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THE PRICE RESPONSIVENESS OF ENERGY DEMAND IN THE PHILIPPINE FOOD PROCESSING SECTOR

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This study attempts to derive reliable estimates of the price elasticity of demand for energy and the elasticities of substitution among labor, capital and energy in Philippine production. Three different methods of increasing complexity are fitted to data for firms employing twenty or more workers, based on annual surveys of the National Census and Statistics Office. The food processing sector in Philippine manufacturing was chosen as the testing ground for the types of analyses proposed.

Findings show a greater degree of price responsiveness of energy demand in the 1970-78 period for the food processing industry than what previous aggregative studies have reported. Furthermore, energy, labor and capital are found to be substitutes for each other.

1. Introduction

The problem addressed by the study was that of deriving reliable estimates of the price elasticity of demand for energy and the elasticities of substitution among labor, capital and energy in Philippine production.

The price elasticity of demand is a measure of the responsiveness of the quantity demanded of a commodity to a change in its real price. The elasticity of substitution between two inputs, on the other hand, is a measure of the responsiveness of the ratio of usage of the two inputs in production to a unit percentage change in the ratio of their respective prices. The larger the absolute elasticity of substitution, the easier it is to switch between the two inputs in response to price changes.

Provision of reliable estimates of these two elasticity concepts is deemed crucial inasmuch as energy pricing is one of several tools currently employed by the government to achieve its energy conservation targets. Specifically, it has imposed various taxes on different energy forms, thereby raising energy prices beyond what market

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forces would have equilibriated to (Table 1). The feasibility and desirability of such a policy significantly depends on the price elasticity of energy demand and on the nature of its impacts on capital formation and employment in the production sector.

The basic strategy employed in this study was to compare different models of energy demand that have appeared in recent iterature by fitting them to a common data set. More sophisticated techniques of data construction were used to counter some of the criticisms on earlier works. Given the complexity of the task at hand, and the need to use less aggregated data, a subsector of Philippine manufacturing was chosen to provide a testing ground for the types of analyses proposed. It was hoped that if the study was fruitful, it could then be extended to cover a broader sector of the economy. Meanwhile, the study focused on the food processing sector of the Philippines, using survey data for the period 1970 to 1978, in the midst of which the first international oil shock transpired.[1]

2. The Food Processing Industry

The food processing industry has consistently been the largest single component of the Philippine manufacturing sector during the entire postwar era. Some industry trends are summarized by statistical tables in the Appendix. From 1955 to 1980, exports of food products comprised from at least 24 to 36 per cent of F.O.B. dollar earnings from total domestic exports. Over the period 1970 to 1980, the industry accounted for over thirty per cent of gross value added in manufacturing, and roughly a quarter to almost thirty per cent of total manufacturing employment. For the period 1974 to 1979,[2] the industry ranked third among major industrial energy users, specifically the subsectors involved in sugar milling, and coconut and vegetable oil processing. The industry is looked upon as a major absorbent of the burgeoning work force and as a strong potential source of direly needed export growth. However, it is beset by serious problems, primary of which is the weak performance of its major raw materials supplier — the agricultural sector. Another problem facing the industry is the shortage of packaging materials of good quality, especially tin cans. There has been a notable trend towards backward integration among the larger firms in the industry,

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[1] A sequel to the study is already underway, this time focusing on the textile industry.

[2] Inadequcy of data on energy consumption at the industry level limits the discussion to this period.

Table 1 — Energy Taxes As A Percentage Of Oil Company Take
(in per cent)

	Premium Gas	Avturbo	Diesel	Fuel Oil	Kerosene	LPG
January 1973	27.1	9.0	0.1	0.2	10.6	5.1*
February 1974	35.7	7.2	15.9	2.0	7.9	6.7
January 1976	39.6	19.1	20.2	12.3	11.5	11.4
August 1979**	90.2	74.7	19.5	14.6	11.0	12.5
March 1981**	100.4	73.8	18.5	10.6	12.3	14.1
July 1983	61.1	34.8	4.1	2.3	1.4	7.7

*As of November 27, 1973.

