Philippine Review of Economics and Business
Vol. XXII, Nos. 3 & 4, September & December 1985

ESTIMATING PRICE AND INCOME ELASTICITIES OF THE DEMAND FOR FOOD: A PHILIPPINE ILLUSTRATION

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The paper illustrates a procedure for estimating price and income elasticities on the demand for food from a single, cross-sectional data set. A linear expenditure system for food is derived and estimated using Philippine data from the 1965 Family Income and Expenditures survey. The parameter estimates reported here do not appear out of line with other estimates.

1. Introduction

It is widely held that price elasticities cannot be estimated from a single household budget data set, since single-year, cross-sectional data hardly display variations in prices. This is not quite accurate, however, as pointed out by Betancourt (1971) and Pollak and Wales (1976). In this paper, we follow Betancourt's procedure, and estimate price and income elasticities of the demand for food using a single household budget data set.

This note then is in the nature of an illustration for estimating price and income elasticities of the demand for food, using Philippine data from the 1965 Family Income and Expenditures Survey of Households. The exercise seems especially useful in the context of a less-developed country where paucity of data is pervasive.

The empirical procedure adopts an augmented Stone-Geary utility function, and under a utility-maximizing hypothesis, comes up with a consumer demand system which includes leisure. To estimate the resulting linear expenditure system (LES), we start by estimating the parameters of a regression model based on the leisure demand function; the estimates obtained are then used to estimate the parameters of the food demand functions. The procedure is recursive with the work-leisure decision held prior to the food allocation decision.

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Section 2 shows the derivation of the LES; section 3 discusses ıe estimation procedure, section 4 contains the data set, and section the results; section 6 makes concluding remarks.

2. Food Demand System and Labor Supply

We consider an augmented Stone-Geary utility function for the ɔusehold:

$$(1)\qquad U = (1-b) \sum_{i=1}^{n} b_i \, ln \, (q_i - c_i) + b \, ln \, (L - \bar{L})$$

here U is utility, q_i is quantity demanded of the ith good $= 1, 2, \ldots n$), and L is hours of leisure. We assume that $\Sigma \, b_i = 1$, ıd $q_i - c_i > 0$ and $L - \bar{L} > 0$. The constant c_i and $\bar{L}$ may be in- ɛrpreted as minimum requirement levels of goods and leisure. The tility function is augmented in the sense of leisure entering additively.

Suppose the money income of the household is given by:

$$(2)\qquad Y = wH + P$$

ʼhere w is the wage rate, H is hours of market work, and P is pro- erty income. Denote the time constraint by:

$$(3)\qquad T = L + H$$

ʼhere T is total fixed time.

Assume that total money income is spent on goods and serv- ːes:

$$(4)\qquad Y = \sum_{i=1}^{n} p_i q_i$$

Combining (2), (3) and (4) into a single constraint, we get:

$$(5)\qquad Y^* = WT + P = \Sigma \, p_i q_i + wL.$$

ːq. (5) can be termed the full-income constraint.

Under a utility-maximizing hypothesis, we maximize (1) sub- ɛct to (5). Forming the Lagrangian function, we have

$$(6) \qquad L = (1-b)\ \Sigma\ b_i\ ln\ (q_i - c_i) + b\ ln\ (L - \bar{L})$$
$$+ \lambda\ (Y^* - \Sigma\ p_i q_i - wL).$$

Taking partial derivatives with respect to q_i, L and λ and equating to zero yields the first-order conditions:

$$(7) \qquad (1-b) \frac{b_i}{q_i - c_i} - \lambda\ P_i = 0$$

$$\frac{b}{L - \bar{L}} - \lambda w = 0$$

$$Y^* - \Sigma\ p_i q_i - wL = 0$$

Summing the first of eq. (7) over all i, using $\Sigma\ b_i = 1$, we get

$\lambda = (1-b)/Y^* - wL - \Sigma\ P_i c_i$ or $\lambda = (1-b)/Y - \Sigma\ p_i c_i$.
Substituting the value of λ in the first two equations we get:

$$(8) \qquad p_i q_i = p_i c_i + b_i\ (Y - \Sigma\ p_i c_i) \qquad i = 1, 2, \ldots n$$

$$(9) \qquad wL = w\bar{L} + b\ (Y^* - \Sigma\ P_i c_i - w\bar{L}).$$

Equations (8) and (9) are the LES equations for goods and leisure. The interpretation given is that the household first decides on expenditures for minimum requirement levels, $\Sigma\ p_i c_i$, and then allocates a portion b_i for goods, and b for leisure, out of the supernumerary incomes $Y - \Sigma\ p_i c_i$ and $Y^* - \Sigma\ p_i c_i - w\bar{L}$, respectively. Equations (8) and (9) form the basis for the estimating equations.

