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METHODS IN CONSUMPTION ANALYSIS: CONSUMER THEORY, ECONOMETRIC ISSUES, AND PHILIPPINE ESTIMATES

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This paper on consumption analysis will be divided into four sections: (1) a review of consumer theory and demand systems; (2) econometric issues involved in using household level data; (3) a review of Philippine estimates; and (4) the use of these estimates in nutrition policy simulation. Most of the effort in consumption analysis in recent years has been directed to obtaining functional forms which allow sufficiently flexible response coefficients, as well as to estimating income-stratum-specific demand parameters which have been used to estimate distributional impacts of various intervention policies.[1]

1. Consumer Theory and Demand Systems

Complete demand systems can be derived in two ways: (1) maximizing a utility function subject to a budget constraint, or (2) apply-

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1. Income-group-specific parameter estimation has been proposed on the grounds that substantial differences in consumption behavior exist at different income levels, and that even when compensated for the income effects of the price changes, the pure substitution, or Slutsky, elasticities are likely to be greater for low income groups. This has led Timmer (1981) to suggest that an income-related "curvature" of the Slutsky matrix exists.

Models used to estimate differential impacts of intervention policies, to be discussed in the last section, typically use separate demand functions for each consumer stratum. Though the structure of models differs – there are partial equilibrium models (e.g., Pinstrup-Andersen et al. 1976, 1978; Perrin and Scobie 1981; Gray 1982), as well as general equilibrium models (Disch 1984; McCarthy and Taylor 1980) – these models have as a common feature a set of income-group specific demand parameters.

ing the duality theory to obtain demand functions from the first derivative of a cost (or expenditure) function. In the first case, we obtain Marshallian demand functions in nominal prices and incomes; in the second, Hicksian (compensated) demand functions in nominal prices and real income.

1.1. *Utility maximization.* The individual consumer is said to maximize a utility function $u = u(q)$ subject to a budget constraint $p'q = y$, where $q = (q_i)$ is an n-element column vector of quantities bought, p is a column vector of prices, and y is total income (or total expenditure). Assuming that the utility function is monotonic and twice-differentiable, and that the Hessian matrix of second partial derivatives $H = \left[\frac{\partial^2 u}{\partial q_i \partial q_j}\right]$ is symmetric, maximization using a Lagrangean function results in a system of $N+1$ equations given by

$$(1)\quad \frac{\partial u}{\partial q_i} = \lambda P_i \text{ and } p'q = y$$

where λ is the Lagrangrean multiplier. Solving the $n+1$ equations simultaneously for Q in terms of p yields a system of demand equations, $q^o = q\ (y, p)$. The demand systems should also satisfy the following restrictions: (1) homogeneity of degree zero in incomes and prices; (2) negative definiteness and symmetry of the Slutsky substitution matrix; and (3) share-weighted sum of income elasticities equal to 1.0.

The imposition of restrictions in empirical applications not only assures that the estimated parameters will satisfy the axioms of consumer theory but also reduces the number of parameters to be estimated from $n\ (n+1)$ to $(n-1)\ (\frac{1}{2}n+1)$ if the three conditions are applied simultaneously.

The Linear expenditure system. One of the first attempts to derive an empirical demand system which satisfied all restrictions was the Linear Expenditure System (LES) (Stone 1954). Stone writes a general formulation for demand as:

$$(2)\quad P_i q_i = \beta_i \gamma + \sum_{j=1}^{n} \beta_{ij} P_j$$

The only form of equation (2) which satisfies the restrictions of adding-up, homogeneity and symmetry is the LES

$$(3)\quad p_i q_i = p_i \gamma_i + b_i\ (Y - \Sigma P_k \gamma_k)$$

with $\Sigma b_i = 1$. The γ_i are often interpreted as minimum or subsistence quantities, while $(Y - \Sigma P_k \gamma_k)$ is supernumerary expenditure, allocated according to the fixed proportions b_i after subsistence requirements have been met.

Samuelson (1947) and Geary (1950) have shown that equation (3) is derived from a utility function of the form:

$$(4) \quad u(q) = f\{\sum_{i=1}^{h} \beta_i \log (q_1 - \gamma_i\} \text{ or}$$

$$(5) \quad u(q) = \prod_{i=1}^{n} (q_i - \gamma_i)\, \beta_i$$

Since U can be written as a transformation of an additive utility function,[2]

$$(6) \quad S_{ij} = \phi Y \frac{\partial q_i}{\partial y} \frac{\partial q_j}{\partial y} \qquad i \neq j$$

So, from the actual demand equations we can calculate, for $i \neq j$

$$(7) \quad S_{ij} = \frac{b_i b_j}{p_i p_j} (Y - P'\gamma)$$

$$\Phi = \frac{-(y - P'\gamma)}{Y}$$

If S is to be negative semi definite, S_{ij} must be negative for all pairs of goods; thus complementarity is ruled out. In addition, inferior goods cannot exist. Calculating elasticities from equation (3), we have

2. A preference ordering, represented by a utility function $u = f(q_1, \ldots, q_n)$, is additive if there exists a differentiable function, $F, F' > 0$ and n functions $f_i(q_i)$, such that $F(f(q_1 \ldots q_n)) = \Sigma f_i(q_i), i = 1, \ldots n$ (Phlips 1974, p. 57). In this case, the utility function is of the form

$$(A.1) \quad u(q) = \delta\{u_1(q_1) + u_2(q_2) + \ldots + u_n(q_n)\}$$

If (A. 1) holds, the Slutsky matrix is diagonal so that the substitution terms S_{ij} are given by:

$$(A.2) \quad S_{ij} = X q_{yi} q_{yj}$$

Where $X = -\phi\, y$ and $\phi = \left[\frac{\partial \log \lambda}{\partial \log Y}\right]^{-1}$ or the inverse of the marginal utility of money.

(8) $E = \emptyset^{-1} b$

$$e_{ij} = -b_i \frac{P_j \gamma_j}{P_i q_i} \qquad i \neq j$$

$$e_{ii} = -1 + (1-b_i) \frac{\gamma_i}{q_i}$$

All goods which are price elastic will have γ parameters less than zero. For $\gamma > 0$, goods must therefore be price inelastic. The restrictiveness of relationships imposed within the system, particularly the negation of complementary and the inelasticity of price coefficients, has led to the formulation of other demand systems.[3]

The S-branch system. One generalization of the LES which allows complementary and independent relationships as well as substitutability is the S-branch system (Brown and Helen 1972; Heien 1982). In addition, the own-price elasticity can range from 0 to $-\infty$.

Consider the consumer who arranges his consumption set into S branches. The subutility function for a branch, composed of various goods q_{si}, is:

(9) $$U_s = \left(\sum_{i=s}^{n_s} \beta_{si} \, q_{si}^{\rho_s} \right)^{1/\rho_s}$$

where $\rho_s = \frac{1}{1-\sigma}$ is the Allen elasticity of substitution (AES) between goods s in the Stn branch and n_s is the number of goods in that branch. These subgroups can then be aggregated into an overall utility function

(10) $$u = \left(\sum_{s=1}^{S} \alpha_s U_s^{\rho} \right)^{1/\rho}$$

3. Among these are the indirect addilog demand system and the Rotterdam demand system. Pante (1977) says that, since the two other systems are also derived similarly (i.e., from utility maximization), the LES, the indirect addilog and the Rotterdam demand system cannot be considered as competitors; however, they vary in terms of the degree of restrictiveness allowable in each system. The Rotterdam system, expressed in terms of prices and real incomes, is the most flexible of the three, since it can incorporate additivity, no additivity or partial additivity. The indirect addilog system, like the LES, is based on additivity though the indirect addilog is based on indirect additivity and the LES on direct additivity. The LES thus excludes inferior goods and complementarily, while the indirect addilog system allows these to a limited extent.

where S refers to the total number of groups and $\sum_{s=1}^{S} n_s = n$ is the total number of goods. Maximization of equation (10) subject to the budget constraint yields demand functions of the form:

$$(11) \quad q_{si} = (\beta_{si} / P_{si})^{\sigma_s} \alpha_s^{\sigma} X_s^{-1} Z_s \; M_m$$

where

$$(12) \quad X_s = \sum_{i \in s}^{n_s} (\beta_{si} / P_{si})^{\sigma_s} \; P_{si}$$

$$(13) \quad Z_s = \alpha_s^{\sigma} X_s \frac{\sigma - 1}{\alpha_s - 1}$$

$$(14) \quad M = \sum_{r=1}^{S} Z_r$$

$$(15) \quad m = \sum_{S=1}^{S} \sum_{\substack{s \\ j \varepsilon s}}^{n_s} P_{sj} q_{sj}$$

Brown and Heien (1972) show that all intergroup pairs are substitutes, but that intragroup pairs may be either substitutes or complements. Giffen paradoxes and inferior goods are both ruled out from the S-branch system.

In practice, the empirical performance of the S-branch system may well depend upon the grouping of the commodities and the plausibility of a common elasticity of substitution between and with subgroups. Quisumbing's (1985) results do not show that this assumption is warranted with a detailed breakdown of food commodities.

