parameter Estimates

The maximum likelihood estimates of the energy sub-model are presented in Table 9. Out of the 27 different parameters of the energy sub-model, only 20 are independent. The remaining parameters can be derived as residuals from the restrictions defined in Equation 6. The t-ratios of the estimated parameters indicate that 12 coefficients are significant at the five or 10 per cent level. For a cross- sectional sample, the number of parameters (45%) that are significant is not surprising. In developed countries where data quality is far better than the data available for the manufacturing sector of Nepal, a similar percentage of parameters have been found to be significant.

The parameters of the equations reported in Table 9 do not have useful meaning in themselves but are used in deriving the elasticities of substitution and price elasticities discussed above. The large value of the intercept term in the equation indicates that substantial scope exists to improve the energy sub-model by introducing other variables. Large values of the intercept occur when the explanatory variables are not able to fully capture the observed variations in the dependent variable, i.e., energy cost or energy cost shares.

Table 9: Coefficient Estimate of the Homogeneous Translog Cost Function Nepalese Manufacturing Sector (1986/87): Energy Sub-model

Parameters	Coefficient	T-Ratio	Parameter	Coefficient	T-Ratio
αO	9.1951	24.4200*	αDK	-0.00115	1.6873**
αW	0.9620	5.3000*	αCC	0.2586	1.8650**
αD	0.0309	0.1400	αCE	-0.2744	1.9500**
αC	0.0003	0.0160	αCK	0.06154	2.9204*
αE	0.0356	0.1390	αCK	0.06154	2.9204*
αK	-0.0287	1.5490	αEE	0.0729	0.2620
αWW	0.2514	1.8140**	αEK	-0.00679	0.3017
αWD	-0.1909	2.0390*	αKK	-0.01032	0.0861
αWC	0.0102	0.1090	DW	-0.3011	4.3400*
αWE	-0.0274	0.1630	DE	0.2460	2.4290*
αWK	-0.0433	2.6860*	DC	-0.0471	0.7500
αDD	0.0124	0.1040	DD	0.0988	1.1670
αDC	-0.0561	0.6030	DK	1.0034	0.5795
αDE	0.2357	1.6740**			

Note: * and ** denote significance at the five and 10 per cent levels respectively. Also note that W, D, C, E and K refer to wood, diesel, coal, electricity, and kerosene. Note that for the translog model when share equations are jointly estimated with the cost function, the degree of freedom equals the number of equations (5) multiplied by the number of observations (38), minus the number of independent coefficients estimated (19). The last four terms refer to dummy variables associated with each energy type. The dummy variable used was industries that had electric motors. Industries that had electric motors that were larger than 1,000 hp were assigned a value of 1 and zero otherwise. The introduction of this dummy variable in the model significantly improved the results.

Comparative Static Results

Own and Cross Price Elasticities. According to economic theory, own-price elasticities are expected to have a negative sign, indicating that the demand for the factor input will fall (increase) when its own price increases (decreases). In Table 10, the own (diagonal elements) and cross-(off diagonal elements) price elasticities corresponding to each energy input are presented. The results indicate that the own price elasticity of demand for *wood and coal in the Nepalese manufacturing industry is positive, i.e., increase in* price *of wood and coal increases demand for these energy inputs. Cases of positive own price elasticities* do occur. If prices are increasing rapidly due to say speculative motives, then this can result in tendencies to buy the commodity even when its prices increase. Also, in some industries, if wood is the only source of energy and output demand of this industry is growing, then it is likely that the industry will continue to buy the factor input even when its price increases. This may be the case with the carpet and rug industries, where demand (export) has been increasing and wood is the main energy source, which also has little substitution (examined below).

In Nepal, many of the firms within an industry may not have been able to modernise, thus wiping out the scope for substitution between energy types. Reliance on the existing technology thus forces such firms to purchase these fuels even when the prices are increasing, especially when the demand for output of such industries is also increasing. In the carpet and rug industries, dyeing requires extensive wood fuel and since alternative technology is not adopted, demand for wood fuel increases when its price increases, given that the export demand for carpets has been increasing. Similar arguments can be made for the tea industry as well, where the chief source of energy is wood fuel. The own-price elasticity of demand for the other energy types have the expected negative sign. A 10 per cent increase in the price of diesel, electricity, and kerosene caused the demand for these energy inputs to decrease by 7.28, 4.9, and 16.9 per cent respectively. Clearly, demand for electricity was the most inelastic, followed by diesel and kerosene.

The cross-price elasticities also presented interesting results. A 10 per cent increase in the price of diesel caused wood demand to decrease by about eight per cent when all other energy input prices held constant. Since a given firm has the option to substitute between energy types, either coal, electricity, or kerosene is likely to be substituted when the price of diesel increases and if permitted by the firm's technology. Based on the results presented in Table 10, diesel and electricity appear to have had the greatest impacts (substitution and complementarily) when their prices increased.

