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

FOOD DEMAND PARAMETERS AND THER APPLICATION TO NUTRITION POLICY SIMULATION

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This paper examines various approaches used for estimating food demand parameters for specific income groups. The study discusses the implications of separability assumptions regarding the consumer's utility function on the estimation of demand parameters. Demand elasticities for four income groups were estimated using the S-Branch system, the Frisch method, and a double-logarithmic demand function. A partial equilibrium model of the food market which utilizes the income-stratum specific elasticities is then used to simulate the nutritional impact of the adoption of modern rice varieties under different assumptions regarding technical progress and marketable surplus.

1. Introduction

This study is among the recent stream of food policy literature which attempts to evaluate the nutritional impact of food policies using disaggregated, income-stratum specific food demand parameters. Demand parameters by income group are necessary for assessing the distributional impact of price and income policies since there is empirical evidence that price, cross-price and income elasticities vary systematically across income groups. Various studies (Pinstrup-Andersen *et al.*, 1976, 1978; Timmer, 1981; Gray, 1982; Trairatvorakul, 1984; for Cali, Colombia, Indonesia, Brazil and Thailand, respectively), as well as a number of Philippine studies reviewed by Bennagen (1982) reveal that the absolute values of price and income elasticities, particularly for staple foods, tend to decline as income increases, suggesting that poor consumers are more responsive to price and income changes than are better-off consumers. While most studies which report differences in price elasticities usually refer to

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uncompensated price elasticities, there is also evidence (Timmer, 1981; Pitt, 1983) that compensated elasticities also vary with income level, suggesting that an income-related "curvature" of the Slutsky matrix exists (Timmer, 1981). In view of the above, average elasticities will not reveal the differential response of various income groups and may not be indicative of true responses especially if the income distribution is very skewed.

Various methodologies have been used to estimate income-stratum specific demand parameters. Many of these have been justified by the need to economize on the number of parameters to be estimated, particularly when using cross-section data sets which may not offer sufficient price variation to yield meaningful price elasticities. Cross-sectional data sets, however, are preferred to time-series data because of the scope they offer for disaggregation on the household level. Thus, the methodologies devised impose restrictions on the parameters using the axioms of demand theory in order to reduce the number of parameters to be estimated. These approaches vary in terms of the assumptions regarding the consumer's underlying demand behaviour. This study applies some of these approaches — notably those which assumed separability of the utility function — to estimate demand parameters and to evaluate alternative estimation methods.

The data set used for the paper consists of the 1978 Food Consumption Survey Data from the Food and Nutrition Research Institute (FNRI), which covered 2,800 households in all regions of the Philippines except Regions IX and XII of Mindanao. Access to the data was made possible through a joint research agreement between FNRI and the Research for Development Department of the Development Academy of the Philippines, where the bulk of the study was conducted. The data set obtained from one-day food weighing contains information on the consumption and cost of 146 commodity groups, in the form of as-purchased, edible portion, and net intake weights as well as their corresponding nutrient equivalents, and information on household-level socioeconomic factors. Since we have information only on the food subgroup, we assume that the utility function is separable into food and nonfood components.[1]

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[1] Due to data limitations, we did not estimate income or total expenditure elasticities, but food budget elasticities. This was due to the understated income data in this data set, whose degree of underestimation may not have been uniform throughout the sample. Food expenditures, however, were reliably collected; this is typical of many household surveys in developing countries. No data on total expenditures were collected. A discussion of the theory behind separability and two-stage budgeting which justifies the procedure used in this paper is presented in a succeeding section.