**Includes contribution to consumer price equalization fund.

Source: Bureau of Energy Utilization

presumably for them to gain better control over raw materials supplies.

Over the period 1974 to 1980, the share of food in total industrial energy use dropped from 7.1 per cent in 1974, to 5.1 per cent in 1980. Energy use in the industry grew at a meager 0.2 per cent per annum, in spite of a 3.9 per cent annual rate of output growth over that period. These trends suggested a substantial conservation effort achieved by the industry. Indeed, a survey of selected firms conducted by the Ministry of Energy showed a certain amount of ingenuity in this regard. For example, a meat processing firm was found to be using biogas for electricity generation, while a coffee/chocolate manufacturer made use of ground coffee shells to provide [illegible]4 per cent of the fuel stock it required for direct-fuel process heating. In general, it appeared that backward integration permitted more food processing firms to gain access to waste products that could be used as noncoventional fuel sources. Moreover, the typically large scale of operations of such firms made such projects viable.

3. Model Estimation

To derive the desired elasticity estimates, three different models of increasing complexity were fitted to data for firms employing twenty or more workers, primarily gleaned from annual surveys conducted by the National Census and Statistics Office. Observations at the four- and five-digit levels of industrial aggregation were used to generate cross-section data, which were then pooled with time series data over 1970 to 1978 to yield a sample size of seventy-two.[3]

Data and Variables

Data required to fit the three models included the prices of capital, labor and energy; the value or quantity of each used in production; and the quantity of output. Labor was divided into production and nonproduction employees. Energy was disaggregated into electricity and other fuels. Capital was categorized into buildings and structures, production machinery, transport equipment, and other fixed assets.

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[3] Food processing industries included were meat processing (3111), dairy products (3112), fruit canning and preservation (31131), flour milling (31163), bakery products (3117), sugar milling (3118), dessicated coconut manufacture (31211), coffee roasting and grinding (31213), and animal feeds preparation (31221). The numbers in parentheses are the Philippine Standard Industrial Classification (PSIC) codes.

Price indices for inputs were constructed using Divisia aggregation.[4] This essentially consisted of aggregating the prices for the n components under each input category, using a moving average of each component's share in total input expenditure as a weight:

$$ln(P_t) - ln(P_{t-1}) = \sum_{i=1}^{n} \overline{w}_{i,t}\ [\ ln(P_{i,t}) - ln(P_{i,t-1})]$$

where $P_{i,t}$ is the price of the i *th* input component in year t and $\overline{w}_{i,t}$ is the two-year moving average expenditure share of the *ith* input component. The labor price index was therefore a Divisia aggregate of the wage per manhour of production and nonproduction labor. The energy price index was a Divisia aggregate of the price per kilowatt-hour of electricity and a Divisia price index of the other fuels. The capital price index was a Divisia aggregate of the user cost of the four categories of capital. User cost was calculated following Gregorio's (1979) adaptation of the Jorgenson (1963) formula:

$$c = [q\ (r + d)\ (1 - uz)]\ /\ (1 - u)$$

where q is the price index of capital goods, r is the rate of interest fixed at 15 per cent, d is the rate of depreciation, u is the effective tax rate fixed at 35 per cent, and z is the discounted value of depreciation charges generated by a peso of investment.

Labor cost was equated to the sum of production and nonproduction payrolls, with imputation for the labor of working owners and unpaid family workers done at the nonproduction wage rate. Energy cost was set to the sum of electricity purchased and total fuel costs. Capital stock was estimated using the replacement cost approach (Power, 1979). This involved calculating the original acquisition cost *(Kg)* of fixed assets as:

$$Kg = n\,D$$

where n is the number of years over which the asset is depreciated, and D is the annual depreciation charge reported in the survey. Since the life of an asset can be broken down into its age *(T)* and its remaining life (reported book value divided by annual depreciation charge), the age of an asset was estimated from time-series data on investment expenditures. The original cost thus derived was then revalued to current year's prices (Kg^t), using the formula:

$$Kg^t = Kg\ (1 + p)^T$$

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[4] See Diewert (1976) and Berndt (1978).