Approaches using the LES and additivity in general have been criticized by Brown and Deaton (1972), and Timmer (1981), among others. Brown and Deaton (1972, p. 1,197) point out that if variations in real income are larger than variations in relative income, the linear expenditure system, like other additive models, will impose a structure on estimated price effects largely independently of actual price effects, and will not *measure* price responses. This is usually true for long time series of broad commodity groups as well as for multiperiod budget data. Timmer (1981) also states that additivity may not be warranted for disaggregated food commodities since substitution between nutrient sources of different costs is quite significant.

Other approaches. Other system approaches include the Frisch (1959) method, which requires an estimate of the marginal utility of money income, income elasticities and budget shares to compute price and cross-price elasticities, and the Betancourt (1971) procedure, which utilizes variation of wage rates across income classes as a proxy for income-stratum specific variation in the price of leisure. Both of these approaches attempt to compute price elasticities in the absence of cross-sectional variation in commodity prices. These have also been criticized due to the assumption of want-independence (or additivity of the utility function) which is imposed so as to obtain the computational formulae (Brown and Deaton 1972; Timmer 1981).

Other approaches to consumer demand have used "pragmatic" approaches and imposed no a priori restrictions, or imposed them only where empirically valid.[4] Unfortunately, the use of such approaches will imply that the demand equations will satisfy the axioms of consumer theory only on an ad hoc basis. Fortunately, recent developments in duality theory permit the estimation of demand parameters from functional forms which allow sufficiently flexible response coefficients, which satisfy the three axioms of consumer theory, and which are computationally convenient. This is discussed in the next section.

1.2 *Duality in Consumer Theory and Flexible Functional Forms*

The application of duality theory to consumer demand permits us to establish a one-to-one correspondence between the direct utility function $u(x;y)$ where maximum utility U is derived from consumption of x subject to the budget constraint Y; the expenditure function $e(p;u)$ which minimizes the cost e of attaining utility level u at prices p; and the indirect utility function $v(p,y)$ which maximizes utility given p and y.[5]

4. Most of the consumer demand studies conducted in the Philippines are of this type, many consisting of single-equation methods without a priori restrictions.

5. A simple exposition of duality in consumer theory can be found in Varian (1978); more detailed discussions are in Deaton and Muellbauer (1980, pp. 37-50).

Given an indirect utility function $v(p, y)$, if $v(p, y)$ is strictly increasing in Y, we can solve for Y as a function of U, to derive the expenditure function $e(p, u)$. Applying Roy's identity to the indirect utility function yields Marshallian demand functions in nominal income and prices, i.e.

$$(16) \quad X_i(p, y) = \frac{\dfrac{\partial v(p, y)}{\partial P_i}}{\dfrac{\partial V(p, y)}{\partial Y}} \quad \text{for } i = 1, \ldots, n$$

assuming that the right hand side is defined and $P >> 0$.

Differentiation of the expenditure function $e(p; u)$, on the other hand, yields Hicksian (compensated) demand functions with prices and real income as explanatory variables, i.e.

$$(17) \quad h_i(p; u) = \frac{\partial e(p; u)}{\partial P_i} \quad \text{for } i = 1, \ldots, n$$

assuming that the derivative is defined and $p >> 0$.

Recall that the demand functions must fulfill the following conditions:

1. homogeneity of degree zero in income and prices
2. symmetry of the compensated cross-price terms
3. weighted sum of income elasticities equal to 1.

Homogeneity of degree zero is assured if the indirect utility function is linearly homogeneous in prices P; while symmetry of compensated cross-price terms follows from Young's theorem as applied to the indirect utility function, i.e., assuming utility maximization.

$$(18) \quad (\partial^2 v^*) / (\partial P_i \partial P_j) = \partial X^*_i / \partial P_j = \partial X^*_j / \partial P_i = (\partial^2 v^*) / \partial P_j \partial P_i) <=> v^*_{ij} = v^*_{ji}$$

Adding-up follows due to maximization subject to a linear budget constraint.

In empirical work, the abovementioned restrictions are more easily imposed on Hicksian demand functions in real income and prices due to the difficulty of imposing cross-equation symmetry restriction on Marshallian demand functions, which have uncompensated price coefficients. Swamy and Binswanger (1983) point out that the use of real income in Hicksian demand functions is dependent upon the definition of a suitable deflator for nominal income, or suitable approximations to the true deflators if the consumer's utility function is unknown. They use Diewert's (1976) finding that if the cost (or indirect utility) function is unknown but is approximated by a flexible functional form,[6] then certain index numbers can be estimated which, when used to deflate nominal income, provide changes in real income that correspond exactly to changes in utility levels. Diewert has shown that any quadratic mean of order r quantity index can approximate an arbitrary nonhomegeneous utility function to the second degree and that any quadratic mean of order r price index can similarly approximate an arbitrary cost or indirect utility function. Swamy and Binswanger use chained Fisher's indices in their study, since, among the quadratic means of order r index numbers, Fisher's quantity and price indices are computationally convenient and satisfy the factor reversal test. Pitt (1982) uses Stone's index $\tilde{P} = \exp(\Sigma w_k \log p_k)$, which is also used by Deaton and Muellbauer (1980a) as an approximation to a "true" price index in the Almost Ideal Demand System (AIDS), $P = \exp(\Sigma_{\alpha k} \log P_K + 1/2\, \Sigma\Sigma\, \gamma k_j \log P_k \log P_j)$. Deaton and Muellbauer (1980a) note that the $\tilde{P}$ approximation would be close if prices were closely collinear.

Three functional forms which have been commonly used in empirical applications are the normalized quadratic (NQ), generalized Leontief (GL) and translog (TL) demand functions, which are derived from their corresponding cost or expenditure functions (from Swamy and Binswanger 1983, pp. 676-677).

Normalized quadratic demand functions (NQ). The normalized quadratic demand function can be written as:

$$(19)\quad X_i = a_i + b_{i1} m + b_{i2} m^2 + \sum_{i=1}^{n-1} C_{ij} (P_j / P_n) \quad i = 1, \ldots, N-1$$

$$X_N = a_N + b_{N1} m + b_{N2} m^2 + .5 \sum_{i=1}^{N-1} \sum_{j=1}^{N-1} C_{ij} (P_i P_j / P_N^2)$$

6. An aggregator functional form is said to be "flexible" if it can provide a second-order approximation to an arbitrary, twice differentiable, linearly homogeneous function.

where $\tilde{P}$ is the price index of all commodities, $m = M/\tilde{P}$ is real income, and C_{ij} are the price coefficients. Note that the equations are normalized by dividing by the price of the nth good; thus, homogeneity is imposed and cannot be tested. The symmetry constraints are:

$$(20)\quad \frac{\partial X_i}{\partial P_N} = -\sum_{j=1}^{N-1} C_{ij} \frac{P_j}{P_N^2} = \frac{\partial X_N}{\partial P_i} = \frac{C_{Ni}}{P_N} \qquad i \neq N$$

$$(21)\quad c_{Ni} = -\sum_{j=1}^{N-1} C_{ij} \frac{P_j}{P_N^2} \qquad i = N$$

which can be imposed by substituting (21) on the right hand side (RHS) of the nth equation in (19). The adding up constraint

$$(22)\quad \sum_i \frac{P_i}{\tilde{P}_i} (b_{i1} + 2\, b_{i2}\, m) = 1$$

can be imposed only for given sample points, usually sample means.[7]

One advantage of the NQ demand system is that the *Nth* quantity can be estimated residually, as long as its price is given, using adding up. Another advantage of the NQ system is its relatively simple expressions for demand elasticities, since only single coefficients are used. This is less subject to error if econometric estimates of the price coefficients are not very reliable. The elasticity formulae for the NQ are:

$$(23)\quad \eta_{ii}^{C} = \frac{C_{ii}\, P_i}{X_i P_n} \qquad i < N \qquad \text{(Own Price-Elasticity)}$$

$$(24)\quad \eta_{NN}^{C} = -\sum_{j=1}^{n-1} C_{Nj} \frac{P_j}{P_N X_N} \qquad \text{(OPE)}$$

$$(25)\quad \eta_{ij}^{C} = \frac{C_{ij}\, P_j}{X_i P_N} \qquad ij < N,\ i \neq j \qquad \text{(Cross-Price Elasticity)}$$

7. Derrivation of the adding-up constraint can be found in Swamy and Binswanger (1983, p. 677).

(26) $\eta_{iN}{}^{C} = -\sum_{j=1}^{n} C_{ij} \dfrac{P_j}{X_i P_N}$ $\quad i < N$ (CPE)

(27) $\eta_{im} = \dfrac{1}{X_i} \; b_{i1} m + 2 b_{i2} m^2$ $\quad$ all i (Income Elasticity)

Generalized Leontief demand functions (GL). Similarly, the generalized Leontief demand function can be expressed as:

(28) $X_i = a_i + b_{i1} m + b_{i2} m^2 + \sum_{j \neq 1} C_{ij} \left(\dfrac{P_j}{P_i} \right)^{1/2} \quad i = 1, \ldots, N$

Homogeneity of degree zero is imposed and cannot be tested, while symmetry implies that $C_{ij} = C_{ji}$ and is imposed for all sample points. The adding up constraint is the same as for NQ. Below, we present the expressions for the elasticities.

