Research Reports

Estimating Industrial Energy Demand with Firm-Level Data: The Case of Indonesia

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INTRODUCTION

A number of recent studies have analyzed the role of energy in the structure of production. Most have used either a single time series for a country's manufacturing sector or time series data pooled by country or manufacturing subsector. The absence of similar data sets for developing countries has precluded the same type of analysis of their production structures. This is unfortunate since the impact of higher energy prices on these countries has been at least as severe as on the industrial countries. Furthermore, since it is likely that their structure of production is significantly different, the results of the existing econometric literature may not be applicable in understanding the role of energy prices in their economies.

Because Indonesia is an oil exporter, its readjustment to higher energy prices differed from that of most of the developing world. Nevertheless, Indonesia is still a poor country, with a 1980 per capita gross domestic product (GDP) of only $430. Continued growth of energy consumption at an annual rate of more than 10 percent (1974–1979) threatens to turn Indonesia into a net energy importer by the end of this century (Gillis, 1980). Underlying this rapid rate is the huge economic subsidy provided energy in Indonesia. As of December 1981, the weighted average price

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of energy in Indonesia was only 35 percent of the international price—as low as 18 percent for kerosene and as high as 79 percent for gasoline. The energy subsidy amounted to 5.4 percent of GDP in 1981–82. One often stated justification for retaining the subsidy is the supposedly adverse effect of higher energy prices on Indonesia's rapidly growing manufacturing sector and the competitiveness of its products in international export markets.

A better understanding of the effect of raising energy prices on the Indonesian manufacturing sector could be achieved if estimates of own- and cross-price elasticities for individual fuels were available. Given the widely different levels of energy consumption across industries, and their heterogeneous nature, these elasticities would best be estimated on an industry-by-industry basis. The difficulty is that Indonesia, like most developing countries, does not have a sufficiently long time series for this kind of analysis.

This paper avoids the time-series data constraint by making use of firm-level sample survey cross-section data. These data, containing information on the operation of thousands of manufacturing firms, permit me to estimate production structures with five energy inputs for 27 manufacturing subsectors. The approach is similar to the two-stage procedure of Fuss (1977) and Pindyck (1979). It differs in that I estimate a variable cost function, which requires cost minimization only among a subset of inputs, and because the estimation procedure takes into consideration the prevalence of corner solutions (nonconsumed inputs) in firm-level data. Because of the wide spatial variation in prices characteristic of island Indonesia, as well as the large number of observations, it is possible to estimate variable cost functions with these kinds of data.

THE MODEL

It is assumed that the production function is weakly separable in the major kinds of energy inputs. Thus, the cost-minimizing mix of energy inputs is independent of the mix of aggregate factors—capital, labor, and materials. Furthermore, if the energy aggregate is homothetic in its components (electricity, gasoline, fuel oil, diesel, and kerosene), cost-minimization becomes a two-stage procedure—optimize the mix of fuels that make up the energy aggregate and then optimize the mix of the energy aggregate, labor, capital, and materials. Finally, it is assumed that materials are weakly separable from the labor, capital, and energy inputs. This assumption is necessary because the data required to construct a materials price index are not available. These assumptions on the structure of production can be summarized by the following production function:

$$Q = F([K, L, E\ (E_1, E_2, E_3, E_4, E_5)]; M) \tag{1}$$

where K, L, and M are capital, labor, and materials respectively, and E is the energy aggregate, which is a homothetic function of the five fuels.

The most common approach to deriving cost functions assumes that firms minimize the total cost of production with respect to all inputs. Such an approach assumes full static equilibrium. Alternatively, one can model the firm as optimizing with respect to a subset of inputs conditional on the quantities of "quasi-fixed" inputs. If factor prices and output levels are exogenously determined and if capital is treated as a quasi-fixed factor, duality implies that cost-minimization given the production function (1) can be uniquely represented by a variable cost-function of the form

$$CV = G(g[P_L,\ P_E(P_{E_1}, P_{E_2}, P_{E_3}, P_{E_4}, P_{E_5}),\ K, Q]; M) \tag{2}$$

where P_E is an aggregate price index for energy.

In Fuss (1977) and Pindyck (1979), the price of energy P_E, which is also unit energy cost to the optimizing firm, is represented by an arbitrary unit cost function. Estimation of this cost function provides estimates of the elasticities of substitution among alternative fuels as well as their own- and cross-price demand elasticities. In addition, estimates of the parameters of the energy cost function can be used to calculate $\hat{P}_E$, an estimate of the energy price index, up to an arbitrary scaling factor. In the second stage, variable cost of industrial output is represented by a nonhomothetic cost function, and $\hat{P}_E$ is used as an instrumental variable for the price of energy. Estimation of this aggregate cost function provides estimates of variable cost elasticities of substitution and demand elasticities for capital, labor, and energy aggregates.