Table 10: Energy Demand Elasticities by Energy Types in the Nepalese Manufacturing Sector

	Wood	Diesel	Coal	Electricity	Kerosene
Wood	0.542	-0.816	0.034	0.644	-0.219
Diesel	-0.705	-0.728	0.349	1.596	0.009
Coal	0.071	0.837	1.981	-2.572	0.703
Electricity	0.241	0.689	-0.464	-0.490	0.001
Kerosene	-2.774	0.136	4.295	0.032	-1.691

The own and cross-price effects also were estimated for different industries based on the NSIC. The results are presented in Table 11. It can be observed from Table 11 that the own price and cross-price demand elasticities were very different across the seven groups of industries. Own-price elasticities varied considerably across the industries. The own-price elasticity of wood, though positive in all the seven groups, varied considerably with the basic metals and fabricated group, registering the highest value, and the beverages' industry, registering the lowest value. The own-price demand elasticity for diesel across all the industries was almost the same (ranges from .53 to .777[2]) except for the paper, chemical, and rubber industries, where the value was found to be relatively more elastic (1.263).

The own-price demand elasticity for coal also exhibited considerable variation with the value ranging from 0 (carpet and rug industries) to 10.57 (wood and wood products' industry). Notice that the carpets and rugs' industries did not use coal as an energy input according to the Census data.

Change in electricity demand due to changes in its own price also had the same narrow range as that of diesel. The own-price demand elasticity of electricity ranges from .22 (carpet and rug industries) to .36 (food and food processing industries). Furthermore, the own-price demand elasticity for electricity is the most inelastic, indicating that the industries did not cut back their demand in the same proportion as price increased. This has implications for the electricity pricing policy for the industrial sector.

Kerosene's own-price demand elasticity also exhibited variations across the industries with a minimum value of 1.41 (beverages industry) and a maximum value of 4.44 (carpet and rug industries). The demand for kerosene energy was clearly very elastic and its value greater than that of diesel. With the exception of chemical-based industries (1.26), own price demand elasticity of diesel for other industries ranged from 0.5 to 0.7.

[2] We have not written the sign of the elasticities, but it is implied in the argument.

Table 11: Energy Demand Own-and Cross-price Elasticities for Different Types of Industries Classified by NSIC

Industry	Wood	Diesel	Coal	Electricity	Kerosene
Food and Food Processing (NSIC 3112-3122)					
Wood	0.521	-0.737	0.090	0.342	-0.21
Diesel	-0.506	-0.680	-0.168	1.345	0.008
Coal	0.470	-1.272	6.166	-7.078	1.709
Electricity	0.132	0.758	-0.526	-0.363	-0.001
Kerosene	-3.233	0.184	4.899	-0.049	-1.803
Beverages (NSIC 3131-3134)					
Wood	0.017	-0.206	0.140	0.098	-0.049
Diesel	-1.047	-0.777	-0.359	2.168	0.130
Coal	0.675	0.133	1.226	-2.087	0.524
Electricity	0.403	0.079	-1.772	-0.352	-0.023
Kerosene	-1.217	0.630	2.693	-0.139	-1.407
Textiles, Apparel and Leather (NSIC 3211-3216, 322, 323, 324)					
Wood	0.474	-0.879	0.137	0.480	-0.212
Diesel	-1.901	-0.773	-0.532	3.209	-0.004
Coal	0.317	-0.570	2.130	-2.647	0.733
Electricity	0.153	0.472	-0.363	-0.263	-0.003
Kerosene	-5.018	-0.048	7.496	-0.199	-2.234
Carpets and Rugs (NSIC 3214)					
Wood	0.152	-0.194	0.000	0.077	-0.047
Diesel	-5.958	-0.529	0.000	8.527	-0.038
Coal	0.000	0.000	0.000	0.000	0.000
Electricity	0.609	2.190	0.000	-0.222	-0.059
Kerosene	-13.573	-0.355	0.000	-2.154	-4.437
Wood and Wood Products (NSIC 3311, 3319, 332)					
Wood	2.535	-2.298	3.584	0.180	-0.581
Diesel	-0.503	-0.631	-0.147	1.268	0.012
Coal	11.617	-2.173	10.567	-11.692	2.763
Electricity	0.023	0.755	-0.470	-0.312	0.003
Kerosene	-2.721	0.258	3.993	0.120	-1.650
Paper, Chemical, Rubber, Plastic and Mineral (NSIC 34, 35, 36)					
Wood	2.886	-2.646	4.085	0.089	-0.639
Diesel	-0.683	-1.263	-0.066	2.031	0.012
Coal	1.740	-0.108	0.828	-1.271	0.418
Electricity	0.012	1.024	-0.388	-0.350	0.006
Kerosene	-2.466	0.156	3.360	0.152	-1.518
Basic Metal and Fabricated (NSIC 371, 381)					
Wood	34.921	27.118	37.129	-3.279	-6.168
Diesel	-1.234	-0.766	-0.178	2.168	0.010
Coal	1.394	-0.147	0.573	-0.836	0.347
Electricity	-0.036	0.525	-0.245	-0.250	0.007
Kerosene	-2.496	0.087	3.744	0.243	-1.579

The cross-price elasticities are also reported in Table 11. Reading across the rows of the table indicates the change in the demand of (row) energy input when the price of the (column) energy input changed. The results can be interpreted in a manner similar to that already described for the whole industry above.