(29) $\eta_{ii}{}^{C} = \dfrac{-1}{2X_i} \sum_{j=1} C_{ij} \left(\dfrac{P_j}{P_i} \right)^{1/2}$ $\quad$ all i (OPE)

(30) $\eta_{ij}{}^{C} = \dfrac{1}{2X_i} C_{ij} \left(\dfrac{P_j}{P_i} \right)^{1/2}$ $\quad$ all i, j $\quad i \neq j$ (CPE)

(31) $\eta_{im} = \dfrac{1}{X_i} \; b_i m + 2 b_{i2} m^2$ $\quad$ all i (income)

Note that the expression for the own-price elasticity is a sum of terms, or separately estimated coefficients. This may be quite sensitive to right hand side variables which are left out or incorrectly measured.

Transcendental logarithmic demand functions (TL): Finally, the transcendental logarithmic (translog) demand function is:

(32) $S_i = a_i + b_{i1} \log m + b_{i2} (\log m)^2 + \sum_{j=i}^{N} C_{ij} \log P_j$

$i = 1, \ldots, N - 1$

where $S_i = X_i P_i / \sum_{i=1}^{N} X_i P_i$ or the expenditure share of commodity i. Homogeneity of degree zero implies that $\sum C_{ij} = 0$ for all i and can be tested and imposed. Symmetry implies that $C_{ij} = C_{ji}$ and can be imposed at all sample points. Since shares add up to one, only N-1 equations are linearly independent and one equation must be dropped for estimation purposes. Thus, adding-up cannot be tested and is a maintained hypothesis.

The elasticities for the TL demand system are given by:

(33) $$\eta_{ii}{}^{C} = \frac{C_{ii}}{S_i} + S_i - 1 \qquad i < N \qquad \text{(OPE)}$$

$$\eta_{NN}{}^{C} = \frac{\sum_{i=1}^{N-1} \sum_{j=1}^{N-1} C_{ij} + S_N - 1}{S_N} \qquad \text{(OPE)}$$

(34) $$\eta_{ij}{}^{C} = \frac{C_{ij}}{S_{ji}} + S_j \qquad i, j < N,\; i \neq j \qquad \text{(CPE)}$$

$$\eta_{iN}{}^{C} = \frac{-\sum_{j=1}^{N-1} C_{ij}}{S_i} + S_N \qquad i < N \qquad \text{(CPE)}$$

(35) $$\eta_{im} = \frac{b_i 1 + 2 b_i 2 \log m}{S_i} + 1 \qquad i < N \qquad \text{(income)}$$

$$\eta_{Nm} = \frac{1 - \sum_{i=1}^{N-1} S_i \eta_{im}}{S_N} \qquad \text{(income)}$$

Since the translog is expressed in terms of budget shares, one empirical advantage is being able to estimate elasticities for the Nth equation provided that price data on the Nth good are available. For example, if the missing category is nonfood, then one can estimate nonfood price and cross-price elasticities given nonfood price data. One disadvantage, which will be discussed in the next section, is its unsuitability to the tobit estimation procedure.

Bantilan's article in this issue points out the limitations of using Taylor's series expansions as approximations to a more general functional form. However, the computational advantages – linearity in parameters, economy in the number of parameters to be estimated – as well as the dubious gains in using a more complicated estimation procedure when data are not of uniformly good quality justify the use of the abovementioned functional forms in this study.

2. Some Econometric Issues Involved in Cross-Section Estimation

Because of the scope for disaggregation by income and other household characteristics, cross-section data have been widely used for estimating income-stratum-specific demand parameters. The use of cross-section data has its corresponding set of issues in estimation and interpretation. This paper reviews only a selected number and does not claim to be exhaustive.[8] Before discussing the specifics of estimation, it is perhaps appropriate to begin with differentiating estimates obtained from time-series versus cross-section data, as well as the scope of these elasticities.

First, demand elasticities estimated from household survey data refer to household consumer demand, and thus do not include industrial demand for materials and intermediate inputs and farm demand for feed. Second, elasticities estimated from cross-section data typically will reflect long-run adjustments of households to regional differences in prices and to expected seasonal price movements, whereas annual time series will tend to reflect shorter-run reaction (Timmer 1981; Kuh 1959).

> . . . higher cross-section slope estimates can be interpreted as long-run coefficients. The fully adjusted response will typically show a higher coefficient than an incompletely adjusted response. Since the cross-section data will also contain some short-run disturbances, however, these coefficients will only approximate fully adjusted long-run coefficients (Kuh, 1959, p.197).

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8. More issues regarding the use of cross-section data are discussed in Bantilan's (1986) paper elsewhere in this issue.

Thus, elasticities obtained from annual time-series are expected to be smaller in absolute value than cross-section estimates.[9] It is important to ascertain the numerical value of differences between time-series and cross-section estimates: as Kuh(1959) points out, if the time-series estimate is some function of the typical cross-section estimate, one estimate can be translated into the other irrespective of the causal factors that determined the discrepancy. Unless this relationship has been systematically established, however, cross-section estimates cannot be used successfully to make time-series predictions.

In the remainder of this paper, we discuss some of the econometric issues which are significant in the use of household level data, namely: (1) allowing for income-varying parameters; (2) the treatment of households observing zero consumption; and (3) corrections for missing or understated data and other matters more directly related to the quality of the data under consideration.

2.1 *Income Stratum Specific Demand Elasticities*

Three methods have been in common use to allow for the variation of demand elasticities across income classes: (1) stratifying the sample into subgroups and estimating separate parameters for each subgroup; (2) using dummy variables (slope and intercept shifters) for each subgroup; and (3) introducing an income-varying term into the regression equation. Researchers with sufficiently large data sets usually apply the first method, stratifying the sample according to some predefined criterion, e.g., percentile points in the income or calorie distribution, rural-urban classification, or occupational grouping, while those with smaller data sets introduce income-varying parameters through a squared income term (Swamy and Binswanger 1983), through structural equations relating parameters to income (Pitt 1982), or through piecewise regression. The use of dummy variables is probably conditional upon the assumption of a constant variance-covariance matrix for the entire sample; if the data were heteroscedastic (as is expected in cross-section data), splitting the sample would be a prefer-

9. Timmer and Alderman (1979), for example, conjecture that the immediate response may be only half of the long-run response, implying an adjustment coefficient of 0.5 in a Newlovian adjustment model, which is in keeping with what little impirical evidence ecists. Timmer and Alderman, however, obtain cross-section results which are more than twice the time-series estimates, which is also the case in Quisumbing's (1985) study.

able procedure since one would not have to impose the same underlying variance-covariance matrix.

The use of the squared income term is fairly popular and is used to allow income elasticities to vary across income groups (Swamy and Binswanger 1983; Pitt 1982; Gray 1982). Swamy and Binswanger probably express undue concern regarding the deviation of this form from the Almost Ideal Demand System (AIDS) (Deaton and Muellbauer 1980). They argue that since the budget constraint is a linear function, introducing a squared term will create nonlinearities. However, all that the linear budget constraint requires is $\Sigma\ p\ .\ X(p,y) = Y$, regardless of the form that $X(p, Y)$ should take. That is, it is possible for $X(p,y)$ to be nonlinear in Y and still satisfy the budget constraint.[10] The possible drawback of using the squared income term is that it may not allow for variation in the *price* elasticities unless income varying terms are specified in a separate equation. This is the case in demand equations which are functions of real income and nominal prices. Note that in the TL, NQ and GL, the price elasticities are computed from the price coefficients alone. Thus, introducing a squared income term will allow compensated income elasticities to vary, but not the Slutsky elasticities. This may not be desirable if there in fact exists an income-related "curvature" of the Slutsky matrix.

One can also test whether splitting the sample is equivalent to a single regression with income-varying parameters by performing a model selection test. Most studies which estimated separate sets of parameters have not done this. For example, Gray (1982) justified the estimation of separate sets instead of dummy variables for separate income groups by citing the adequate number of degrees of freedom and the imposition of the same underlying variance-covariance matrix if the equations were estimated together. If the criterion used to split the sample is a continuous variable, e.g., income, it may be advisable to test for equality of variance first before estimating separate regressions since it may be desirable to have parameters which do not exhibit discontinuities once the threshold income is reached. However, if the criterion variable is qualitative (e.g., occupation or location) avoiding discontinuities is no longer relevant. In any case, the issue of model selection is an area which deserves further attention.

10. This was pointed out by R. Sah in a discussion.

2.2 *Limited Dependent Variables: The Case of Nonconsuming Households*

Another related econometric issue is the treatment of households which do not report positive consumption of a commodity. Regional taste differences, seasonality, or regional differences in availability, among others, may be reasons for zero consumption. Another, of course is that lower income households will not be able to afford consumption of some commodities at prevailing prices. Dropping households reporting zero consumption not only reduces the sample size but also creates a truncation bias since those households are part of the market but do not choose to consume, whereas using OLS techniques on transformed variables (e.g., variables to which a positive number has been added to avoid indeterminate results in logarithmic models) will result in inconsistent and biased estimates because the assumptions underlying the classical regression model do not hold. An appropriate estimation procedure to use is Tobin's (1958) limited dependent variable model, since it permits a positive probability of observing nonconsumption.