In the stage in which the demand for aggregate inputs is modeled, the variable cost function (2) is represented by a nonhomothetic translog second-order approximation of the form

$$\begin{aligned} \log CV = {} & \alpha_0 + \Sigma\alpha_i \log P_i + \Sigma\alpha_k \log F_k + \tfrac{1}{2} \sum_i \sum_j \gamma_{ij} \log P_i \log P_j \\ & + \tfrac{1}{2} \sum_k \sum_m \gamma_{km} \log F_k \log F_m + \tfrac{1}{2} \sum_k \sum_i \gamma_{ki} \log F_k \log P_i \\ & + \tfrac{1}{2} \sum_i \sum_k \gamma_{ik} \log P_i \log F_k \end{aligned} \tag{3}$$

where $i, j = E, L$; $k, m = Q, K$, and F_k is the quantity of the kth quasi-fixed factor or output. From Shepard's lemma, the variable cost-minimizing level of use of the ith variable factor $V_i = \partial CV/\partial P_i$. Therefore, input demand functions in terms of cost shares are given by

$$\partial \log CV/\partial \log P_i = \frac{P_i V_i}{CV} = S_i$$

or (4)

$$S_i = \alpha_i + \sum_j \gamma_{ij} \log P_j + \sum_k \gamma_{ki} \log F_k, \qquad i = E, L.$$

The linear share equations (4) can be estimated b the usual Zellner-efficient techniques. Since the two variable input shares must sum to 1, only one of them needs to be estimated. To identify the parameters α_0, α_i, α_k and γ_{km}, the variable cost function itself (3) must be estimated along with any one of the share equations (4).

In order that the variable cost function and the share equations satisfy the properties of a neoclassical production structure, the following parameter restrictions are required:

$$\sum_i \alpha_i = 1, \quad \sum_j \gamma_{ij} = \sum_i \gamma_{ij} = 0, \quad \sum_i \gamma_{ik} = 0, \quad \gamma_{ij} = \gamma_{ji}, \quad i \neq j,$$
$$\gamma_{ik} = \gamma_{ki}, \quad \gamma_{km} = \gamma_{mk}, \quad m \neq k$$

In the stage in which the demand for alternative fuels is modeled, the price of energy (the cost per unit to the optimizing firm) can be represented by a homothetic translog cost function with constant returns to scale (Fuss, 1977; Pindyck, 1979):

$$P_E = \beta_0 + \sum_i \beta_i \log P_i + \sum_i \sum_j \beta_{ij} \log P_i \log P_j \tag{5}$$

Cost minimization implies demand equations in terms of each fuel's share in aggregate energy cost.

$$S_i = \beta_i + \sum_j \beta_{ij} \ln P_j, \qquad i = 1, \ldots, 5 \tag{6}$$

with the following parametric restrictions:

$$\sum_i \beta_i = 1, \quad \sum_j \beta_{ij} = \sum_i \beta_{ij} = 0, \quad \beta_{ij} = \beta_{ji}, \quad i \neq j.$$

Error terms are appended to (6) to reflect errors in optimization, errors in measuring the observed shares, and other random disturbances.

Estimation of such input demand equations as these presents special problems when the data are at the level of the firm. As would be expected, most firms do not use all five fuels. Standard approaches to estimating this model result in inconsistent parameter estimates because the random disturbances have nonzero means and are correlated with the exogenous variables. Moreover, dropping those firms that do not use all of the inputs would reduce the sample size severely and still result in biased estimates.[1]

What is required is an estimator that allows for a pile-up of density whenever the use of one or more inputs is zero. A multivariate extension of the limited dependent model of Tobin (1958) (tobit) provides a likely candidate for estimating equations such as (6) since it provides for a positive probability of observing zero input levels. Occasionally, only one fuel is used by a firm, and thus allowance must also be made for a pile-up of density for unit shares. Rosett and Nelson (1975) have extended Tobin's model to the case of double truncation, and theirs seems the appropriate estimator in this situation.

The parameter estimates obtained by the application of a tobit-type estimator to the share equations (6) are not those of a cost function. When corner solutions occur, marginal rates of transformation may not equal the input price ratios. The relationship between optimal input levels and prices thus depends on whether the relevant Kuhn-Tucker first-order conditions are met with equality, that is, whether the *unconstrained* cost minimum occurs at some point where an input's use is negative.