ːre p is the annual percentage rate of change in prices of capital ds over the period $(t-T)$. Finally, the entire series was deflated obtain a constant cost measure of gross capital stock, and then ıced by the amount of straight-line economic depreciation ːges in order to obtain net capital stock in year t. The quantity ːapital services was then assumed to be proportional to net capital ːk for each category. This was then multiplied by the applicable cost of capital. Capital cost was then equated to the sum of the ducts for all four categories. Total cost was the sum of labor, ːgy and capital costs. Quantity of output was calculated as cen- value added divided by the implicit price index for food manu- ures.

ple Demand Model

The first model used was the usual simple demand model. This sisted of a double-log transformation of a single equation expres- ; quantity of energy demanded *(E)* as a function of the energy ːe index *(PE)*, real output *(Q)*, and time *(T)* proxying for techni- change:

$$1n(E) = a + b\ 1n(Q) + c\ 1n(PE) + d\ T + u$$

ere *1n* stands for the natural logarithm, u is the stochastic dis- bance term, and a, b, c, and d are the coefficients to be estimated. coefficient b is the output elasticity and c is the price elasticity energy demand. The regression equation for this model turned to be:

$$\begin{array}{l} 1n(E) = -1.72 + \underset{(5.2)}{0.23}\ 1n(Q) - \underset{(-2.0)}{0.71}\ 1n(PE) + \underset{(2.8)}{0.10}\ T \end{array}$$

$$R^2 = 0.72$$

ote: Numbers in parentheses are the t-ratios. All slope coefficients are significant at the 0.05 level).

teworthy in the above result were the relatively small *output* elas- ty of energy demand (0.23), the relatively large absolute *price* sticity of energy demand (0.71), and the positive coefficient the time variable, as contrasted with results of other studies ich used aggregate data for the entire economy. The small output sticity was consistent with the fact noted earlier that the food cessing sector was able to maintain an impressive rate of output wth during the period, while containing the growth rate of its nand for commercial energy. The relatively large absolute price elasticity suggested that the sector enjoyed greater flexibility in adjusting its commercial energy purchases to changes in energy prices. Finally, the unexpected positive sign for the coefficient of the time variable was explained by suggesting that instead of capturing the impact of technical change on energy use, the time variable was capturing the effects of omitted variables in the model, specifically those with a strong time trend. Such variables would include the prices of the other inputs which combine with energy in the production process. This inadequacy of the simple demand model was thus brought to fore.

Static Translog Model

To correct this shortcoming, the second model used was the static Translog. This model consisted of a system of simultaneous equations, derived from the minimizing conditions for a transcendental logarithmic (Translog) total cost function, for a given set of input prices.[5] Each equation expressed an input's share in total production cost as a function of relative input prices and technical change. The study considered three input aggregates: capital, labor and commercial energy. Initial regressions showed the time variable (proxying for technical change) to be an insignificant explanatory factor, in contrast to the simple demand model result. This was taken to lend credence to the hypothesis forwarded above, i.e., the time variable was merely capturing the effects of the other input prices, which in the Translog model were no longer omitted variables. The time variable was thus dropped in subsequent regressions. The final estimating equations were therefore:

$$KSHARE = a_k + b_k \, ln(PL/PE) + c_k \, ln(PK/PE) + u_k$$
$$LSHARE = a_l + b_l \, ln(PL/PE) + c_l \, ln(PK/PE) + u_l$$

where *KSHARE* and *LSHARE* are the respective shares of capital and labor in total production costs; *ln(PL/PE)* and *ln(PK/PE)* are the natural logarithms of the ratios of the Divisia price index for labor *(PL)* and the Divisia price index for capital *(PK)* to the Divisia price index for energy *(PE)*, respectively; u_k and u_l are the stochastic disturbance terms; and a_k, a_l, b_k, b_l, c_k, *and* c_l are the coefficients to be estimated. In actual estimation, one input share equation, in this case the energy share equation, is always dropped to leave a system of linearly independent equations, since the sum of the factor shares is unity. The parameters of the dropped equation are

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[5] Christensen, Jorgenson and Lau (1971) is the seminal article on the Translog model.