The stochastic model underlying tobit is given by the following relationship:

$$(36) \qquad Y_t = X_t \beta + u_t \text{ if } X_t \beta + u_t \geq 0 \qquad t = 1, 2, \ldots, n$$
$$\text{if } X_t \beta + u_t < 0$$

where n is the number of observations, Y_t is the dependent variable, X_t is a vector of independent variables, β is a vector of unknown coefficients and u_t is a normal and independently distributed error term, $u_t \sim N(0, \sigma^2)$. Tobit models immediately rule out certain functional forms. Pitt (1982) shows that if expenditure share is the dependent variable in a tobit demand model and if demand is inelastic, an increase in own-price implies an increase in the probability of consuming (positive) quantities of the commodity. Novshek and Sonnenschein (1979) have shown that such a response on the part of marginal consumers is inconsistent with neoclassical demand theory. They argue that, when considering the demand for differentiated products (e.g. food), price-induced changes in market demand are decomposed into income *(I)*, substitution *(S)*, and change-of-commodity *(C)* effects. By neoclassical theory, *(S)* is negative. Thus, even if individual demand functions are upward sloping, *(C)* will guarantee that market demand for a commodity must slope downward whenever there are differentiated commodities which are sufficiently close to the commodity in question (Novshek and Sonnenschein 1979, p. 1375). As Pitt points out, in the tobit model, the probability of consuming is given by the normal cumulative function evaluated at the expected value of the unobserved latent variable $Y^*_t = X_t\beta + u_t$. Since expenditure, and therefore $E(Y^*_t)$, is an increasing function of own-price if demand is inelastic, the probability of consumption rises with own-price even if expected demand will normally fall. Because tobit models are estimated using maximum likelihood methods, it is also desirable to use functional forms which are linear in the parameters to be estimated for ease of estimation. Having ruled out translog models,[11] we can use the normalized quadratic or generalized Leontief, or the simple functional forms used by Pitt (1982) with income-varying parameters.

The use of the tobit model permits the decomposition of the market elasticity of demand (e_i) into two components: (1) the elasticity of the probability of consumption with respect to X_i, or the participation elasticity (e_iP); and (2) the elasticity of the expected consumption of consuming households with respect to X_i, or the nonlimit consumption elasticity (e_iN) (Pitt 1982; following Thraen, Hammond and Buxton 1978). In the tobit model (36), the expected value of the dependent variable y is given by

$$(37) \quad E(y) = \sigma zF(z) + \sigma f(z)$$

where $z = XB / \sigma$, $F(\ )$ is the normal cummulative distribution function and $f(\ )$ is the unit normal density. The elasticity of $E(y)$ with respect to X_i is

$$(38) \quad e_i = \frac{\partial E(y)}{\partial X_i} \cdot \frac{X_i}{E(y)} = \sigma(\partial z / \partial X_i)\ F(z)\ X_i / E(y)$$

which can be decomposed as

$$(39) \quad e_i = \frac{\partial F(z)}{\partial X_i} \cdot \frac{X_i}{F(z)} + \frac{\partial E(\tilde{y})}{\partial X_i} \cdot \frac{X_i}{E(\tilde{y})}$$

$$= e_i p + e_i n$$

11. Using the tobit model also rules out double-log models unless the dependent variable is first transformed by adding a positive number, and then performing an adjustment in the computation of the elasticities. Although Belarmino (1983) and Regalado (1984) did not use tobit they used double-log methods on transformed variables.

where $E(\tilde{y}) = E(y)/F(z)$ is the expectation of y for $y > 0$. While it is impossible to perform an elasticity decomposition with time-series data, cross-section data and the use of the tobit model permit us to estimate both limit and nonlimit adjustments to price and income changes.

2.3 *Other Estimation Issues*

Perhaps one problem which constantly nags users of household level data is their uneven quality, particularly in developing countries. Nonrandom sampling, extreme observations, problems of aggregation, as well as biases in the measurement of certain variables, often necessities the use of adjustments and intensive data cleaning.[12] Many of these problems are inherent in the data set once the researcher gains access to it, sampling and interviewing having been accomplished beforehand. In this section we propose a procedure which may be used to correct for understated data when the degree of bias is unknown, using information obtained from another sample.

Understatement of income data is a chronic problem encountered in household surveys. Income elasticities estimated from understated income data would tend to be unrealiable. In addition, we also do not know whether the degree of income understatement differs across income classes. A common practice is to use total expenditure instead of income as an explanatory variable. However, most of the food consumption surveys do not collect data on total expenditures; while they collect income data, they are severely understated, with measured food expenditure often exceeding measured income. In a past study, we used food budget as a proxy variable and assumed separability of the utility function into food and nonfood (Quisumbing 1985). In this study, we will construct data from the 1975 Family Income and Expenditure Survey conducted by the NCSO and the 1978 and 1982 FNRI surveys to construct a total expenditure variable.

Using the FIES data, which contain data on total expenditure and expenditures on selected commodities, as well as household characteristics, we can estimate an equation for food expenditure F_i as a function of total expenditure E_i and a vector of other characteristics $\bar{C}_i$:

12. Biases due to nonrandom sampling are discussed more exhaustively in the paper by Bantilan, this issue.

(40) $F_i = f(E_i, \bar{C}_i)$

These other characteristics would also be observable from the FNRI data set, which has an observation on all the variables *except* total expenditure. Once the equation $F_i = f(E_i, \bar{C}_i)$ has been estimated, we can express the equation as:

(41) $E_i = g(F_i, \bar{C}_i)$

where we are now obtaining the inverse of the estimated equation. When estimating the demand for specific food commodities using FNRI data, quantity, price and food expenditure data for a household can be obtained from the FNRI data set, and the value of the variable used as a proxy for total expenditure will be predicted for each sample household using equation (41), food expenditure and the vector of common household characteristics. The empirical performance of this alternative procedure has yet to be verified.

3. Philippine Demand Elasticity Estimates

A number of studies have attempted to estimate demand parameters from Philippine data. These studies vary according to methodology, degree of commodity aggregation, type of data, and sample stratification. This paper focuses on the methodological aspects of the abovementioned studies and concentrates only on those for which comparable estimates are available. It therefore does not include earlier work estimating demand functions for single commodities. It also chooses to highlight the studies on food demand which constitute the bulk of Philippine consumption studies. A more exhaustive review of staple food consumption studies in the Philippines is found in Bennagen (1982). Table 1 presents the estimates from the studies reviewed in this paper.

3.1 *Data Sources and Methodology*

Earlier demand studies used aggregate time-series data to estimate demand functions. Among these is Pante's (1971) estimation of alternative static and dynamic demand functions for four commodity groups (food, beverages and tobacco, durables, and miscellaneous) using time-series data from 1949 to 1974. A major achievement of this study was the construction of a more reliable series for personal consumption expenditure. Pante tested the empirical performance of single-equation estimation methods and three system methods, namely, the LES, the Rotterdam demand system, and the indirect addilog system. The LES outperformed the other system models in predicting expenditures, but the Rotterdam model performed better than the other system and single equation methods on the basis of $(1-R^2)$ and information accuracy criteria. However, Pante says that the single equation method has the advantages of flexibility in specification and simplicity in estimation and thus may be worth using in studies of single or a few commodities. The degree of commodity aggregation and the fact that aggregate time series data were used do not make these estimates useful for distribution-oriented analysis. Nevertheless, these estimates can provide a benchmark on the national level and is one of the first attempts to use system approaches in demand parameter estimation.

Grouped cross-section data are provided by the Family Income and Expenditure Surveys (FIES) conducted by the National Census and Statistics Office. A number of studies have used this data set, among which are those of Goldman and Ranade (1976), Arboleda (1982), and Canlas (1983). Although FIES data are available for 1965, 1971 and 1975, each study was able to make use of only one year in its estimation, thus posing a problem in estimating price elasticities in the absence of relative price variation through time. Goldman and Ranade did not estimate price elasticities, while Arboleda and Canlas used system methods incorporating restrictions on demand functions to do so; i.e., variants of the LES. Arboleda (1982) applied the extended linear expenditure system to 1975 FIES data for the analysis of expenditures and saving. Restrictions on demand parameters were used to compute residually for price elasticities for broad commodity groups. Unfortunately, the results were not realistic; some of the computed price elasticities were large and positive in contrast to earlier estimates. Part of this is due to the inappropriate application of a full demand system to a data set whose reliability is questionable. For example, income (and saving) statistics provided by the FIES remain suspect because of the observed dissaving in an implausibly large number of income groups. Errors in measurement will then be reflected in the results.

Canlas's (1983) study used an augmented Stone-Geary utility function with leisure explicitly considered. Canlas used the Betancourt

(1971) procedure to model the demand for leisure using wage rates as a proxy for the demand for leisure, and then used these results to estimate some LES parameters. In effect, variation of wage rates was treated as the source of price variation in the model. His results (in Table 1) appear plausible and are within the range of other elasticity estimates. This suggests that, where data are scarce, the LES can provide a quick way of estimating demand parameters.