In general, optimal shares are given by (6) only if none of the input nonnegativity restrictions are binding. The formulation and estimation of production and demand structures in the presence of corner solutions is a problem that is not easily solved. Our approach is to estimate the share equations (6), treating them as reduced-form input demand equations. As the estimated coefficients are not those of an underlying cost function, the usual symmetry restrictions of cost functions are not applicable. In any case, the lack of a computationally tractable multivariate estimator requires us to estimate the equations singly. Homogeneity of degree zero in prices is imposed. There is no guarantee that predicted shares will add up.

The energy price index, $\hat{P}_E$, is approximated by a geometric index

$$\ln \hat{P}_E = \Sigma_i \hat{S}_i^* \ln P_i \tag{7}$$

where

$$\hat{S}_i^* = \hat{S}_i / \Sigma_i \hat{S}_i \tag{8}$$

1. This bias, known as sample selection bias, comes about because firms that would choose a lower-than-average fuel share, given prices, may not use the fuel at all, thus truncating the observed energy share distribution.

where $\hat{S}_i$ is the expected value of S_i. The normalization of these expected values (8) is required to guarantee the linear homogeneity of the price index $\hat{P}_E$ in the individual fuel prices. Note that by substituting the share equations (6) into the translog cost function (5), a translog price index can also be written as a geometrically weighted price index, with shares as weights.

In summary, the complete model is estimated through the following two-stage procedure:

1. Estimate the set of share equations (6) with a doubly truncated tobit estimator. An estimate of an aggregate price index $\hat{P}_E$ is obtained by using the normalized expected shares as weights in (7).
2. Estimate the cost function (3) along with one share equation (4) by Zellner-efficient techniques, replacing P_E by its instrumental variable $\hat{P}_E$.

DATA

The data used in the estimation are taken from the Industrial Surveys (Survai Industri) of 1976, 1977, and 1978, conducted by the Central Bureau of Statistics (Biro Pusat Statistik) of the Republic of Indonesia. These surveys contain information on the activities of a large sample of Indonesian manufacturing establishments with 20 or more employees.[2]

The five energy inputs studied—electricity, gasoline, fuel oil, diesel fuel, and kerosene—accounted for about 86 percent of total energy use by value of large and medium-sized manufacturing firms in 1977. Local market price data for energy inputs were available for all firms. Although the government nominally set the wholesale price of petroleum-derivative fuels during the period 1976–78, actual prices at the point of final sale varied. For example, offical published statistics for 1976 demonstrate *average* provincial retail prices for kerosene ranging from Rp 29.11 to

2. As these are multiple cross-sections, many firms appear more than once in the data, leading to the possibility that disturbances may not be independent. Allowing for a firm-specific time-invariant random variable is troublesome in the tobit context. If the firm-specific component is independent of the other exogenous variables, we have the tobit version of the variance components model. Estimation is burdensome computationally since evaluation of a two-dimensional normal integral is required. An alternative approach, the fixed-effect model, requires direct estimation of the firm-specific effects and a long time series for consistency. Robinson (1982) has demonstrated that under mild weak-dependence conditions of the disturbance, the tobit estimator is strongly consistent and asymptotically normal although not in general asymptotically efficient. Reported standard errors may be biased.

Rp 60.62 per liter. The range of prices in 1977 and 1978 was of the same magnitude. It is the substantial spatial variation of prices characteristic of Indonesia (as well as the large sample size) that makes it possible to estimate price response from cross-section data with reasonable precision.

Direct measures of capital stock are not available from the manufacturing surveys. Instead, capital was measured as the horsepower of installed machines except electric power generators. Although horsepower is probably a poor measure of the intersectoral variance of capital input, it may do a good job of capturing intrasectoral interfirm variations in capital. This is all that is required with the relatively fine sectoral disaggregation with which we are working.

EMPIRICAL RESULTS

The model described earlier was estimated separately for seven two-digit ISIC sectors: 31, 32, 33, 34, 35, 36, and 38. Even at the two-digit level, it seems likely that product mix is not homogeneous across firms. That is, the cost functions for the three-digit sectors that make up a two-digit sector may vary. Therefore it would be inappropriate to estimate only a single cost function for each two-digit sector. To avoid the cost of estimating separate models for all three-digit sectors, but still get at intersectoral differences in elasticities, dummy variables representing three-digit ISIC codes were introduced. These dummy variables allow the intercepts of the share equations and the intercepts and linear-term parameters of the cost equations to vary. In addition, because it is likely that product mix and production efficiency are also not homogeneous across regions, dummy variables representing firm location—Java-Madura or Outer Islands, urban or rural—were introduced in the same manner. Thus, there are four different cost functions, one for each geographic location, for each of 27 three-digit sectors for a total of 108. A description of the three-digit sectors identifed in the analysis is found in the Appendix.