Table 2 — Estimation Results For The Translog Model

-Oil Shock: 1970 To 1973 (36 Observations)

$$\text{HARE} = 0.20 + \underset{(3.1)}{0.14}\ \mathit{In(PL/PE)} - \underset{(-2.5)}{0.14}\ \mathit{In(PK/PE)}$$

$$\text{HARE} = 0.71 - \underset{(-2.9)}{0.13}\ \mathit{In(PL/PE)} + \underset{(3.1)}{0.14}\ \mathit{In(PK/PE)}$$

$$\text{HARE} = 0.08 - 0.01\ \mathit{In(PL)} - 0.003\ \mathit{In(PK)} + 0.02\ \mathit{In(PE)}$$

st-Oil Shock: 1974 To 1978 (45 Observations)

$$\text{HARE} = 0.40 + \underset{(2.3)}{0.11}\ \mathit{In(PL/PE)} - \underset{(-0.5)}{0.04^{*}}\ \mathit{In(PK/PE)}$$

$$\text{HARE} = 0.59 - \underset{(-2.7)}{0.11}\ \mathit{In(PL/PE)} + \underset{(2.3)}{0.11}\ \mathit{In(PK/PE)}$$

$$\text{HARE} = 0.009 + 0.001\ \mathit{In(PL)} - 0.07\ \mathit{In(PK)} + 0.07\ \mathit{In(PE)}$$

tes: Numbers in parentheses are t-ratios. An asterisk (*) denotes coefficients that are not significant at the 0.05 level.

imation procedure: Iterative Zellner

en estimated from the coefficient estimates of the remaining
uations.

The Translog results are given in Table 2. The regression was
ne over two subperiods, the pre-Oil Shock I years (1970-73)
d the post-Oil Shock I years (1974-78). This division of the obser-
tions was necessary because the sudden increase in energy prices
1973-74 produced a wide scatter of observations, to which the
anslog model could not be suitably fitted. This arose from a pro-
rty of the model that the total cost function is only a local appro-
mation to the true cost curve. If observations are too scattered,
e monotonicity and concavity conditions on the production iso-
iants are violated. Here it should be noted that all slope coeffi-

Table 3 — Elasticity Estimates for the Translog Model: Philippine Food Processing

	1970–73	1974–78	1970–78
Allen Partial Elasticities:			
S_{kl}	1.71	1.62	1.66
S_{ke}	0.91	0.12	0.47
S_{le}	0.38	1.02	0.73
Own-Price Elasticities:			
E_{kk}	–0.69	–0.58	–0.63
E_{ll}	–1.00	–0.97	–0.98
E_{ee}	–0.66	–0.42	–0.52
Cross-Price Elasticities:			
E_{lk}	0.97	0.81	0.88
E_{kl}	0.62	0.56	0.59
E_{le}	0.03	0.16	0.10
E_{el}	0.15	0.35	0.26
E_{ke}	0.06	0.02	0.04
E_{ek}	0.52	0.06	0.26

cients were found to be significant at the 0.05 level, except that for the capital-energy price ratio in the capital share equation for the post–Oil Shock regression. It was difficult to determine to what extent this was due to an inadequacy of the model in capturing post-Oil Shock realities, or to some errors in the data for the latter period.

Price Elasticity. The desired elasticity estimates were calculated from the above coefficients (Table 3). The price elasticity of demand for energy (E_{ee}) was –0.66 for 1970-73 and –0.42 for 1974-79, for a –0.52 average over the entire period. While these figures were slightly below the –0.71 estimate from the simple demand model, they were still significantly higher than those of earlier studies. For example, Alejo (1983) calculated the price elasticity of aggregate demand for energy to be in the range –0.48 to –0.10 over the 1973-79 period. Hence, this further supports the hypothesis that the food processing sector enjoyed greater flexibility in adjusting its commercial energy purchases in response to price changes.