3. Estimation Procedure

We rewrite eq. (8) in the following form:

$$(8a) \qquad p_i q_i = (p_i c_i - b_i\ \Sigma\ p_i c_i) + b_i\ Y$$

The above can form the basis for a regression model. If prices and income data are available, as in time-series data, then the parameters b_i and c_i can be estimated. Since we have no price variation in a single household budget data set, we adopt a recursive procedure

/hereby we first estimate the parameters of a demand-for-leisure r labor supply equation, which estimates are then used to estimate ome parameters of the LES for goods.

More formally, we derive from (9) the equivalent equation:

9a) $Y = b \ \Sigma \ p_i c_i + (1-b) \ (T - \bar{L})w + (1-b) P.$

/e have data on income Y, wage rate w, and unearned or property ncome F. We estimate the equation:

10) $Y = \beta_0 + \beta_1 \ w + \beta_2 \ P + \in$

vhere $\in$ is a standard normal error term. We set the estimates $\hat{\beta}_0$, $\hat{\beta}_1$ nd $\hat{\beta}_2$ equal to the following:

$$\begin{aligned} \hat{\beta}_0 &= b \ \Sigma \ p_i c_i \\ \hat{\beta}_1 &= (1-b) \ (T - \bar{L}) \quad (11) \\ \hat{\beta}_2 &= (1-b) \end{aligned}$$

t follows that:

$$b = 1 - \hat{\beta}_2 \quad \text{and}$$

$$\Sigma \ p_i c_i = \frac{\hat{\beta}_0}{1 - \hat{\beta}_2}$$

From equation (8a), we form the regression model:

12) $p_i q_i = \alpha_{0i} + \alpha_i \ Y + u_i$

vhere u_i is a standard normal error term. We have observations on $p_i q_i$ and Y and we derive the estimates $\hat{\alpha}_{0i}$ and $\hat{\alpha}_i$.

13) $\hat{\alpha}_{0i} = p_i c_i - b_i \ \Sigma \ p_i c_i \qquad \hat{\alpha}_i = b_i$

ince we already have an estimate of $\Sigma \ p_i c_i$ from (11), we can get n estimate of $p_i c_i$ from (13).

We need $p_i c_i$ and $\Sigma \ p_i c_i$ to estimate income and price elasicities. From eq. (8), we derive the income elasticity, $\in_y$, which is qual to:

14) $\in_y = \dfrac{b_i}{s_i}$

where s_i is the average share of the expenditures on the *i*th good, that is,

$$s_i = \frac{p_i q_i}{Y}$$

The price elasticity $\epsilon_{p_{ii}}$ from eq. (8) is given by:

$$(15) \qquad \epsilon_{p_{ii}} = \frac{p_i c_i}{p_i q_i} (1 - b_i) - 1.$$

4. Data

The data used for estimation are drawn from the 1965 Family Income and Expenditures Survey of Households, carried out by the Bureau of Census and Statistics.

The food groups included in the survey are: (1) Cereals; (2) Fish and other Sea Foods; (3) Meat and Eggs; (4) Milk and Dairy Products; (5) Roots; (6) Miscellaneous; (7) Food Consumed Outside.

Data on average income and expenditures of households are available for 12 income groups. Income can be decomposed into wages and unearned or property income.

To estimate equation (10), we used average expenditure items as dependent variable.

To obtain a measure of the wage rate, we divide average wages of the household by the sum of the estimated annual hours worked by the husband and wife. Using data from the Labor Force Survey, we took that the husband worked 8 hours per day while the wife worked 7.3 hours per day, and multiplied the daily rates by 250 working days in a year. The total number of hours worked in a year, using this procedure is 3,825. We divide average wages of the household by 3,825 to get the hourly wage rate.