The Energy Submodel

Table 1 presents estimates of the energy submodel for sectors 31 (agricultural processing) and 38 (fabricated metal products, machinery, and transport equipment). The parameter estimates of the other five energy submodels are not presented for reasons of space. The complete set of parameter and elasticity estimates and formula are available from the author. Five share equations were estimated by doubly truncated tobit maximum-likelihood methods for each of the seven two-digit sectors analyzed. The dependent variables were the shares of electricity, gasoline, fuel oil, diesel, and kerosene. The set of independent variables is the same in each share equation: the logarithms of the prices of the five fuels and dummy variables for island location (Java or Outer Islands), urban/rural location, and for all but one three-digit sector. Prices for fuels were expressed in rupiah per ton of oil equivalent.

Estimated own- and cross-price elasticities for 2 of the 27 three-digit sectors (311 and 381) are presented in Table 2. These are partial elasticities, reflecting the substitution possibilities among energy inputs that are consistent with a constant level of aggregate energy input. All the own-price elasticities in Table 2 are significantly different from zero, and 7 of the 10 are different from -1 at the .01 level. Eleven of 20 cross-price elasticities are significantly different from zero in both of the three-digit sectors of Table 2. All of these 11 are greater than zero in sector 311, and 10 of 11 are greater than zero in sector 381.

Of the 134 own-price elasticities estimated for all 27 sectors, 117 are significantly different from zero at the .05 level of significance.[3] Of these, 90 are less than -1, indicating elastic demand. Most of the inelastic own-price response is for fuel oil and electricity. Indeed, 16 out of 27 and 13 out of 27 own-price elasticities for fuel oil and electricity respectively are greater than -1. Price responsiveness would appear to be significant and pervasive but also to vary substantially in magnitude across fuels and sectors.

Out of 546 total cross-price elasticities, 266 are significantly different from zero. The large number of statistically significant cross-price elasticities is indicative of the precision of the estimates with cross-section data. As expected, most fuels in most sectors are substitutes—233 out of the 266 statistically significant cross-price elasticities are positive. Of some interest, the statistically significant cross-price elasticities of all fuels for all sectors with respect to the price of electricity are positive. Among pair-wise patterns of substitutability, fuel oil and electricity seems to be one of the strongest. Twenty-four of the 27 fuel-oil elasticities with respect to the price of electricity are statistically significant and positive, as are 18 of 27 electricity with respect to fuel-oil price elasticities. In addition, the elasticity of kerosene demand with respect to the price of fuel oil is large and significant in 18 of 27 cases, and exceeds 1.0 in 17 of the sectors studied. Thus, increases in the price of fuel oil may induce substantial substitution of kerosene for fuel oil in many manufacturing

3. Five own-price elasticities have positive signs, thus violating the postulate of cost-minimizing factor demand theory. None of these elasticities is statistically different from zero even at very weak levels of significance. Fuel shares in these cases are very small, and thus the elasticities are not very meaningful.

Table 1. Parameter Estimates of the Energy Share Equations

	Exogeneous Variables											
Shares	*Electricity*	*Gasoline*	*Fuel Oil*	*Diesel*	*Kerosene*	*Java*	*Urban*	*SSect1*	*SSect2*	*SSect3*	*SSect4*	*Intercept*
					Sector 31 (N = 3125):							
Electricity	−0.2354	−0.0940	0.0806	0.1826	0.0663	−0.2728	0.4692	−0.3764	−0.6339	−0.1360		0.9044
	0.0504	0.1510	0.0891	0.0866	0.1046	0.0316	0.0231	0.0360	0.0398	0.0670		0.1829
Gasoline	0.0031	−0.4496	−0.0832	0.2566	0.2731	−0.0508	−0.1147	−0.4654	−0.3549	−0.1214		0.7791
	0.0500	0.1338	0.0832	0.0784	0.0951	0.0284	0.0213	0.0335	0.0354	0.0628		0.1666
Fuel oil	0.1667	−0.0729	−0.2040	−0.0987	0.2089	0.3360	−0.1977	0.3827	0.5584	0.1636		0.2616
	0.0495	0.1357	0.0808	0.0778	0.0947	0.0281	0.0212	0.0368	0.0391	0.0684		0.1680
Diesel	−0.1123	1.4570	−0.1985	−1.3401	0.1939	−0.1105	−0.0451	0.3578	0.0910	−0.2745		−2.3434
	0.1057	0.2886	0.1769	0.1543	0.2032	0.0608	0.0430	0.0847	0.0909	0.1956		0.3655
Kerosene	0.0255	0.3352	0.4009	0.2738	−1.0353	−0.2338	−0.0140	0.2209	0.2038	0.2364		−0.8575
	0.0601	0.1646	0.0990	0.0950	0.1062	0.0358	0.0255	0.0452	0.0479	0.0811		0.2026
					Sector 38 (N = 1329)							
Electricity	−1.1387	0.3465	0.0982	0.3771	0.3169	−0.3328	0.4508	−0.3410	−0.0151	−0.4004	−0.2573	2.6393
	0.0850	0.1769	0.1104	0.1450	0.1553	0.0556	0.0455	0.1141	0.1173	0.1206	0.1175	0.2670
Gasoline	0.0224	−0.1276	−0.0889	−0.1147	0.3089	0.0045	0.0318	0.0405	0.0252	0.1112	0.1255	0.0307
	0.0477	0.0970	0.0631	0.0840	0.0875	0.0306	0.0244	0.0644	0.0669	0.0678	0.0664	0.1493
Fuel Oil	0.7406	−0.2069	−0.0985	−0.2905	−0.1447	0.2185	−0.3112	0.4188	0.2578	0.4766	0.4148	−1.4660
	0.0701	0.1458	0.0864	0.1195	0.1268	0.0428	0.0346	0.1038	0.1068	0.1086	0.1063	0.2237
Diesel	0.3561	0.2286	−0.0238	−0.1493	−0.4115	−0.1557	−0.1221	1.2000	0.9998	1.2232	0.9379	−2.6703
	0.0517	0.1104	0.0665	0.1564	0.1013	0.0370	0.0247	0.3133	0.3142	0.3141	0.3143	0.3487
Kerosene	0.0459	0.1115	0.1971	0.1854	−0.5398	0.0519	−0.0025	−0.2616	−0.2684	0.2226	−0.2859	−0.1198
	0.0464	0.0961	0.0587	0.0794	0.0796	0.0299	0.0239	0.0570	0.0595	0.0605	0.0595	0.1400