Elasticity of Substitution. To gain an idea of how this flexi- lity was made possible, the estimates of the elasticity of substi- tion among factors were analyzed. Over the entire period, the erage Allen partial elasticity of substitution between capital and ergy was 0.47, and that between labor and energy was 0.73. Labor d capital were therefore substitutable for energy in varying degrees. fact, all three inputs were substitutes for each other, with the eatest degree occurring between labor and capital. Hence, an in- ease in the price of energy was met by a reduction in commercial ergy purchases, partially through investment in more energy-effi- ent structures and equipment, and by increased use of labor (in- uding better on-site housekeeping measures).[6]

Specifically, a unit percentage increase in energy price brought out an average 0.10 per cent increase in employment (E_{le}) and 0.04 per cent increase in capital stock (E_{ke}) in the food processing ctor for the period. While these figures seemed small, the implica- ons for the absolute total effects could be expected to be consi- erable, given the total percentage increase in energy prices over e entire period, and the employment size and value of fixed assets presented by the sector.

Cross-country Comparison. These results were then compared ith those for other countries, if only to gain an idea of the range f existing estimates. The concept of the full elasticity of substi- tion *(FES)* was used for comparison purposes, in order to correct r differences arising from the number of inputs considered in e various studies.[7] However, differences associated with the mple, as well as differences in certain data measurement techniques specially with regards to capital estimation) can be expected to ominate the observed differences in the parameter estimates. Table shows the FES estimates for six other studies, only one of which as for a developing country (Thailand) and provided estimates t the disaggregated industrial level. Moreover, all the developed ountry studies stopped short of the onset of the oil crisis in their eriod coverage. This and the Thai study essentially covered the eriod of the first oil crisis.

All the studies were in agreement regarding the signs of the

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[6] It would also have been interesting to determine to what extent this exibility was made possible by a shift to noncommercial energy usage, as was bserved earlier, by considering noncommercial energy as a fourth input in e model. However, data on noncommercial energy use were not available.

[7] See Kang and Brown (1981) for details.

Table 4 — Cross-Country Comparison of Translog Results: Full Elasticity of Substitution

	FES_{kl}	FES_{lk}	FES_{ke}	FES_{ek}	FES_{le}	FES_{el}
This study:						
Philippines						
1970—78						
Food Processing	1.57	1.51	0.56	0.89	0.62	1.24
Saicheua (1984):						
Thailand						
1974—77						
Food Processing	1.31	0.73	2.50	1.54	3.07	2.26
Metals & Machinery	1.67	1.88	1.63	2.50	1.41	0.80
Berndt & Wood (1975): a						
United States						
1947—71						
All Manufacturing	0.75	0.56	0.31	0.32	0.50	0.64
Ozatalay et al.(1979):a						
Cross-country						
1963—74						
All Manufacturing	1.04	0.96	0.86	0.99	0.85	1.02

Table 4 (Continued)

	FES_{kl}	FES_{lk}	FES_{ke}	FES_{ek}	FES_{le}	FES_{el}
Griffin & Gregory (1976):b Cross-country 1955—69 All Manufacturing	0.17	0.19	0.92	0.33	n.a.	n.a.
Hudson & Jorgenson (1974):b United States 1947-71 Inter-industry	0.74	0.56	—0.09	0.24	n.a.	n.a.
Fuss (1977):b Canada 1961—71 All Manufacturing	0.69	0.96	0.44	0.76	n.a.	n.a.

[a] As calculated by Saicheua (1984). The original works cited did not calculate the FES.

[b] As calculated by Kang and Brown (1981). The original works did not also calculate the FES.

FES estimates for all factors, except for the Hudson and Jorgenson estimate of FES_{ke}, which arose because of their positive price elasticity estimate for energy demand. The Berndt and Wood study covered the same time period as the Hudson and Jorgenson study, also for the United States. The main difference was that the Hudson and Jorgenson study aggregated over all sectors of the economy, rather than just manufacturing. This again was taken to be indicative of the dangers of using highly aggregated data.