Although a number of elasticity estimates exist for the Philippines, relatively few studies have used these to simulate the nutritional impact of food market intervention policies, notably those of Regalado (1983) and Mendoza (1982). This study uses the estimated income-group specific elasticities in a partial-equilibrium, market equilibrium displacement model into which exogenous changes (demand shifts, supply shifts, and price wedges) are introduced. After the new equilibrium quantities are obtained, these are mutiplied by their corresponding nutrient weights. The model is an extension of Perrin and Scobie's (1981) paper, to cover four income strata, and is used to simulate the nutritional effects of agricultural policies, for example, the potential increase in nutrient consumption due to the introduction of high yielding varieties of rice.[2]

This paper is organized into four sections. The first reviews literature on consumer demand as it relates to various ways of estimating food demand parameters. The second presents the results of the estimation procedure and compares these to other estimates from the Philippines and other studies using cross-section data. The third section presents the market intervention model, its modification for the rice supply shift policy, and the results of the simulations, while the fourth presents conclusions and implications for further research.

2. Consumer Demand Theory and Demand Parameter Estimation

This section focuses on the implications of the structure of consumer preferences on general and particular restrictions on demand functions. These restrictions play a significant part in the empirical estimation of demand parameters. There are three general restrictions which can be derived from the maximization of a utility function subject to a budget constraint, namely: homogeneity, symmetry, and adding-up. The imposition of these restrictions facilitates empirical work considerably by ensuring that the axioms of consumer theory are satisfied and reducing the number of parameters to be estimated.

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[2] Note that the model only yields the *potential* increase in nutrient intake, which is, of course dependent on actual market conditions as well as the correspondence between the simulated policy (e.g. a supply shift) and the real world. In practice, specifying effects of broad food policies on price wedges and supply and demand shifters may be more complicated, since "exogenous income effects via changed employment patterns and endogenous income effects for producers due to output or price changes must be added to the price effects" (Timmer, 1980, 1983). In short, this suggests that future work must be directed toward endogenizing some aspects of the model which would be the case if a general equilibrium extension of this work were pursued.

Separability. Additional restrictions based on assumptions regarding the separability of the utility function have often been imposed due to the need to reduce further the number of parameters to be estimated. Some of these restrictions may be formulated in such a way so as to reflect the nature of the consumer's allocation problem (e.g. Strotz's (1959) utility tree and two-stage budgeting), but the primary consideration appears to be the estimation of price elasticities if there is little price variation in the data set. A second consideration is the desire to measure interrelatedness among food commodities without unduly restricting the relationships between commodities to substitutability and without severe problems of multicollinearity in food prices. One approach which addresses the first consideration is that of Frisch (1957), which relies on the assumption of additivity (want-independence), an estimate of the marginal utility of money, budget shares and income elasticities to compute price elasticities residually. Another approach is that of Heien (1982), from Brown and Heien (1974), which uses the concept of a weakly separable utility function to group commodities into subgroups (or branches).

According to Leontief (1947), a necessary and sufficient condition for a function to be separable is that the marginal rate of substitution between any two variables belonging to the same group be independent of the value of any variable in any other group.[3] The assumption of weak separability lends itself to an intuitively appealing approach to the allocation problem discussed by Strotz (1957). According to Strotz, the consumer's preferences can be represented by a "utility tree." Households first allocate their income optimally to broad groups of commodities to branches of the utility function, with a budget allotment Yr to each branch. Then, in the second stage, each branch budget allotment is optimally spent, with

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[3] The necessity proof (Phlips, 1974:68-69) says that if the n commodities are partitioned in m groups, with n_r $(r=1, \ldots, m)$ commodities in each group, the utility function.

(A.1) $u = u(q_{11}, \ldots, q_{1n}, \ldots, q_{r1}, \ldots, q_{rn_r}, \ldots, q_{m1}, \ldots, q_{mn_m})$
expressed in the form

(A.2) $u = U\, u_1(q_1), u_2(q_2), \ldots, u_r(q_r), \ldots, u_m(q_m)$ where each u_r is a 'branch' utility function, if and only if