Note: SSect1 to SSect3 in Sector 31 refer to subsectors 311, 312, and 313. SSect1 to SSect4 in Sector 38 refer to subsectors 381, 382, 383, and 384. Asymptotic standard errors below coefficients. Column headings with fuel names refer to prices.

Table 2. Partial Fuel Price Elasticities

	Electricity	*Gasoline*	*Fuel Oil*	*Diesel*	*Kerosene*
			Sector 311		
Electricity	−1.3388	−0.0166	0.3813	0.6138	0.3487
	0.1149	0.3440	0.2030	0.1974	0.2383
Gasoline	0.1088	−2.3020	−0.1602	0.8987	0.9502
	0.1558	0.4168	0.2592	0.2442	0.2962
Fuel oil	0.6944	0.3694	−0.8084	0.3345	0.7517
	0.0671	0.1840	0.1096	0.1056	0.1284
Diesel	−0.1922	3.4725	−0.3936	−4.0597	0.5228
	0.2468	0.6739	0.4130	0.3604	0.4746
Kerosene	0.1896	0.9904	1.1603	0.8318	−3.5536
	0.1554	0.4256	0.2561	0.2457	0.2747
			Sector 381		
Electricity	−2.8214	0.9196	0.4613	0.9761	0.8649
	0.1569	0.3265	0.2038	0.2675	0.2866
Gasoline	0.2181	−1.3492	−0.2028	−0.3002	1.3016
	0.1806	0.3670	0.2387	0.3176	0.3307
Fuel oil	1.6326	0.0739	−0.7477	−0.0637	0.1763
	0.1152	0.2399	0.1420	0.1965	0.2085
Diesel	1.2988	0.8543	−0.0260	−1.4636	−1.3779
	0.1802	0.3849	0.2318	0.5452	0.3533
Kerosene	0.3023	0.6443	1.0906	1.0295	−3.7509
	0.2420	0.5011	0.3061	0.4139	0.4150

Note: Row headings are quantities; column headings are prices. Approximate standard errors below elasticities.

sectors. This is of interest because Indonesia has heavily subsidized kerosene (the primary fuel of the household sector), since the early 1970s. Recently, the rate of subsidization has fallen, resulting in a significantly lower fuel oil/kerosene price ratio.

The Aggregate Model

The aggregate model estimates the parameters of the underlying variable cost function containing capital, output, labor, and aggregate energy as factors. Capital and output are treated as fixed, and the price of energy is measured as a price index whose weights are derived from the estimated energy submodel. In addition, the same set of location and three-digit ISIC dummy variables that appeared in the energy submodel are included in the estimation of the aggregate cost function. Note that these dummy variables allow both the intercept and first-order slope terms for all factors in the cost funtion to vary. Table 3 presents the results of estimating