To estimate (12), average expenditures of each of the 12 income groups on the *i*th food item where $i = 1, 2, 3, 4, 5, 6, 7$ is regressed on income, the latter measured by the average expenditures on all consumer items.

We estimated equations (10) and (12) using four separate subsamples: Philippines, urban, Manila, and rural. Estimates of

Table 1 — Means and Standard Deviation: Labor Supply Regressions

Variable	Philippines		Urban		Manila		Rural	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
E	4559.5	3773.5	5018.2	3917.2	5514.6	4791.0	3618.9	2242.7
W	1.0	1.0	0.977	1.0	0.992	1.14	0.977	0.925
P	996.1	1600.2	1100.0	1755.2	1250.2	2092.0	609.1	759.7

price and income elasticities for each subsample are given. Summary statistics for the variables used in the estimation are shown in Tables 1 and 2.

This note reports only ordinary least-squares estimates, though to correct for heteroscedasticity, weighted least squares would be more appropriate, where the square roots of the sample size for each income group serve as weights.

5. Results

The results of estimating eq. (10) are shown in Table 3. Using standard statistical criteria, the labor supply regressions display goodness of fit. In Table 4, we show estimates of β_0 and β_2, from which we are able to get estimates of $\Sigma p_i c_i$. To illustrate for the Philippine sample, we have $\hat{\beta}_0$ = 918.889 and $\hat{\beta}_2$ = 0.215. An estimate of $\Sigma p_i c_i$ is $\hat{\beta}_0 / 1 - \hat{\beta}_2$ = 918.889/0.785 = 1,170.55.

The next step involves an estimation of $p_i c_i$ and to do this, we need an estimate of eq. (12). The results are reported in Tables 5, 6, 7, 8 for the various subsamples. Again, the t-ratios are significant, and the adjusted coefficients of determination, $\bar{R}^2$, are supportive of the functional forms used. The estimates of $p_i c_i$ for $i = 1, 2, \ldots 7$ are shown in Table 9. Having estimated $p_i c_i$ we can estimate income and price elasticities using eqs. (14) and (15), respectively. The elasticities are reported in Table 10. We obtain the expected signs: positive for income elasticity and negative for price elasticity.

Let us focus on the price and income elasticities for the Philippine sample. The absolute values of the price elasticities are all less than one, i.e., inelastic. But we note a varying degree of inelasticity. For cereals, a one per cent increase in price leads to 0.258 per cent decrease in quantity consumed. This is to be expected since rice which constitutes a large proportion of cereals consumed is a staple commodity. The price elasticity for fish and other sea foods is also relatively low. The inference we get is that when the price of fish goes up, we do not observe a large decrease in the amount consumed. It may well be that for the majority of consumers, fish constitutes the main source of protein. From a welfare standpoint of the consumer, it pays to keep the price of cereals and fish low.

Two food items — meat and eggs, milk and dairy products —

Table 2 — Means and Standard Deviations: LES Estimates

Variable	Philippines		Urban		Manila		Rural	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
P_1q_1	714	193.3	693.9	197.3	606.3	213.0	728.9	208.8
P_2q_2	348.5	150.2	362.0	145.8	349.2	151.9	340.3	152.3
P_3q_3	317.9	285.7	367.3	300.5	442.6	372.8	223.1	163.2
P_4q_4	99.3	84.8	118.0	71.7	151.3	93.3	67.8	56.2
P_5q_5	193.1	106.1	196.4	110.5	216.7	139.9	183.0	89.8
P_6q_6	278.7	154.9	304.0	154.7	314.4	170.2	241.6	115.3
P_7q_7	161.2	166.4	206.1	171.4	267.9	191.8	95.3	92.3
Y	4559.5	3773.5	5018.2	3917.2	5515.0	4790.6	3618.9	2242.7

Table 3 — Labor Supply Regressions 1965

Philippines: $E = 918.889 + 3401.241\ w + 0.215\ P$
(19.531) (1.952)
$\bar{R}^2 = 0.998$
$F = 2536.798$
$n = 12$