(A.3) $$\frac{\partial}{\partial q_{SK}} \left(\frac{\partial f}{\partial q_{ri}} \Big/ \frac{\partial f}{\partial q_{rj}} \right) = 0$$ for all, S, r, i, j, K $(S, r = 1, \ldots, 1, \ldots, m;\ S \neq r_1,\ K = 1, \ldots, n_s;\ i, j = 1, \ldots, n_r)$. Weak separability requires only that (A.3) be fulfilled.

no reference to the other branches. More formally, the consumer wants to maximize

(1) $u = U\,[u(q_1), u_2(q_2), \ldots, U_r(q_r), \ldots, U_m(q_m)]$ subject to

(2) $\sum_{j=i}^{n_i} q_{rj}\, P_{rj} = Y_r$, r being the branch food, and the additional constraints

(3) $q_{sk} = \overline{q}_{sk}$, where s is the subset for all other commodities, quantities of which are already preallocated.

The utility function then reduces to

(4) $u = U\,[u_1(\overline{q}_1), u_2(\overline{q}_2), \ldots, U_r(q_r) \ldots, U_m(\overline{q}_m)]$

so we are actually maximizing the branch U_r subject to its preallotted budget. Hence, the conditional demand functions for the goods in branch r are of the form

(5) $\psi_{ri}(F_r, Y_r, \overline{q}) = \psi_{ri}(P_r, Y_r)$,

while the ordinary demand functions are of the form

(6) $q_{ri} = \lambda_{ri}(P, Y) = \psi_{ri}(P_r, Y_r)$

where P is the vector of all prices. Thus, the demand for a commodity in a branch can be expressed as a function of the prices in and the budget allotment to that branch. As we shall see later, in the S-branch system, further groupings within a branch can also be made.

Separability results in a two-tier structure for the elasticity matrix; one tier for within-group effects, and another for between-group effects.

If, however, we partition the commodities and impose the condition that the marginal rate of substitution between any two goods belonging to different groups is independent of the consumption of any good in any third group, this implies independence between groups and additivity between groups. This has been termed "want independence" by Frisch (1959). In this case, the utility function is of the form

(7) $U(q) = \delta\,\{U_1(q_1) + U_2(q_2) + \ldots + U_n(q_n)\}$

If (7) holds, the Slutsky matrix is diagonal, so that the substitution terms S_{ij} are given by:

(8) $S_{ij} = \chi q_{yi} q_{yj}$

where $\chi = -\phi \; Y$ and $\phi = [\frac{\partial \log \lambda^{-}}{\partial \log y}]^{-1}$ or the inverse of the income elasticity of the marginal utility of money. Frisch has called ϕ^{-1} as w, the income flexibility of the marginal utility of money; other authors (e.g. Pinstrup-Andersen *et al.* 1976) have called it the coefficient of money flexibility.[4]

Empirical Models of Demand Systems

Demand equation systems have been formulated to take into account system-wide restrictions on parameters implied by the postulates of consumer theory. This is in contrast to single equation methods which, although practical and empirically convenient, do not guarantee that restrictions are satisfied. One such demand system is the linear expenditure system (LES) which has been constructed to satisfy the axioms of demand theory (Stone, 1954). However, the LES has been criticized due to its imposed structure of price effects (Deaton and Muellbauer, 1980). For example, inferior goods cannot exist, complementarity is ruled out, and goods are constrained to be price inelastic, for those goods for which the minimum or subsistence parameters are positive. These limitations are particularly disturbing in estimating food demand parameters, since we do not want to negate complementarity effects.

S-Branch System. In an attempt to generalize the LES, Brown and Heien (1972) propose the S-branch system (SBS) which allows complementarity, substitutability and independent relationships between the quantities demanded. In addition, the own-price elasticity can range from 0 to $-\infty$. The SBS is derived from the following branch (or subgroup) utility functions

$$U_s = (\sum_{i=s}^{n_s} \beta_{si} \; q_{si}{}^{r_s})^{1/r_s}$$

[4] For the weakly separable utility function, the Slutsky terms are given by:
(A.4) $S_{ij} = \gamma^{rs} q_{Yi} q_{Yj}$, for $i \in r$, $j \in S$. $r \neq s$; i.e., if goods i and j belong to two distinct groups, then their compensated cross-price derivatives are proportional to the product of their income derivatives, the constant of proportionality depending only on the groups involved.

where $\sigma_s = \frac{1}{1-r_s}$ is theAllen elasticity of substitution (AES)

between goods in the S^{th} branch and n_s is the number of goods in that branch. The subgroup utility functions can be aggregated into an overall utility function.