In terms of the magnitude of the estimates, there appeared to be a wide divergence in the results. It was quite surprising that the Griffin and Gregory cross-country study estimates were generally very low, considering that their data exhibited a wider range of price variation than the other time-series studies, and in view of the commonly held notion that cross-country observations permit estimation of long-run price elasticities. Aside from this study, all the other studies which included observations over a wider range of price variation exhibited larger FES, than those for single-country studies that did not include observations for the oil crisis period. Except for the Saicheua, and the Griffin and Gregory studies, the FES between capital and labor tended to be larger than those between capital and energy. Moreover, for those studies for which the estimates of the FES between labor and energy were available, it appeared that the elasticity of substitution between labor and energy was generally larger than that between capital and energy, except in the case of the metals and machinery industry of Thailand. Results for this industry were shown for the sake of being able to compare the degree of variability in elasticity estimates for different industries. It appeared, therefore, that the strength of the substitutability relationship between factors can be expected to vary significantly across industries; hence, the need to explore these relationships further for other Philippine industries.

Dynamic Optimization Model

A natural extension to the static Translog model is the dynamic optimization model, in which capital is more aptly represented as a quasi-fixed input, the stock adjustment of which entails a cost that is included in the cost-minimizing decisions of the firm.[8] However, an attempt to fit this model to the food processing data failed due to the functional form of the nonlinear equation for capital stock adjustment. In this equation, the square root of an expression involving the ratio of two parameter estimates had to be taken; in the

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[8] See Berndt *et al.* (1980) and Denny *et al.* (1981) for a complete discussion and successful applications.

rocess of iteration, these two parameter estimates took opposite igns which failed to yield a solution, even when different starting alues were provided.

4. Conclusion

In conclusion, the findings showed that for the food processing ndustry, there was a greater dgree of price responsiveness of energy lemand in the 1970-78 period than what most aggregative studies o date would have indicated. The importance of undertaking elasicity estimation for other industries at the finest level of disaggreation permissible was delineated, in order to determine whether the ery low elasticity estimates obtained in earlier studies were the reult of aggregation bias, or were averages for widely disparate elasicities among different industries. If the general price responsiveness f energy demand were underestimated, a falsely perceived need or larger price increases than what was necessary to meet conseration targets would have resulted in welfare losses.

Energy, labor and capital were found to be substitutes for each ther. However, taking into account the artificially low price of capial that prevailed during the period, the policy of taxing energy may have sharpened the problem of capital deepening in a country already troubled by scarcity of capital and foreign exchange. in order to alleviate this, the process of substitution must be steered in the direction of labor, by realigning the cost of capital with that of energy.

Finally, the need to pursue this kind of analysis for a broader sector of the economy was pointed out. Only then could a general energy pricing policy be formulated on less tenuous ground.

Appendix Table 1 — Exports of Food, 1955 — 80

(F.O.B. Thousand US$)

	Sugar	Fruits	Fish Products	Food	Total Exports
1955	111,512	20,460	86	132,193	397,653
1960	143,482	29,226	65	175,110	558,897
1965	146,784	35,025	219	197,376	766,686
1970	196,496	53,871	2,091	272,331	1,057,073
1975	616,169	154,178	16,571	828,450	2,292,407
1980	662,525	366,911	138,227	1,395,935	5,750,882

Source: *Central Bank Statistical Bulletin 1981.*

Appendix Table 2 — Food and Industrial Energy Consumption 1974 — 1980

(in thousand barrels of oil-equivalent)

	Food	Industry
1974	2684	37,795
1975	2656	42,634
1976	2760	44,746
1977	2762	50,052
1978	2812	50,997
1979	3063	52,911
1980	2717	53,020

Source: Ministry of Energy.

Appendix Table 3 — Annual Growth in the Physical Volume of Food Production 1955 -- 80

(in per cent)

	Food	Manufacturing
1955 – 65	6.9	6.9
1965 – 70	1.3	4.8
1970 – 75	4.8	5.9
1975 – 80	6.4	4.3

Source: *Central Bank Statistical Bulletin*, various years

Appendix Table 4 — Commercial Energy Source Mix of the Food Processing Industry, 1979

(in per cent of total)

Commercial Energy Source	Per cent Share	
Electricity	36.88	
Petroleum	63.12	
Industrial Fuel Oil		37.51
Diesel Oil		18.07
Gasoline		7.06
L P G		0.04
Kerosene		0.44
	100.00	

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