Urban : $E = 1048.398 + 4444.453\ w - 0.337\ P$
(28.434) (3.752)
$\bar{R}^2 = 0.998$
$F = 4886.105$
$n = 12$

Manila : $E = 1463.121 + 3789.934\ w + 0.232\ P$
(11.042) (1.242)
$\bar{R}^2 = 0.992$
$F = 671.800$
$n = 12$

Rural : $E = 1201.035 + 2194.246\ w + 0.448\ P$
(20.119) (2.375)
$\bar{R}^2 = 0.964$
$F = 336.538$
$n = 12$

Table 4 — Parameters Estimated from the Labor Supply Regressions and the LES

	$\hat{\beta}_0$	$\hat{\beta}_2$	$\Sigma p_i c_i$
Philippines	918.889	0.215	1,170.85
Urban	1048.398	- 0.337	784.14
Manila	1403.121	0.232	1,905.10
Rural	1201.035	0.448	2,175.79

Table 5 — Linear Expenditure Systems: Philippines, 1965

P_1q_1	=	502.545	+	0.0464 Y	$\bar{R}^2 = 0.783$
				(6.375)	$F = 40.646$
					$n = 12$
P_2q_2	=	180.322	+	0.037 Y	$\bar{R}^2 = 0.845$
				(7.819)	$F = 61.140$
					$n = 12$
P_3q_3	=	−26.406	+	0.076 Y	$\bar{R}^2 = 0.994$
				(44.208)	$F = 1954.403$
					$n = 12$
P_4q_4	=	0.038	+	0.022 Y	$\bar{R}^2 = 0.934$
				(12.499)	$F = 156.237$
					$n = 12$
P_5q_5	=	66.061	+	0.028 Y	$\bar{R}^2 = 0.981$
				(23.803)	$F = 566.607$
					$n = 12$
P_6q_6	=	97.339	+	0.040 Y	$\bar{R}^2 = 0.934$
				(12.507)	$F = 156.417$
					$n = 12$
P_7q_7	=	−39.052	+	0.044 Y	$\bar{R}^2 = 0.991$
				(34.900)	$F = 1218.013$
					$n = 12$

Table 6 — Linear Expenditure Systems: Urban, 1965

P_1q_1	=	460.569	+	0.046 Y	$\bar{R}^2 = 0.838$
				(7.599)	$F = 56.739$
					$n = 12$
P_2q_2	=	188.65	+	0.034 Y	$\bar{R}^2 = 0.848$
				(7.903)	$F = 62.454$
					$n = 12$
P_3q_3	=	−15.423	+	0.076 Y	$R^2 = 0.967$
				(29.325)	$F = 859.99$
					$n = 12$
P_4q_4	=	37.26	+	0.016 Y	$\bar{R}^2 = 0.749$
				(5.813)	$F = 33.789$
					$n = 12$
P_5q_5	=	55.492	+	0.028 Y	$\bar{R}^2 = 0.990$
				(33.634)	$F = 1131.23$
					$n = 12$
P_6q_6	=	111.677	+	0.038 Y	$\bar{R}^2 = 0.936$
				(12.759)	$F = 162.79$
					$n = 12$
P_7q_7	=	−11.258	+	0.043 Y	$\bar{R}^2 = 0.973$
				(12.928)	$F = 480.844$
					$n = 12$

Table 7 — Linear Expenditure Systems: Manila, 1965

P_1q_1	=	386.453	+	0.039 Y (6.399)	$\bar{R}^2 = 0.784$, $F = 40.956$, $n = 12$
P_2q_2	=	185.33	+	0.029 Y (8.500)	$\bar{R}^2 = 0.866$, $F = 72.264$, $n = 12$
P_3q_3	=	23.791	+	0.076 Y (14.077)	$\bar{R}^2 = 0.947$, $F = 198.17$, $n = 12$
P_4q_4	=	49.447	+	0.018 Y (9.984)	$\bar{R}^2 = 0.889$, $F = 89.952$, $n = 12$
P_5q_5	=	58.506	+	0.029 Y (16.258)	$\bar{R}^2 = 0.959$, $F = 264.327$, $n = 12$
P_6q_6	=	127.447	+	0.034 Y (10.089)	$\bar{R}^2 = 0.901$, $F = 101.794$, $n = 12$
P_7q_7	=	57.427	+	0.0384 Y (9.974)	$\bar{R}^2 = 0.899$, $F = 99.48$, $n = 12$