(10) $U = (\sum_{s=i}^{S} \alpha_s U_s^r)^{1/r}$

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

(11) $q_{si} = (\beta_{si}/P_{si})^{\delta_s} \alpha_{si}^{\delta} X_s^{-1} Z_s Mm$

where $S_s = \sum_{LES}^{n_s} (\beta_{si}/P_{si})^{\delta_s} p_{si}$; $Z_s = \alpha_s^{\delta} X_s^{\frac{\delta - 1}{\alpha_s - 1}}$, $M = \sum_{r=i}^{s} Z_r$ and

$m = \sum_{s=i}^{S} \sum_{j \varepsilon S}^{n_s} P_{sj} q_{sj}$.[5]

Empirically, (11) can be estimated as:

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[5] Elasticities for the SBS are computed as follows (Heien, 1982: 221):

(A.5) $e_{si,rj}^{P} = (\delta - 1) W_{rj}$ (intergroup) price elasticity of demand for i with respect to good j; $S \neq r$

(A.6) $e_{si,sj}^{P} = (\delta - 1) W_{sj} + (\sigma_s - \sigma) W_{sj}$ *(intragroup)* price elasticity of demand for i with respect to good j

(A.7) $e_{si,sj}^{p} = (\delta - 1) W_{si} + (\delta_s - \delta) W_{si} - \delta_s$ (own price elasticity of demand

(A.8) $e_{si}^{M} = 1.0$

(A.9) $W_{rj} = P_{rj} q_{rj} / m$ overall expenditure proportion.

(A.10) $W_{sj} = P_{rj} q_{rj} / m_r$ group expenditure proportion

The system also satisfies the restrictions of homogeneity, symmetry, additivity and negativity.

$$(12)\ ln\ q_{si} = (\delta - 1)\ lnP + (\delta_s - \delta)\ lnP_s - \delta_s\ lnP_{si} + ln\ m$$

where $P = \prod_{r=i}^{s} \prod_{j \in r}^{n_r} P_{rj}^{W_{rj}}$ and $P_s = \prod_{j \in s}^{n_s} P_{sj}^{\bar{W}_{sj}}$ (Heien, 1982).

With this, we have reduced the number of parameters to be estimated by expressing the demand for the ith good in the S^{th} branch as a function of a geometric price index of all goods, a geometric price index of goods in the same branch, the own-price, and income. However, since the weights W_{rj} used are average weights, the restrictions on the system may be satisfied only to the extent that the actual budget weights equal the sample average. For this reason, Heien (1982) has called this the almost complete system (ACS).

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

Frisch Method. The Frisch method, on the other hand, assumes want independence in order to estimate price elasticities residually. Frisch (1957) assumes an additive utility function as in (7). Under additivity, (8) is assumed to hold for all pairs of goods. The S_{ij} defined in (8) define the off-diagonal terms of the Slutsky matrix. Using the relationship $\Sigma_k\ S_{ik} P_k = 0$, the diagonal terms are given by

$$(13)\quad S_{ii} = \frac{-\chi\,\partial\, q_i}{P_i\,\partial\, Y} \quad (1 - P_i \frac{\partial qi}{\partial} \quad)$$

In elasticity terms, using $e^*_{ij} = S_{ij} P_j / q_j$ and $e_{ij} = e^*_{ij} - E_i W_j,$

$$(14)\quad e_{ii} = \phi\ E_i - E_i W_i\ (1 + \phi\ E_i) \quad i = 1, \ldots, n$$

$$(15)\quad e_{ij} = -E_i W_j\ (1 + \phi\ E_j) \qquad i \neq j.$$

The relations (14) and (15) permit the estimation of price and cross-price elasticities given ϕ, the Engel elasticities, and budget shares.