The studies using the FIES data used fairly aggregated commodity groups. Disaggregated commodity data are available from two other sources, the Ministry of Agriculture Special Studies Division (MA-SSD), Food Consumption Surveys, and the Food and Nuttition Research Institute (FNRI) Nationwide Nutrition Surveys. The MA-SSD surveys are probably the most popular data source for food demand studies (see Table 1). The MA-SSD conducts quarterly nationwide food consumption surveys, with a sample of 1,000 households in each survey, selected through a random sample stratified by region, sub-region and jurisdiction unit (cities and municipalities). The basic data collected are quantities, expenditures, and prices of 167 food commodities consumedl by the household during the past week prior to the interview, as well as household characteristics, e.g., household size, income and occupation of the principal wage earner, educational attainment and ages of the household members (Belarmino 1985).

Most of the studies based on the MA-SSD data used single-equation, double-log demand functions (e.g. Ferrer- Guldager 1977; Kunkel et al. 1978; Snell 1980; Bouis 1982; and Regalado 1984). Relatively few used the double-log method together with system methods, e.g., San Juan (1978) and Belarmino (1983), who estimated price and income elasticities using a double-log demand function and cross-price elasticities using the Frisch method. A number of studies also stratified the sample according to location (Kunkel et al. 1978; Bouis 1982) and by income group (Snell 1980; Belarmino 1985; Regalado 1984).

The FNRI Nationwide Nutrition Survey data have not been as well utilized for demand parameter estimation although they are extensively used for nutrition-related studies. The FNRI has conducted two nationwide surveys, one in 1978 and another in 1982, covering 2,800 and 2,880 households, respectively, in all regions except Regions IX and XII of Mindanao. Households were selected through a three-stage sampling design. The population was first stratified into urban-rural, and the sampling units for the stages were

TABLE 1
SUMMARY OF PREVIOUS ELASTICITY ESTIMATES, SELECTED FOOD ITEMS, PHILIPPINES

Data Base / Study	Survey Used	Methodology and Data Used	Commodity	Price Elasticity			Income Elasticity		
1. *MA-SSD Surveys*									
1.1 Ferrer-Guldager (1977)	1970-73 (4 rounds)	Double-log, original data	Rice			-0.528	-0.02		
			Corn and corn products			-0.360	-0.24		
			Leafy vegetables			-0.60	-2.24		
			Fruit vegetables			-0.75	0.20		
			Fresh fish			-.60	0.21		
			Pork			-0.60	0.30		
			Beef			-0.47	0.30		
			Poultry meat			-0.50	0.20		
			Eggs			-0.50	0.35		
				Manila	*Urban*	*Rural*	*Manila*	*Urban*	*Rural*
1.2 Kunkel *et al.* (1978)	1970-73 (4 rounds	Double-log, original data	Rice	-0.53	-0.63	-0.31	n.a.	-.03	n.s.
			Corn and corn products	-0.96	-1.37	-1.30	n.s.	-0.18	-0.26
			Leafy vegetables	-0.52	-0.60	-0.57	3.0	0.24	0.19
			Fruit vegetables	-0.8	-0.78	-0.71	2.6	0.18	0.25
			Fresh fish	-0.56	-0.60	-0.52	0.22	0.21	0.23
			Pork	-0.75	-0.55	-0.53	0.34	0.31	0.29
			Beef	0.38	-0.48	-0.49	0.38	0.27	0.19
			Poultry	-0.87	-0.38	-0.54	0.26	0.18	0.11
			Eggs	-0.51	-0.45	-0.44	0.24	0.36	0.29
1.3 San Juan (1978)	1974-76	Double-log, original data for price and income elasticities; Frisch method for cross-price elasticities	Rice		-0.4015			0.3056	
			Corn		0.0688			0.9396	
			Wheat products		-1.6534			0.6060	
			Vegetables		-1.1388			0.4138	
			Fruits		-0.4006			0.3808	
			Fresh fish		-1.5243			0.4589	
			Pork		-1.2051			0.6224	
			Beef-Carabeef		-3.1562			0.7230	

Table 1 (Continued)

Data Base / Study	Survey Used	Methodology and Data Used	Commodity	Price Elasticity	Income Elasticity			
			Poultry	-0.9776		0.4929		
			Eggs	-0.5473		0.6228		
			Dairy products	-0.4452		0.4760		
1.4 Snall (1980)	1970-76	Double-log, grouped data, with constaints	(Deflated estimates, Model 3.c)		P400	P400-799	P800-1499	P1500
			Rice	-0.45	-0.33	-0.18	-0.01	0.11
			Corn	-1.14	0.06	-0.27	-0.46	-1.39
			Wheat	-1.10	-0.71	0.11	0.39	0.56
1.5 Bouis (1982)	1973-76 (15 rounds)	Double-log, original data	Rice	-0.63	0.09			
			Corn	-1.34	-0.27			
			Wheat	-0.78	0.41			

Data Base / Study	Survey Used	Methodology and Data Used	Commodity	Price Elasticitiy				Food Expenditure Elasticity			
				Stratum				Stratum			
				I	II	III	IV	I	II	III	IV
1.6 Belarmino (1983)	1973-76	Double-log single equation, original data (Matrix B)	Rice and rice products	-2.18	-1.92	-1.72	-1.72	1.50	1.32	1.21	1.06
			Corn and corn products	-2.55	-2.18	-2.11	-2.11	0.210	0.16	0.12	0.09
			Pork	-2.24	-1.54	-1.71	-1.40	0.98	1.15		
			Wheat and wheat products	-1.31	-1.21	-1.12	-0.99	0.91	1.00	1.08	1.11
			Pork	-2.24	-1.54	-1.71	-1.40	0.9	1.15	1.26	1.28
			Beef	-2.63	-1.58	-1.49	-1.39	0.73	0.80	1.02	1.10
			Poultry	-2.17	0.30	-1.25	-1.64	0.82	0.91	1.04	1.13
			Processed meat	-5.33	-2.53	-1.75	-1.45	0.46	0.62	0.76	0.83

Table 1 (Continued)

Data Base / Study	Survey Used	Methodology and Data Used	Commodity	Price Elasticitiy				Food Expenditure Elasticity			
				Stratum				Stratum			
				I	II	III	IV	I	II	III	IV
			Egg	-1.46	-1.10	-1.08	-2.10	0.85	1.02	1.08	0.97
			Dairy products	-1.29	-1.34	-1.09	-0.92	0.99	1.29	1.49	1.44
			Crustaceans and mollusks	-1.36	-1.23	-1.15	-1.10	0.55	0.63	0.78	0.94
			Fish	-1.00	-0.83	-0.87	-0.92	1.16	1.30	1.39	1.39
			Processed Fish	-0.06	-0.05	-0.10	-0.16	0.85	0.92	0.89	0.93
			Fruit	-1.03	-0.97	-0.91	-0.83	1.16	1.30	1.39	1.39
			Leafy-yellow vegetables	-0.50	-0.44	-0.10	-0.30	0.66	0.73	0.87	0.82
			Fruit vegetables	-0.85	-0.97	-0.90	-0.93	0.75	0.80	0.79	0.86
			Leguminous	-0.91	-0.83	-0.78	-0.74	0.59	0.60	0.62	0.67
			Rootcrops, bulbs and tubers	-1.141	-1.25	-140	-1.39	0.53	0.43	0.56	0.60
			Oil	-0.87	-0.76	-0.75	-0.66	0.57	0.53	0.54	0.54
			Sugar	-0.79	-0.81	-0.65	-0.69	0.50	0.54	0.56	0.49
			Miscellaneous	-0.31	-0.29	-.030	-0.35	0.66	0.73	0.70	0.75
		Price and income coefficientsf from double-log demand functions, using Zellner's seemingly unrelated regression technique; cross-price elasticities using Risch method (Matrix D)	Rice and rice products	-2.24	-1.92	-1.68	-1.59	0.15	0.08	0.40	0.12
			Corn and corn products	-2.53	-2.18	-2.10	-1.94	-0.04	-0.07	-0.17	0.03
			Wheat and wheat products	-1.36	-1.34	-1.11	-0.94	0.31	0.34	0.45	0.32
			Pork	-2.28	-1.68	-1.82	-1.68	0.26	0.60	0.70	0.41
			Beef	-2.27	-1.54	-1.42	-1.34	0.16	0.18	0.71	0.41
			Poultry	-2.21	0.46	-1.28	-1.59	0.02	0.35	0.49	0.37
			Processed meat	-5.29	-2.53	-1.76	-1.50	0.10	0.29	0.62	0.12
			Egg	-1.53	-1.12	-1.14	-2.39	0.23	0.42	0.44	0.31
			Dairy products	-1.28	-1.26	-0.10	-0.79	0.39	0.58	0.56	0.30

Table 1 (Continued)