Table 8 — Linear Expenditure Systems: Rural, 1965

P_1q_1	=	415.711	+	0.086 Y (7.975)	$\bar{R}^2 = 0.85$, $F = 63.602$, $n = 12$
P_2q_2	=	99.498	+	0.066 Y (15.600)	$\bar{R}^2 = 0.056$, $F = 243.372$, $n = 12$
P_3q_3	=	− 33.789	+	0.0709 Y (14.016)	$\bar{R}^2 = 0.947$, $F = 196.458$, $n = 12$
P_4q_4	=	−18.400	+	0.024 Y (9.588)	$\bar{R}^2 = 0.892$, $F = 91.932$, $n = 12$
P_5q_5	=	56.387	+	0.035 Y (5.656)	$\bar{R}^2 = 0.789$, $F = 32.099$, $n = 12$
P_6q_6	=	61.87	+	0.049 Y (11.792)	$\bar{R}^2 = 0.926$, $F = 139.045$, $n = 12$
P_7q_7	=	−27.399	+	0.034 Y (4.599)	$\bar{R}^2 = 0.647$, $F = 21.157$, $n = 12$

Table 9 — Parameters Estimated from the LES

	Philippines	Urban	Manila	Rural
P_1c_1	555.85	496.64	460.75	602.83
P_2c_2	228.63	215.31	240.58	243.10
P_3c_3	61.38	44.17	168.58	101.28
P_4c_4	24.62	49.81	83.74	27.32
P_5c_5	97.67	77.45	113.75	132.54
P_6c_6	144.20	141.47	192.22	168.48
P_7c_7	12.45	22.46	130.58	46.58

have price elasticities close to one. A relatively large decline in quantity consumed is induced by a given price increase. The consumption of these two items is however quite responsive to an increase in income, evident from the income elasticity of 1.083 for meat and eggs, and 0.999 for milk and dairy products. It seems therefore that a policy designed to increase income can lead to an increase in the consumption of these food items.

The remaining food items in the list — roots, miscellaneous, and food consumed outside — are not unusual. Roots and miscellaneous have price and income elasticities almost midway in magnitude between cereals and fish on one hand, and meat and eggs, milk and dairy products, on the other. Food consumed outside is a luxury as shown by the income elasticity greater than one.

We also report in Table 10 individual elasticities for urban, Manila and rural areas to provide a comparative view of the orders of magnitude. For each case, quite the same pattern as in the Philippine sample is observed for the price and income elasticity measures.

6. Concluding Remarks

In this paper we have illustrated a procedure for estimating price and income elasticities using single-year household budget data. Comparing the estimates with other studies, the results do not appear out of line. The main motivation for this exercise has been to take advantage of a data set which is collected on a regular basis.

Table 10 — Price and Income Elasticities

Commodity	Philippines		Urban		Manila		Rural	
	$\epsilon_{P_{ii}}$	ϵ_y	$\epsilon_{P_{ii}}$	ϵ_y	$\epsilon_{P_{ii}}$	ϵ_y	$\epsilon_{P_{ii}}$	ϵ_y
1. Cereals	−0.258	0.296	−0.317	0.336	−0.269	0.362	−0.479	0.429
2. Fish and other Sea Foods	−0.382	0.483	−0.425	0.479	−0.331	0.469	−0.333	0.707
3. Meat and Eggs	−0.821	1.083	−0.890	1.042	−0.648	0.946	−0.578	1.151
4. Milk and Dairy Products	−0.757	0.999	−0.578	0.684	−0.457	0.673	−0.606	1.271
5. Roots	−0.508	0.658	−0.617	0.717	−0.490	0.729	−0.301	0.592
6. Miscellaneous	−0.503	0.651	−0.552	0.633	−0.409	0.595	−0.337	0.744
7. Food Consumed Outside	−0.926	1.242	−0.896	1.050	−0.531	0.786	−0.528	1.287

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