The additivity assumption, however, imposes a particularly simple structure on the substitution matrix: inferior goods and complementarity are both ruled out, and for a large number of goods, the price elasticity is approximately proportional to the expenditure elasticity. The structure may turn out to be different from the actual relationship between the elasticities.

In most studies, an estimate of ϕ or its inverse w is usually obtained by calculating the price elasticity of one commodity and then substituting that into (14). The Betancourt procedure utilizes income-class wage variation, while Pinstrup-Andersen *et al.* (1976) estimates price elasticities for standardized commodities to arrive at alternative values of ϕ which are then averaged. This study uses the latter approach, with rice, sugar, milk and cooking oil chosen as the standardized commodities.

Estimation Procedure

Both the Frisch and SBS methods were used to estimate complete price, cross-price and income elasticity matrices for 16 commodities and four income groups from the 1978 FNRI survey data. (A summary of sample characteristics is presented in Table 1). Since income data were underestimated and data on total expenditures were not collected, the food quantities were regressed on food prices and total food expenditure. This specification assumes that the utility function is weakly separable into food and nonfood. Elasticities were also estimated from an ordinary double-log demand function. In the SBS and the double log cases, the seemingly unrelated regressions (SUR) technique was used on the entire system of equations after dropping the equation for miscellaneous products.[6] Elasticities for miscellaneous products were then estimated residually. The output from the double-log regressions was used to compute the coefficient of money flexibility for the Frisch method, as well as to generate the food budget elasticities which are analogous to the Engel elasticities in the original model.

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[6] The use of the SUR (Zellner, 1962) requires the existence of a nonsingular variance-covariance matrix for the disturbances. However, the satisfaction of the budget constraint implies linear dependence of the joint distribution of disturbances if prices and income (or food budget) are exogenous. Since we have $n + 1$ equations in n unknowns, defined by the n demand functions and the budget constraint, the solution is to delete one equation from the system (Barten, 1977).

Table 1 — Selected Sample Characteristics
1978 Nationwide Nutrition Survey, FNRI

	Quartile			
	I	II	III	IV
Annual Per Capita Income Range (in pesos)	4-330	33-679	680-1357	1360-30,500
Average Per Capita Income (in pesos)	190	490	985	2,887
Daily Per Capita Calorie Intake (Kcal.)	1,589	1,789	1,882	2,155
Per cent of RDA (2036 Kcal.)	78	87	92	105
Daily Per Capita Protein Intake (gm.)	43.6	52.1	56.1	69.2
Per cent of RDA (51.5 gm.)	85	101	109	134
Daily Per Capita Iron Intake (mg.)	9.6	11.3	11.8	13.7
Per cent of RDA (12.0 mg.)	80	94	98	114
Daily Per Capita Vit. A Intake (I.U.)	1,870	2,343	2,645	3,753
Per cent of RDA (3618 I.U.)	52	65	73	104
Ratio of Measured Food Expenditures to Measured Income[1] (in per cent)	520.13	185.47	114.41	65.92
Number of Households	682	715	702	700

[1] The size of the measured food budget proportion relative to income suggests a great degree of income understatement.

3. Demand Elasticity Estimates

Food budget elasticities for the DL (double-log) and SBS methods are presented in Tables 2 and 3, while own-price elasticities for DL, SBS and the Frisch methods are found in Tables 4 to 6. (Complete price and cross-price elasticity matrices were estimated, but are not reported here).