Data Base / Study	Survey Used	Methodology and Data Used	Commodity	Price Elasticitiy Stratum I	II	III	IV	Food Expenditure Elasticity Stratum I	II	III	IV
			Crustaceans and mollusks	-1.38	-1.26	-1.17	-1.14	0.11	0.15	0.15	0.26
			Fish	-0.87	-.054	-0.67	-0.69	0.37	0.34	0.24	0.27
			Processed fish	-0.03	-0.05	-0.08	-0.11	0.29	0.26	0.14	0.19
			Fruit	-1.05	-0.95	-0.88	-0.78	0.15	0.40	0.65	0.47
			Leafy-yellow vegetables	-0.53	-0.39	-0.42	-0.22	0.11	0.17	0.31	0.32
			Fruit vegetables	-0.81	-0.79	-0.76	-0.68	0.20	0.30	0.31	0.32
			Leguminous	-0.81	-0.96	-0.90	-0.97	0.22	0.25	0.31	0.36
			Rootcrops, bulbs and tubers	-1.45	-1.27	-1.43	-1.41	-0.02	0.21	0.41	0.28
			Oil	-0.83	-0.68	-0.73	-0.60	0.22	0.28	0.28	0.15
			Sugar	-0.78	-0.78	-0.50	-0.62	0.18	0.11	0.36	0.06
			Miscellaneous	-0.26	-0.25	-0.26	-0.30	0.10	0.15	0.20	0.23
1.7 Regalado (1984)	1973-76	Double-log, original and groupedddata	Rice	-2.48	-2.64	-2.19	-1.91	0.25	0.10	0.44	0.07
			Corn	-1.39	-1.02	-0.78	-0.48	0.16	0.24	0.36	0.07
			Wheat	-.165	-1.60	-1.36	-1.04	0.43	0.42	0.56	0.23
			Sugar	-0.72	-0.58	-0.37	-0.44	0.18	0.13	0.37	0.05
			Oil	-0.66	-0.54	-0.53	-0.38	0.24	0.28	0.31	0.10
			Fish	-1.35	-0.91	-0.87	-0.48	0.47	0.40	0.24	0.06
			Meat	-1.39	-0.50	-0.52	-0.17	0.41	0.81	0.93	0.32
			Eggs	-1.22	-0.50	-0.04	-0.53	0.33	0.68	0.41	0.23
			Milk	-1.78	-0.89	-0.53	-0.11	0.38	0.53	0.52	0.09
			Fruits	-1.12	-0.99	-0.80	-0.62	0.13	0.412	0.68	0.12
			Vegetables	-1.02	-0.92	-0.90	-0.80	0.09	0.321	0.39	0.19
			Miscellaneous	-0.26	-0.18	-0.16	-0.09	0.12	0.091	0.16	0.09
			Fish and seafoods	-0.73	-0.29	-0.19	-0.04	2.07	1.00	0.91	0.56
			Meat	-2.06	-2.62	-2.27	-2.05	1.75	2.80	3.24	4.17

Table 1 (Continued)

Data Base / Study	Survey Used	Methodology and Data Used	Commodity	Price Elasticitiy				Food Expenditure Elasticity			
				Stratum				Stratum			
				I	II	III	IV	I	II	III	IV
			Poultry	-0.79	-1.07	-0.75	-1.72	0.94	0.88	1.58	1.99
			Eggs	-5.29	-1.60	-1.84	-2.59	1.85	2.21	2.69	2.27
			Milk and milk	(1)							
			products	-2.88	-5.11	-2.26	-0.71	1.15	2.55	2.12	1.91
			Fats and oils	-1.39	-0.93	-1.22	-0.47	1.80	1.96	1.61	1.11
			Miscellaneous (OLS)	-1.58	-1.44	-1.39	-1.55	0.94	0.73	0.82	0.92
		Almost complete system (ACS) formulation of S-brand system	Energy Foods	(2)							
			Rice and rice products	-0.53	-0.89	-0.55	6.63	1.91	1.64	1.24	0.61
			Corn and corn pro-	(1)							
			ducts	-0.07	-0.12	-0.52	-0.51	-1.23	-1.47	-0.53	0.08
			Other cereal products	-0.08	-0.20	-0.38	3.81	2.08	1.89	1.29	2.44
			Starchy roots and	(1)							
			tubers	-0.03	-0.06	-0.50	0.67	1.04	1.02	0.99	1.11
			Sugars and syrups	-0.05	-013	-1.12	-079	2.21	1.47	1.49	1.65
			Fats and oils	-0.05	-0.14	-0.90	-1.40	1.59	1.86	1.87	1.64
			Body-Building Foods	(2)							
			Dried beans, nuts and seeds	-0.03	-0.10	-4.46	-1.22	1.15	0.85	1.03	0.31
			Fish and seafoods	-0.35	-0.86	-1.86	-1.69	2.26	2.70	1.88	2.27
			Meat	-0.15	-0.30	-5.24	1.54	2.46	2.44	1.69	1.50
			Poultry	-0.05	-0.09	-1.08	-1.05	1.70	0.92	0.98	0.67
			Eggs	-0.06	-0.16	-1.63	2.04	2.01	2.77	3.29	4.47
			Milk and milk products	-0.06	-0.15	-1.82	3.63	1.08	0.95	1.69	2.13
			Regulating Foods								
			Green Leafy and yellow vegetables	-0.04	-0.30	0.08	-1.11	1.90	2.29	2.64	2.37
			Vitamin C-rich foods	-0.06	-0.40	-2.57	-0.74	1.47	2.46	2.29	2.11
			Other fruits and	(1)							
			vegetables	-0.16	-0.85	-0.62	-0.70	1.64	1.82	1.62	1.10

Table 1 (Continued)

Data and Base/Study	Survey Used	Methodology and Data Used	Commodity	Price Elasticity	Income Elasticity					
					Per Capita Income			*Food Peso Value Elasticity Per Capita Income*		
					P500	*P500-P1500*	*P1500*	*P500*	*P500 P1500*	*P1500*
2. FNRI										
2.1 FNRI 91981	1978	Double-log, original data	Rice		0.12	0.15	-0.08	1.11	0.52	0.06
			Corn		-0.21	-0.21	-0.15	-1.02	-0.49	-0.16
			Sweetpotatoes		-0.07	0.02	-0.03	0.01	-0.07	-0.07
			Cassava		-0.09	-0.16	-0.03	-0.23	-0.20	0.02
			Wheat		-0.19	0.67	0.26	1.08	1.00	1.08
			Green Leafy vegetables		0.10	-0.14	0.20	-0.10	-0.04	-0.29
			Vit. C rich foods		0.45	0.32	0.05	1.22	1.12	1.03
			Other fruits/vegs.		0.29	0.56	0.24	1.05	0.87	0.59
			Fresh fish		0.39	0.27	0.13	0.89	0.58	0.19
			Fresh meat		0.03	0.46	0.72	1.15	1.70	1.65
			Poultry		0.04	0.11	0.33	0.41	0.49	0.69
			Eggs		0.09	0.65	0.23	0.73	1.02	0.99
			Milk and milk products		0.28	1.31	0.45	1.51	1.92	1.80
2.2 FNRI (1984)	1982	Double-log original data	Rice		0.05	0.33	-0.04	1.82	0.79	0.17
			Corn		-0.10	-0.36	-0.02	-1.70	-0.73	-0.21
			Sweet potatoes		0.15	-0.17	-0.09	-0.15	0.16	0.08
			Cassava		-0.25	-0.05	-0.06	-0.25	-0.10	-0.05
			Wheat		0.58	0.75	0.51	1.27	1.49	1.49
			Green leafy vegetables		-0.12	-0.18	-0.19	-0.37	-0.21	-0.22
			Vit. C. rich foods		0.31	0.46	0.35	1.64	1.28	1.37
			Other fruits/vegetables		0.05	0.51	0.23	1.19	1.45	1.16
			Fresh fish		0.40	0.69	0.15	1.03	0.89	0.41
			Fresh meat		-0.01	0.59	0.90	1.20	1.70	2.23

Table 1 (Continued)

Data and Base/Study	Survey Used	Methodology and Data Used	Commodity	Price Elasticity				Income Elasticity			
						Per Capita Income			*Food Peso Value Elasticity Per Capita Income*		
						P500	*P500-P1999*	*P2000*	*P500*	*P500-P1999*	*P2000*
			Poultry			0.12	0.26	0.46	0.35	0.74	1.18
			Eggs			0.09	0.54	0.32	0.68	1.10	1.21
			Milk and milk products			0.11	0.93	0.85	1.14	1.87	1.75
						Stratum				**Stratum**	
				I	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**
2.3 Quisumbing (1985a)	1978	Double-log seemingly unrelated regressions	Rice and riceproducts	-1.45	-1.95	-1.20	-1.0	1.71	1.48	1.07	0.55
			Corn and corn products	-2.10	-1.57	1.51	-2.09	1.90	1.42	0.22	0.05
			Other cereals products	-3.38	-3.03	-2.69	-2.84	1.63	2.18	1.29	2.28
			Starchy roots and tubers	-3.44	-3.50	-1.77	-1.20	0.63	1.05	0.98	1.24
			Sugar and syrups	-2.05	-1.44	-0.85	-0.58	1.77	1.30	1.45	1.42
			Dried beans, nuts and seeds	-1.95	-1.03	-1.77	-0.93	1.66	1.81	1.94	1.47
			Green leafy and yellow vegetables	-2.69	-2.67	-2.04	-1.93	1.12	0.64	0.92	0.41
			Vitamin C rich foods	-2.39	-2.04	-1.25	-0.92	2.34	2.55	2.14	2.53
			Other fruits and vegetables	-2.15	-1.82	-1.64	-1.41	2.01	2.53	1.51	1.44
3. NCSO-FIES								*Rural*		*Urban*	
								Lower 40%	*Upper 10%*	*Lower 40%*	*Upper 10%*
3.1 Goldman and Ranade (1976)	1971	Grouped data	Cereals and products					1.05	0.41	0.26	0.37
			Seafood and fish					1.53	0.62	0.48	0.54
			Meat and eggs					1.63	1.09	1.87	0.97
			Milk and dairy products					2.34	1.04	1.32	0.75
			Fruits and vegetables					1.01	0.67	0.67	0.67