Table 3. Parameter Estimates of the Aggregate Model

	Sector 31		*Sector 38*	
Intercept	8.976	(0.508)	8.575	(0.996)
P_L	1.138	(0.0492)	1.3266	(0.054)
K	−0.5773	(0.0635)	0.130	(0.115)
Y	0.0825	(0.0751)	0.148	(0.124)
P_E	−0.138	(0.0492)	−0.326	(0.0538)
Java	1.439	(0.173)	−0.0595	(0.2675)
Urban	0.223	(0.130)	−0.300	(0.215)
SSect1	0.152	(0.241)	−1.049	(0.867)
SSect2	−0.132	(0.278)	−1.094	(0.890)
SSect3	0.654	(0.525)	−1.913	(0.894)
SSect4	—	—	−1.183	(0.885)
$P_E * P_L$	−0.0195	(0.0047)	−0.0405	(.0052)
$P_E * P_E$	0.0195	(0.0047)	0.0405	(.0052)
$P_L * P_L$	0.0195	(0.0047)	0.0405	(.0052)
$K * P_E$	0.0190	(0.0019)	0.0142	(.0022)
$K * P_L$	−0.0190	(0.0019)	−0.0142	(.0022)
$Y * P_E$	0.0013	(0.0020)	0.0105	(.0024)
$Y * P_L$	−0.0013	(0.0020)	−0.0105	(.0024)
$K * K$	0.0955	(0.0078)	0.0048	(.0089)
$Y * Y$	0.0346	(0.0065)	0.0047	(.0093)
$K * Y$	0.0141	(0.0056)	−0.0002	(.0067)
Java*K	0.0076	(0.0183)	−0.0836	(.0350)
Urban*K	−0.0321	(0.0137)	−0.0138	(.0243)
SSect1*K	0.0323	(0.0286)	−0.0545	(.0944)
SSect2*K	0.1040	(0.0308)	0.0190	(.0974)
SSect3*K	0.1760	(0.0553)	−0.1122	(.0954)
SSect4*K	—	—	−0.0637	(.0943)
Java*Y	−0.160	(0.0164)	0.0075	(.0305)
Urban*Y	−0.0304	(0.0127)	0.0323	(.0227)
SSect1*Y	−0.116	(0.0230)	0.1110	(.0836)
SSect2*Y	−0.135	(0.0265)	0.1008	(.0873)
SSect3*Y	−0.187	(0.0568)	0.2168	(.0850)
SSect4*Y	—	—	0.1491	(.0852)
Java*P_E	0.0139	(0.0068)	0.0102	(.0088)
Urban*P_E	0.0328	(0.0052)	−0.0029	(.0072)
SSect1*P_E	0.0105	(0.0104)	−0.0599	(.0193)
SSect2*P_E	0.0160	(0.0122)	0.0134	(.0198)
SSect3*P_E	0.0664	(0.0176)	0.0345	(.0204)
SSect4*P_E	—	—	0.0173	(.0199)
Java*P_L	−0.0139	(0.0068)	−0.0102	(.0088)
Urban*P_L	−0.0328	(0.0052)	0.0029	(.0072)
SSect1*P_L	−0.0105	(0.0104)	−0.0599	(.0193)
SSect2*P_L	−0.0160	(0.0122)	−0.0134	(.0198)
SSect3*P_L	−0.0664	(0.0176)	−0.0345	(.0204)
SSect4*P_L	—	—	−0.0173	(.0199)

Note: Numbers in parentheses are asymptotic standard errors.

variable cost function jointly with the energy share equation for sectors 31 and 38.[4]

Own- and cross-price elasticities for variable factors are presented in Table 4. In a model with only two variable factors, cross-price elasticities are equal to minus the own-price elasticities, that is, $\eta_{EL} = -\eta_{EE}$ and $\eta_{LE} = -\eta_{LL}$. All the own-price elasticities for energy and labor are negative and significantly different from zero at the .05 level with the sole exception of the own-price elasticities of sector 332. For energy, own-price elasticities range from -0.074 in the wood furniture sector (332) to -0.830 in cement and cement products (363). Other sectors that are more responsive to changes in energy prices are structural clay products (ISIC 364, $\eta_{EE} = -0.786$), other nonmetallic mineral products (ISIC 369, $\eta_{EE} = -0.753$), and beverages (ISIC 313, $\eta_{EE} = -0.705$). Only one own-price energy elasticity has an absolute value less than 0.34, while 21 out of 27 of them are above 0.50. These results are comparable to the range of estimates found by other investigators and surveyed in Pindyck (1979).

Own-price elasticities for labor ($=\eta_{LE}$) are generally much smaller in magnitude than they are for energy. They range from -0.006 in the wood furniture sector (332) to -0.449 in ceramics and porcelain (361). Moreover, 25 out of 27 of them are less than 0.25 in absolute value, and 12 of these are less than 0.10. In every sector, the own-price responsiveness of labor was less than that of energy. Pindyck (1979) obtained a similar result in the 10 developed countries he studied. Remember, however, that our elasticities are conditional on capital's being quasi-fixed. The Le Chatelier principle requires that the own-price response of variable factors decrease in absolute value with the number of quasi-fixed factors.