Food Budget Elasticities

Food budget elasticities estimated from both DL and SBS methods generally exhibit the same behavior across quantities and are within the same range. As expected, food budget elasticities vary across commodities. Within the energy foods group, elasticities for other cereal products, fats/oils and sugars are higher than those for rice, corn, and starchy roots, reflecting the higher elasticities for so-called luxury items. Fish and seafoods are less food budget elastic compared to poultry, milk, eggs and meat, in that order. A monotonic decline in the food budget elasticities is shown for rice, sugars, and fish as we move from low to high income quartiles. An increase and then a decrease is exhibited by dried beans, other fruits and vegetables, eggs, milk, and fats/oils. The elasticities for corn (although negative, being a less-preferred staple), meat and poultry show a general upward trend, while the other commodities exhibit erratic behavior. Both SBS and DL methods provide strikingly similar estimates of food budget elasticities, in spite of the difference in the specification of the price variables. More obvious differences, however, appear in the estimates of the own-price elasticities.

Own-Price Elasticities

Since each method has a different approach to obtaining own-price elasticities, we shall discuss each in turn and then summarize and evaluate the methods.

DL estimates. Price elasticities were estimated from simple double-log demand functions in which only significant cross price variables were included. While we were able to impose homogeneity where empirically valid, the non-inclusion of statistically insignificant cross-price variables meant that symmetry was not imposed. Table 4 shows that the own-price elasticities are all negative and statistically significant at α = 0.05 except for fish/seafoods and milk in quartile IV. Across commodities, rice, corn, sugars, fats, and oils and fish have smaller elasticities (in absolute value) compared to other cereal products (mostly wheat-based), fruits and vegetables, meat, eggs, and milk. Staple foods, namely rice and corn, and fish, the most

Table 2 – Food Budget Elasticities, 1978 FNRI Survey SUR Results[1]

Commodity	Quartile I	Quartile II	Quartile III	Quartile IV
Rice and rice products	1.708*	1.477*	1.071*	0.553*
Corn and corn products	–1.898*	–1.418*	–0.220	0.046
Other cereal products	1.625*	2.177*	1.285*	2.280*
Starchy roots and tubers	0.627*	1.047*	0.983*	1.235*
Sugars and syrups	1.771*	1.302*	1.449*	1.419*
Dried beans, nuts and seeds	1.657*	1.808*	1.944*	1.465*
Green leafy and yellow vegetables	1.115*	0.638*	0.916*	0.406
Vitamin C-rich foods	2.338*	2.551*	2.137*	2.528*
Other fruits and vegetables	2.014*	2.527*	1.506*	1.435*
Fish and seafoods	2.066*	1.001*	0.905*	0.557*
Meat	1.754*	2.802*	3.244*	4.171*
Poultry	0.941*	0.877*	1.583*	1.987*
Eggs	1.854*	2.209*	2.691*	2.269*
Milk and milk products	1.145*	2.547*	2.115*	1.908*
Fats and oils	1.802*	1.964*	1.609*	1.109*

[1] Asterisks indicate statistical significance at $\alpha = 0.05$.

important protein source next to rice, are not as price elastic compared to nonstaples and luxury items. The absolute values of the price elasticities decline as income increases for sugar, the fruit and vegetables group, fish and seafoods, and meat. A U-shaped pattern is visible for corn/corn products, other cereal products, and eggs, i.e., elasticities decline initially, and then increase. This is probably due to shifts towards higher quality products in the higher income ranges. An inverted U-shaped pattern is shown by rice and starchy roots, with a peak in quartile II.

The decline in the own-price elasticities reflects falling food bud-

Table 3 — Food Budget Elasticities, S-Branch Estimates 1978 FNRI Survey

Commodity	Quartile I	Quartile II	Quartile III	Quartile IV
Rice and rice products	1.908	1.644	1.242	0.612
Corn and corn products	–1.225	–1.472	–0.528	0.077
Other cereal products	2.080	1.891	1.289	2.439
Starchy roots and tubers	1.041	1.023	0.986	1.107
Sugars and syrups	2.205	1.473	1.492	1.651
Dried beans, nuts and seeds	1.592	1.856	1.870	1.642
Green leafy and yellow vegetables	1.149	0.846	1.033	0.314
Vitamin C rich foods	2.260	2.695	1.880	2.270
Other fruits and vegetables	2.458	2.440	1.686	1.504
Fish and seafoods	1.704	0.924	0.980	0.673
Meat	2.014	2.774	3.292	4.469
Poultry	1.076	0.953	1.685	2.125
Eggs	1.897	2.289	2.641	2.367
Milk and milk products	1.466	2.455	2.294	2.114
Fats and oils	1.640	1.823	1.619	1.102