Table 1 (Continued)

Data and Base/Study	Survey Used	Methodology and Data Used	Commodity	Price Elasticity	Income Elasticity
3.2 Canlas (1983)	1965	Linear expenditure systems, Betancourt procedure, grouped data	Cereals	-0.258	0.296
			Fish and seafoods	-0.382	0.483
			Meat and eggs	-0.821	1.083
			Milk and dairy products	-0.775	0.999
			Roots	-0.508	0.658
			Miscellaneous	-0.503	0.651
			Food consumed outside home	-0.926	1.242
4. Ministry of Agriculture Integrated Agricultural Production and Marketing Proj. (IAPMP) (1980)	Mixed time series of cross section data	Econometric and simulation techniques	Rice	-0.37	0.20
			Corn, food	-0.40	-0.20
			sweet potatoes	-0.25	0.25
			Cassava	-0.20	0.20
			Wheat	-1.30	0.45

provinces, barangays and households. Although the surveys included an anthropometric and medical section, for our purposes we focus on the food consumption surveys. The data were obtained through one-day food weighing conducted by trained nutritionists. These data contain information on the consumption and cost of 146 commodity groups, together with their nutrient intake equivalents. The surveys also provide data on selected household characteristics, namely, per capita income, education, fertility and health practices, sources of livelihood and extent of home food production. Since each survey covered only one time period, and pooled estimation is still in progress, the problem of price variation appears again. Both sets of FNRI estimates (FNRI 1981, 1984) do not include price elasticities but income and food budget (food expenditure) elasticities. Quisumbing (1985) constructed a price series from the FNRI data and used various approaches (double-log, S-branch system and the Frisch method) to estimate price elasticities. She found that the double-log equations with estimated homogeneity restrictions using seemingly unrelated regressions (Zellner 1962) performed better than the more restrictive S-branch and Frisch methods. She did not estimate income elasticities since the income data were understated relative to the food expenditure data; instead she estimated food budget elasticities.

Although most of the studies mentioned above used household level data, no attempt was made to introduce demographic scaling; most simply expressed variables in per capita (instead of per equivalent adult) terms. Also, the treatment of nonconsuming households was not satisfactory; either these were dropped from the analysis or variables were transformed by adding a positive number to avoid indeterminacy in double-log regressions. As was pointed out earlier, a transformation which does not alter the shape of the distribution but simply shifts it upward does not remove the clustering of observations of the dependent variable. Further work will have to incorporate limited dependent variable analysis. In the next section we compare the various estimates.

3.2 *Comparison of Demand Elasticity Estimates*

A perusal of Table 1 reveals wide variation in the magnitudes of the elasticity estimates, even when identical data sets are used. Methodology and grouping do have a significant effect on empirical results. For example, estimates of price elasticities from the FNRI data set are larger in absolute value than those from the MA-SSD. This is to be expected since the MA-SSD data, covering a longer time period, would exhibit greater price variation compared to a one-period, cross-section data set, and thus would yield smaller elasticity estimates. The FNRI estimates, however, are comparable in magnitude to those from Brazil (Gray 1982), Indonesia (Timmer and Alderman 1979), and Thailand (Trairatvorakul 1982), which were based on cross-section data collected in a one-year period.[13]

Among the MA-SSD based estimates, there is also variation between income-group-specific estimates and nonstratified sample estimates. Estimates of the own-price elasticity for rice from unstratified sample studies range from –0.40 (San Juan 1978) to –0.53 (Ferrer-Guldager 1977). Stratified sample studies (e.g., Kunkel et al. 1978, by rural/urban, and Bouis 1982b, by region and income group) range from –0.31 to –0.63. However, the absolute values of the own-price elasticities for rice estimated by Belarmino (1985) and Regalado (1984), which stratify by income, are quite large. Bouis has suggested that the large values may have been due to the pooling of Luzon, Visayas and Mindanao observations in estimation. Since these regions differ markedly in cereal consumption patterns, pooling them would increase quantity relative to price variation and thus would result in larger elasticity estimates. His own results were obtained by taking the consumption-share weighted average of elasticities computed separately for Luzon, Visayas and Mindanao.[14]

We also examine elasticity patterns from income-group-specific estimates. In the studies by Belarmino (1985), Regalado (1984), and Quisumbing (1985), the absolute values of the price elasticities decline as income increases. A "parabolic" pattern is observable for rice in the Regalado and Quisumbing studies, i.e., the own-price elasticity rises from the first to the second income stratum and then declines. The decline in the own-price elasticities is due to falling budget shares and income (or food budget) elasticities for staple foods as income increases. However, the nonlinearities indicate that the relationship between (uncompensated) price elasticities and income is not mono-

13. For a description of these estimates and data sources see Quisumbing (1985).

14. Howarth Bouis pointed this out in a discussion.

tonic. Moreover, in Quisumbing's study, this behavior is more noticeable for energy foods such as rice, corn, other cereal products, and roots. The peak in the rice own-price elasticity in the second income stratum of the Regalado and Quisumbing studies reflects the consumer's increased ability to purchase and substitute preferred energy foods for less preferred ones, e.g., rice for corn. Having satisfied his or her hunger or "bulk" constraint to some degree, the consumer can consider diversifying his or her diet (Bouis 1982). The higher values of the elasticities may also be due to the existence of a wider range of affordable substitutes in the energy food s group once income reaches the second stratum level.

There seems to be limited scope for evaluating the benefits of system approaches vis-a-vis single equation methods, since there are relatively few system studies. Belarmino (1985) compared single-equation to seeming-unrelated-regression and Frisch methods and concluded that the single-equation approach yielded more plausible results. Quisumbing (1985) also found that the double-log functional form, estimated as a system, performed better than S-branch and Frisch estimates. However, the above comparisons are faulty in that they compare two extremes: a "pragmatic" nonrestricted demand function and highly restrictive, additive demand systems. The drawback of using the pragmatic approach is the satisfaction of restrictions purely on an ad hoc basis; while the defect of the restrictive systems is their lack of flexibility. There is a lot of scope for using flexible functional forms which can incorporate the restrictions of consumer theory in demand analysis, as well as refining the methodology for including variables other than prices and incomes in the estimating equations. The generation of reliable, disaggregated demand paramaters is an important undertaking in the light of their role in consumption and nutrition policy analysis, which is discussed in the last section of this paper.

4. Models for Consumption and Nutrition Analysis

4.1 *Review*

Income-group specific demand parameters are important inputs into models which estimate the distributional impact of food policies. These models can be classified into three types: (1) models estimating the overall demand for nutrients; (2) partial equilibrium models using commodity-specific demand functions; and (3) general equilibrium models using commodity-specific demand functions.

Models of the first type are not as popular as those of the second and third, probably due to the limitations inherent in estimating overall nutrient demand. This approach was used by Reutlinger and Selowsky (1976) to estimate the magnitude of the malnourished population using a characteristic demand function relating a nutritional characteristic (calorie) to income levels, and then integrating the intake distributions up to the required level of calorie consumption. Knudsen and Scandizzo (1982) estimate calorie demand functions for developing countries, stratified according to their calorie consumption levels. They derive price and income elasticities for total calorie consumption and use these to investigate the potential impact of income growth, redistribution and price changes in alleviating calorie under consumption. Gray (1982) also estimates demand functions for calorie and protein by regressing the total amount of nutrients as a function of prices and income, and uses the resulting calorie and protein demand functions to examine the tradeoff between dietary quality and quantity.

Approaches of the above type can be criticized on several counts. With regard to the Reutlinger-Selowsky calculation, apart from data unreliability, a question can be raised regarding correlation between income and nutrient distributions. According to Sukhatme, as cited in Taylor (1977) population distributions for income, calorie intake, and calorie requirements are bound to be correlated, making a calculation based on marginal distributions of the Reutlinger-Selowsky type biased. A more fundamental problem, however, is whether nutrient prices in nutrient demand equations of the Knudsen-Scandizzo (1982) or Gray (1982) studies are properly defined. Typically, the price is obtained by dividing the nutrient content of the commodity by its observed market price. Evenson (1985) argues that the demand for food is actually a demand for nutrients plus a demand for nonnutrient characteristics (e.g., taste), and that the price of food is composed of the basic nutrient price (the shadow price of nutrients) plus a taste factor. Methods which calculate nutrient demand as a function of the composite price do not therefore estimate the true demand for nutrients.

The second and third approaches estimate the commodity consumption effects of exogenously introduced changes in a market equilibrium model. They estimate the change in commodity consumption for each income group, using separate demand functions for each each group, and multiply the resultant changes by their nutrient equivalents to obtain an estimate of the total change in nutrient consumption. The two types of models differ in model structure, the first being partial-equilibrium in nature, with income and price changes in the food sector being determined, for the most part, exogenously, and the second incorporating endogeneity and intersectoral effects through a general equilibrium framework.