Table 4 provides estimates of the elasticities of average total cost with respect to the price of aggregate energy and each of the five fuels. These elasticities tell us the effect of energy price increases on the total cost of output, assuming constant levels of output and capital. If total cost is exhaustive of output—that is, unit total cost equals the ex-factory unit price of output—these elasticities represent proportional increases in the prices of manufactured output in response to a rise in the price of energy.

Four subsectors in the two-digit sector 36, nonmetallic mineral products, are the most cost-sensitive. The largest cost–energy-price elasticities are 0.157 in ceramics and porcelain (361) and 0.080 in glass and glass

4. The parametric restrictions necessary for homotheticity and homogeneity were tested for all seven cost functions. Since these are nested hypotheses, homotheticity was tested first, and then, conditional on the validity of that hypothesis, homogeneity was tested. The overall level of significance is set at 0.05, divided equally between the two tests. Homotheticity is rejected in all cases except sectors 31, 33, and 34. Proceeding conditionally on the hypothesis of homotheticity for these sectors, homogeneity is not rejected only for sector 34.

Table 4. Energy and Total Cost Elasticities

Sector	$\eta_{EE}{}^a = -\eta_{EL}$	$\eta_{LL}{}^a = -\eta_{LE}$	$\eta_{TC,E}$	$\eta_{TC,1}{}^b$	$\eta_{TC,2}{}^b$	$\eta_{TC,3}{}^b$	$\eta_{TC,4}{}^b$	$\eta_{TC,5}{}^b$
311	−0.7053 (0.0244)	−0.1704 (0.0059)	0.0184	0.0038	0.0019	0.0090	0.0013	0.0024
312	−0.6777 (0.0196)	−0.2160 (0.0063)	0.0296	0.0032	0.0044	0.0173	0.0010	0.0036
313	−0.7207 (0.0349)	−0.1132 (0.0055)	0.0136	0.0050	0.0030	0.0037	0.0002	0.0017
314	−0.6899 (0.0542)	−0.0662 (0.0052)	0.0028	0.0011	0.0008	0.0006	0.0001	0.0002
3211	−0.6214 (0.0239)	−0.1619 (0.0062)	0.0300	0.0185	0.0015	0.0064	0.0015	0.0021
321	−0.6045 (0.0358)	−0.0968 (0.0057)	0.0213	0.0113	0.0016	0.0063	0.0006	0.0015
322	−0.4641 (0.0637)	−0.0390 (0.0054)	0.0099	0.0076	0.0012	0.0009	0.0001	0.0001
323	−0.6184 (0.0306)	−0.1191 (0.0059)	0.0078	0.0036	0.0007	0.0029	0.0003	0.0002
324	−0.4749 (0.0619)	−0.0412 (0.0054)	0.0141	0.0071	0.0023	0.0039	0.0004	0.0005
331	−0.4168 (0.0440)	−0.0775 (0.0082)	0.0222	0.0015	0.0041	0.0159	0.0004	0.0002
332	−0.0742 (0.0873)	−0.0064 (0.0075)	0.0220	0.0079	0.0039	0.0101	0.0000	0.0001
341	−0.4923 (0.0416)	−0.1107 (0.0093)	0.0235	0.0041	0.0027	0.0125	0.0025	0.0016
342	−0.3724 (0.0656)	−0.0491 (0.0086)	0.0240	0.0142	0.0040	0.0038	0.0004	0.0016
351	−0.5747 (0.0331)	−0.1637 (0.0094)	0.0377	0.0047	0.0030	0.0246	0.0038	0.0016
352	−0.5013 (0.0618)	−0.0676 (0.0083)	0.0134	0.0039	0.0030	0.0049	0.0003	0.0013
355	−0.5679 (0.0288)	−0.1947 (0.0099)	0.0141	0.0032	0.0014	0.0069	0.0016	0.0009
356	−0.5749 (0.0357)	−0.1487 (0.0092)	0.0289	0.0069	0.0022	0.0165	0.0023	0.0009
361	−0.5252 (0.0228)	−0.4489 (0.0195)	0.1567	0.0274	0.0109	0.0482	0.0565	0.0136
362	−0.6400 (0.0308)	−0.3314 (0.0159)	0.0799	0.0154	0.0045	0.0196	0.0351	0.0053
363	−0.8295 (0.0918)	−0.1071 (0.0118)	0.0293	0.0099	0.0037	0.0142	0.0008	0.0007
364	−0.7856 (0.0588)	−0.1706 (0.0128)	0.0752	0.0032	0.0054	0.0480	0.0123	0.0062
369	−0.7528 (0.0482)	−0.2095 (0.0134)	0.0486	0.0004	0.0044	0.0402	0.0023	0.0013
381	−0.5795 (0.0349)	−0.1016 (0.0061)	0.0166	0.0049	0.0023	0.0072	0.0010	0.0011
382	−0.5173 (0.0483)	−0.0626 (0.0058)	0.0210	0.0107	0.0026	0.0058	0.0005	0.0013
383	−0.5567 (0.0405)	−0.0821 (0.0060)	0.0117	0.0035	0.0020	0.0047	0.0007	0.0008
384	−0.5030 (0.0508)	−0.0575 (0.0058)	0.0093	0.0030	0.0017	0.0038	0.0002	0.0005
385	−0.4114 (0.0656)	−0.0355 (0.0057)	0.0097	0.0053	0.0011	0.0015	0.0000	0.0018