get shares and food budget elasticities for necessity or staple foods as income increases, similar to what has been described by Timmer (1981). However, the nonlinearities seem to indicate that the relationship between the e_{ii} and income is not monotonic. Moreover, this behavior is more noticeable for energy foods such as rice, corn, other cereal products, and roots. The higher values of the e_{ii} in the second quartile may be due to the existence of a wider range of affordable substitutes among energy foods once income reaches the second quartile level, or as Bouis (1982) suggests, having satisfied his

Table 4 – Own-Price Elasticities, 1978 FNRI Survey
SUR Results[1]

mmodity	Quartile I	II	III	IV
ce and rice products	–1.449*	–1.950*	–1.200*	–1.000*
rn and corn products	–2.101*	–1.565*	–1.514*	–2.088*
her cereal products	–3.378*	–3.034*	–2.689*	–2.836*
archy roots and tubers	–3.440*	–3.499*	–1.772*	–1.200*
gars and syrups	–2.053*	–1.435*	–0.853*	–0.576*
ied beans, nuts and seeds	–1.945*	–1.030*	–1.768*	–0.925*
reen leafy and yellow vegetables	–2.694	–2.669*	–2.036*	–1.930*
itamin C rich foods	–2.388*	–2.044*	–1.251*	–0.918*
ther fruits and vegetables	–2.147*	–1.817*	–1.635*	–1.409*
sh and seafoods	–0.733*	–0.290*	–0.194*	–0.039
eat	–3.058*	–2.618*	–2.272*	–2.052*
oultry	–0.791*	–1.065*	–0.751*	–1.723*
ggs	–5.286*	–1.599*	–1.841*	–2.591*
ilk and milk products	–2.884*	–5.109*	–2.255*	–0.706
ats and oils	–1.388*	–0.729*	–1.220*	–0.465*
iscellaneous	–1.577*	–1.442*	–1.394*	–1.550*

Asterisks indicate statistical significance at $\alpha = 0.05$.

hunger or "bulk" constraint to some degree, he can consider diversifying his diet.

SBS Estimates. Equation (12), the ACS formulation of the SBS, was estimated using the SUR technique. Theoretical restrictions such as homogeneity, homotheticity, and the appropriateness of the S-branch specification were also tested. In the last case, this amounted to testing whether individual elasticities of substitution were equal (1) to the subgroup elasticity of substitution, and (2) to the overall elasticity of substitution. Homogeneity did not hold for all of the commodities, and the test for a unitary food budget elasticity (homothecity) was likewise rejected. The assumption of common subgroup and overall elasticities of substitution does not also seem to be warranted. This could be because the groupings – energy foods, bodybuilding foods, regulating foods – while based on nutritional similarities, bring together nutrient sources of varying degrees of desirability from the consumer's perspective.

Recall that equation (12) has three price variables: an overall price index P, the subgroup price index P_s and the own price P_{si}. Coefficient estimates of P_{si} are significant for the majority of the regressions, but the overall price index P and the subgroup price index P_s do not perform as well. In fact, the energy foods group appears to be the only group where the regressions indicate the significance of the subgroup index for the majority of the commodities, a result consistent with the high degree of interaction among energy foods as revealed by DL cross-price elasticities.