Models using the partial-equilibrium framework classify food policies into three types (Perrin and Scobie 1981):

1. *Supply shifters.* Agricultural production policies fall into this category. These include public investment in agricultural research which generates new information and techniques, public investment in rural infrastructure, direct subsidies of agricultural inputs, and food import policies.[15]
2. *Demand shifters.* such as direct income transfers, certain types of food stamp programs and nutrition-oriented consumer education programs.
3. *Price wedges* between producers' and consumers' prices. These include simple food stamp plans, ration shops, bounties paid to producers, as well as general agricultural price intervention policies carried out by marketing boards and some food import agencies.

Pinstrup-Andersen and associates' (1976, 1978) work fits into this classification. One study estimates the potential effects of food supply shifts on nutrient consumption by different income groups in Cali, Colombia (Pinstrup-Andersen, de Londoño and Hoover 1976). The results of the study are used to suggest commodity priorities in agricultural policy: commodities where supply increases yield the greatest nutritional impact on low income groups, e.g., staples, should be given importance. In the second study, Pinstrup-Andersen and Caicedo (1978) investigate the effects of income redistribution policies on nutrition consumption. Gray (1982) uses a similar approach specifying separately computed price and income changes, to estimate the effects of specific commodity subsidies and the Brazilian alcogas production program. Perrin and Scobie (1981) generalize the model and examine the cost effectiveness of market intervention policies in terms of treasury costs associated with incremental increases in calorie consumption.

In the Philippines, partial equilibrium models have been used in studies by Regalado (1984) and Quisumbing (1985a, 1985b) at the

15. Food import policies can be viewed as a way of maintaining a price wedge between domestic producers' prices and the subsidized consumer price.

national level, and by Mendoza (1982) at the village level.[16] Regalado (1984) applies methodology similar to that of Pinstrup-Andersen et al. (1976, 1978) to look at the consumption and nutrition effects of price increases in rice and cooking oil as well as alternative income redistribution policies under different assumptions regarding supply elasticities and targeting. She also estimates the minimum income change and price discount by commodity needed to increase calorie and protein consumption up to the recommended daily allowance (RDA). Mendoza (1982) follows a similar procedure using village-level data from San Pablo City, Laguna. Quisumbing (1985b) estimates the effects of price subsidies and income transfers under various assumptions regarding supply elasticities and degree of targeting, and like Perrin and Scobie (1981), computes the treasury costs of some targeted intervention policies. An extension of the model which considers income and consumption effects on rice producers is used to simulate the effects of the adoption of modern rice varieties, and another application examines the effect of the removal of nominal protection on food.

The main drawbacks of partial equilibrium models are the need to specify price and income changes exogenously, as well as the neglect of intersectoral and macroeconomic consequences of food policies. These are especially significant in a developing country where the food sector — production and processing — is macroeconomically important, and where general food price policies may affect the level of the budget and trade deficits.. As Taylor (1977a) points out, the importance of the food sector may be heightened by some of the macroeconomic implications of Engel's law. In a supply shortfall, for example, low income and price elasticities for staple foods mean that food prices in an uncontrolled market would rise by far more than their consumption would decline. Real consumer income would fall because of inelastic quantity response to price increases, and the reduction would spill over into other markets. Some of these effects are modeled by Taylor (1977b) in a study of food subsidies in Egypt. A general equilibrium macro-model of Egypt with rural, urban and food processing sectors is used to simulate the effects of price, wage, and investment increases. The model resembles a closed Leontief input-output system, except that prices are determined endogenously by sectoral markup rates. Consumer demand responses to price and income changes are modeled upon the Stone-Geary linear expenditure system, with parameters

16. The numerical results of these studies will be reviewed in Section 4.2.

calculated from income elasticities and a guess at the income flexibility of demand. Another macro model is formulated by McCarthy and Taylor (1980) to examine macro and nutritional consequences of food policies in Pakistan. It is a computable general equilibrium model with a detailed breakdown of the food sector and three rural and three urban income classes. The agricultural sectors are basically price-clearing (under fixed supply) while the nonagricultural sectors follow markup pricing.

Other general equilibrium models are discussed in the paper by Habito (1985, this issue). While most of these do not directly address potential nutritional effects, it is relatively straight forward to compute these changes once the new equilibrium consumption amounts (at the equilibrium set of prices) have been estimated.

Finally, we turn to a brief review of the results from nutrition policy models in the Philippines.

4.2 *A Review of Philippine Consumption-Nutrition Models*

Relatively few studies have been undertaken in the Philippines estimating the potential nutritional effects of food policies using the models discussed previously.[17] Among these are those of Regalado (1984) and Quisumbing (1985), which are essentially partial equilibrium models.

Effects of price subsidies. Quisumbing's (1985a, 1985b) results from simulating the nutritional impact of a 10% subsidy on selected commodities (rice, corn, oil and rootcrops, as well as combinations of the above) for the lowest income group, reveal that the calorie gain for the nutritionally at-risk group is greater when rice and oil are subsidized followed by a subsidy in rice alone. Calorie gains for the lowest income group are greater the more precise the degree of targetting i.e., estimated gains in nutrient consumption when the price subsidy is directed to the first quartile are greater than when the subsidy is given to the first and second quartiles, or to all the quartiles. Calorie gains are also greater if elastic food supplies are assumed.

17. There are of course project specific estimates from actual nutrition intervention programs as well as a study on the Philippine Pilot Food Discount Project which is in its analysis stage at the International Food Policy Research Institute.

Regalado's (1984) results, simulating a 10% rice price increase, are consistent with the above findings. Total estimated changes in calorie intake by income stratum are relatively large and negative because of the great reduction in the quantity of rice consumed, the main calorie source. Substitution of other foods, even if they were energy sources, did not balance the loss in calories from rice. Only stratum IV, the highest income group, enjoyed a more than sufficient diet despite the 10% rice price increase, while consumption in the lower three groups became deficient. In terms of absolute changes in intakes, however, the lowest quartile had the least reduction in calorie intakes, probably because they substituted cheaper calorie sources more readily than the higher income groups.

In terms of increasing calorie consumption by the lowest income groups, however, price subsidies are relatively expensive to implement, even if strictly targetted, as indicated in Quisumbing's (1985b) computations of treasury costs. Her study shows that the most cost effective way of increasing consumption is through an income or food budget transfer. This is because the costs of price subsidies tend to rise nonlinearly as a function of the desired calorie gain, while the cost function for an income transfer is linear.

Effects of income transfers. Both Regalado (1984) and Quisumbing (1985b) estimate the effects of income changes on nutritional intake. Quisumbing's results indicate that nutrient gains at deficit groups are higher under unitary supply elasticities than under zero supply elasticities. This is due to the fact that, under inelastic supplies, consumers with increased incomes are competing for a fixed supply of goods, and the resultant increase in price due to an upward shift in demand will dampen the increase in demand by the lower income groups. Quisumbing's (1985b) results also show that targeted income transfers yield greater nutritional improvements by deficit groups and are more cost-effective in terms of absolute nutrient gains per peso.

Regalado's (1984) computations estimate the minimum income change required to meet both calorie and protein requirements. She finds that an 82% increase in annual per capita income is needed for the first stratum to close the calorie gap while a 46% increase is required by the second. The upper two income groups, strata III and IV, can suffer decreases of 11% and 147%, respectively, and still be sufficient with respect to calories. This is indicative of the inequality in the distribution of income and the degree of poverty at the lower income levels, although it is possible that the basic income data are understated. In absolute terms, the 82% for the lowest stratum is equivalent to about P338 incremental income per capita per year. Thus, an average household of six members should receive a total income of about P5,625 in stratum I, which is within the range of the food threshold poverty line in the rural and Metro Manila areas of P5,201-P7,123 fo 1975 (Mangahas 1985).

Effects of general agricultural policies. Quisumbing (1985b) examines the nutritional effects of two agricultural policies: (1) adoption of modern rice varieties; and (2) removal of nominal protection on food. In the first case, the study investigated the effects of different supply shift assumptions and different rates of technical progress between large and small farms. Results show that the adoption of modern varieties has a favorable distributional impact on nutrition. The gains for all groups are also greater, the higher the cumulative shift in the supply curve. With regard to differential rates of technical progress, the gains of the lowest income group are greater under assumptions of equal rates of technical progress between large and small farms. This is not surprising since 40% of the household heads in the lowest income group are employed in small farms.

The removal of nominal protection on food has, in general, insignificant but negative effects on calorie consumption. The second quartile appears to be the most adversely affected by this policy, probably due to its high degree of price responsiveness. However, since the nutritional effects on the other quartiles are insignificant, and since the welfare losses as a result of the protective structure are large, the removal of nominal protection would probably have beneficial effects for the economy at large. Targeted subsidies or transfers to at-risk groups are more efficient than general price subsidies which may create producer disincentives.

Although the policies examined by the previously conducted Philippine studies are important, a broader range of policies, as well as a deeper understanding of the macroeconomic and intersectoral consequences of food policies, can only be studied in the framework of a general equilibrium model. Incorporating endogeneity of incomes and prices as well as other general equilibrium effects will be pursued in the course of this research, so that a balanced perspective of agricultural development policy will be achieved.

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