[a]Elasticities are followed by approximate standard errors in parentheses.
[b]1 = electricity, 2 = gasoline, 3 = fuel oil, 4 = diesel, 5 = kerosene.

products (362). After four nonmetallic minerals sectors, the most energy-cost-sensitive sectors are basic chemicals (351), spinning and weaving (3211), other food products (312), and cement products (363). The elasticity of total cost of basic chemicals, ranked fifth out of 27, is only one-fourth that of the first-ranked sector. For 18 out of 27 sectors analyzed, a 1 percent increase in energy prices results in a 0.025 percent increase in total costs or less. These total cost elasticities would appear to be about the same as Fuss (1977) found for Canadian manufacturing (0.03) but somewhat lower than most estimates of Pindyck (1979) for the manufacturing sectors of 10 industrialized countries. His estimates for 1972 ranged from 0.032 in the United States to 0.067 in Italy. The simple average of the Indonesian total cost elasticities is about 0.029, which is the same as Pindyck's estimate for the United States manufacturing sector in 1963.

Table 4 also provides estimates of total cost elasticities with respect to the prices of individual fuels. Nonmetallic mineral sectors dominate the top ranks in all cases. Fuel oil's price would appear to be the most important of the five in influencing costs of production, with kerosene being least important. All five textile sectors (32), as well as beverages (313), tobacco (314), printing and publishing (342), machinery (382), and measuring and optical equipment (385), are more cost-sensitive to the price of electricity than to any other fuel price. The ceramic and porcelain (361) and glass and glass products (362) sectors are most sensitive to the price of diesel. All other sectors are more cost-sensitive to the fuel-oil price than to any other fuel price.

To study the effects of large increases in energy prices, the estimated cost equations have been used to predict energy demand and variable cost for a doubling of energy prices. As noted, such an increase in price would not have been sufficient to bring a weighted average energy price up to its international level as of December 1981. A doubling of energy prices induces a reduction in energy consumption in the range of 30 to 40 percent for most sectors. Only in wood furniture manufacturing (332) is the reduction less than 20 percent. In 17 of 27 sectors, the doubling of energy prices results in less than a 2 percent rise in total cost. Besides the nonmetallic mineral sectors (36), the sectors most affected are basic chemicals (351), spinning and weaving (3211), other food products (312), plastic wares (356), and printing and publishing (342).

Are these cost elasticities large? That is, would increasing energy prices in Indonesia result in a significant loss of competitiveness for manufacturing sectors and serious inflationary pressure? A 3 percent increase in total costs resulting from a doubling of energy prices does not seem large. Indeed, for 23 out of 27 sectors, the cost increase would be less than this. This cost increase seems particularly small when compared with the effect on total costs of such government interventions as tariffs, sales taxes, export incentives, subsidized borrowing, and investment regulation. Relatively minor alterations in these programs will have a much greater impact on the competitiveness and prices of most manufacturing subsectors than the largest energy price adjustments considered (Pitt 1981a, 1981b).

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APPENDIX THREE-DIGIT ISIC CODES

31		
	311	Food processing
	312	Other food products
	313	Beverages
	314	Tobacco products
32		
	3211	Spinning and weaving
	321	Textiles except 3211
	322	Wearing apparel
	323	Leather and leather substitutes
	324	Leather footwear
33		
	331	Wood and wood products
	332	Wood furniture
34		
	341	Paper and paper products
	342	Printing and publishing
35		
	351	Basic chemicals
	352	Other chemical products
	355	Rubber products
	356	Plastic wares
36		
	361	Ceramic and porcelain
	362	Glass and glass products
	363	Cement and cement products
	364	Structural clay products
	369	Other nonmetallic metal products
38		
	381	Fabricated metal products
	382	Machinery except electrical
	383	Electrical machinery
	384	Transport equipment
	385	Measuring and optical equipment