Energy Substitution in the Nepalese Manufacturing Sector

The estimated parameters of the translog function can be used to derive the Allen-Uzawa partial elasticities of substitution and complementarity between pairs of energy inputs. The substitution-complementarity relationship between the energy inputs is presented in Table 12 for the entire manufacturing establishment. Positive values of these elasticities imply substitution relationship and negative values imply complementarity relationships.

Table 12: Elasticities of Substitution and Complementarity between Energy Types Nepalese Manufacturing Sector

	Wood	Diesel	Coal	Electricity
Diesel	-3.807	--	--	--
Coal	0.385	3.904	--	--
Electricity	1.298	3.216	-5.182	--
Kerosene	-14.974	0.633	48.020	0.065

Diesel and wood, kerosene and wood, and electricity and coal were found to be complements, given the negative signs of the elasticities between these pairs of inputs. Electricity was found to be a substitute for all types of energy except coal. Kerosene was also found to be a substitute for diesel, coal, and electricity. The results indicate that energy types exhibit substitution and complementarity relationships in the manufacturing sector of Nepal. These relationships arise due to changes in relative energy prices. Based on the census data, many industries used more than one energy type in their production process. It might be the case that different energy types were used at different stages of production. Thus, the observed complementarity relationship between wood and diesel energy inputs could be an indication that such industries cut back (increase) energy consumption when either one of the energy prices decreased (increased). Since production involves different activities that require the use of different types of energy, energy curtailment (due to price change) at one stage will also lead to curtailment of the other type of energy at the following stage of production. Complementarity relationships between energy inputs in different industrial groups might reflect different stages of production before the final output was produced. Greater substitution between energy types indicates a more flexible production technology, since the industry had the ability to substitute cheaper fuels for the ones whose prices had increased.

The results for the industrial different group are reported in Table 13. Based on these results, it can be stated that a good deal of substitution takes place between energy types in the manufacturing sector. Also some pairs of inputs display a complementarity relationship. Wood is a substitute for electricity and coal, but is a complement to kerosene and diesel. Diesel is a substitute for all other energy types. Kerosene is a substitute for diesel, coal, and electricity but is a complement to the other two energy types. Coal is a substitute for all energy types except electricity.

Table 13 : Substitution and Complementarity Relationship between Energy Inputs Nepalese Processing Sector (1986/1987)

Industry	Wood	Diesel	Coal	Electicity
Food and Food Manufacturing (NSIC 3112-3122)				
Diesel	-2.683	--	--	
Coal	2.491	-4.629	--	
Electricity	0.702	2.759	-14.514	
Kerosene	-17.139	0.669	135.071	-0.100
Beverages (NSIC 3131-3134)				
Diesel	-1.769			
Coal	1.140	1.140		
Electricity	0.680	0.680	-14.414	
Kerosene	-2.056	5.410	21.906	-0.959
Textiles, Apparel, and Leather (NSIC 3211-3216, 322, 323, 324)				
Diesel	-9.661			
Coal	1.610	-6.260	--	
Electricity	0.775	5.185	-4.276	
Kerosene	-25.495	-0.522	88.265	-0.321
Carpets and Rugs (NSIC 3214)				
Diesel	-6.928	--		
Coal	0.000	0.000		
Electricity	0.708	78.228	0.000	
Kerosene	-15.783	-12.690	0.000	-19.765
Wood and Wood Products (NSIC 3311, 3319, 332)				
Diesel	-6.925	--		
Coal	160.017	-6.548	--	
Electricity	0.323	2.274	-20.969	--
Kerosene	-37.479	0.776	178.247	0.214
Paper, Chemical, Rubber, Plastic, and Minerals (NSIC 34, 35, 36)				
Diesel	-10.382	--	--	--
Coal	26.437	-0.425	--	--
Electricity	0.176	4.019	-2.514	
Kerosene	-37.479	0.612	21.746	0.300
Basic Metal and Fabricated (NSIC 371, 381)				
Diesel	-176.317	--		--
Coal	199.085	-0.956		
Electricity	-5.162	3.413	-1.316	--
Kerosene	-356.556	0.568	20.074	0.382