The results of the regressions of Equation (12) can be found in Quisumbing (1985), but the computed price elasticities are presented in Table 5, following the formulae in Note 5. Most of the computed e_{ii} are negative in the first three quartiles. For most of the energy foods, the estimates are much lower than those obtained from DL; SBS estimates are also lower for other fruits and vegetables in all quartiles and for green leafy and yellow vegetables in the first three. The estimates for body-building foods exhibit wide fluctuations. Behavior of the e_{ii}, however, becomes quite erratic and contrary to theoretical expectations in quartile IV, where large and *positive* e_{ii} is observed.

Although the complete price elasticity matrices are not presented here, we shall summarize some of the general findings.

Recall that the separability assumption theoretically implies a two-tier structure of the elasticity matrix. In addition, separability

Table 5 — Own-Price Elasticities, S-Branch Results

Commodity	Quartile I	Quartile II	Quartile III	Quartile IV
Energy Foods				
Rice and rice products	–0.530	–0.893	–0.550	6.627
Corn and corn products	–0.068	–0.118	–0.519	–0.508
Other cereal products	–0.075	–0.198	–0.378	3.812
Starchy roots and tubers	–0.031	–0.060	–0.501	0.666
Sugars and syrups	–0.051	–0.128	–1.115	–0.794
Fats and oils	–0.054	–0.136	–0.902	–1.401
Body-Building Foods				
Dried beans, nuts and seeds	–0.034	–0.099	–4.458	–1.215
Fish and seafoods	–0.352	–0.846	–1.858	–1.692
Meat	–0.154	–0.295	–5.242	1.535
Poultry	–0.045	–0.085	–1.075	–1.048
Eggs	–0.063	–0.156	–1.630	2.036
Milk and milk products	–0.056	–0.145	–1.817	3.633
Regulating Foods				
Green leafy and yellow vegetables	–0.035	–0.301	0.076	–1.112
Vitamin C-rich foods	–0.060	–0.401	–2.572	–0.743
Other fruits and vegetables	–0.160	–0.849	–0.624	–0.698
Miscellaneous	–1.654	–1.274	–1.040	–0.536

in the SBS places restrictions on between-group substitution effects: all goods from different goods must be substitutes, with the magnitude of the elasticity proportional to the budget share (Heien, 1982). The computed complete price and cross-price elasticity matrices reflect, in general, substantial intragroup interaction and smaller intergroup effects, with elasticities proportional to the budget share. Thus, since rice accounts for a significant portion of the food budget, the intergroup effects caused by responses to changes in the rice price are quite high. Intergroup interactions with respect to the prices of other energy foods are also large, although not as large as those with the rice price. Contrary to theoretical expectations, substitutability between groups is not the predominant relation. It is only in quartile IV that substitutability is dominant. Heien's (1982) results are similar in the sense that while there are large intergroup substitution effects, not all intergroup relations indicate substitution.

The empirical performance of the S-branch system, while generally similar to Heien's results, leaves much to be desired. This may be due to two reasons. First, the grouping of nutritionally related commodities may have very little connection with the structure of consumer preferences. At the lower income levels, for example, consumers may simply purchase what they can afford, to satisfy a "bulk constraint," and then diversify as income increases. The question also arises whether substitutability is the proper relationship between food groups. A proper balance of nutrients involves the presence of several food groups; while there may be intragroup substitutability between sources of calorie, protein and vitamins, for example, energy, body-building and regulating foods may actually be complementary to each other. This is a hypothesis which deserves further examination.

Second, the price structure imposed by variants of the linear expenditure system (LES), of which the S-branch system is one example, may be quite different from actual interactions. Brown and Deaton (1973) have argued that if variations in real income are much larger than variations in relative prices, then the LES, like other additive models, will impose a structure on estimated price effects largely independent of the structure of actual price effects. Thus, attempts to economize on the number of parameters to be estimated by imposing rather severe restrictions on the structure of preferences may actually lead to misleading results. We now turn to the last estimation used in the study, the Frisch method.

Frisch Method Estimates. As mentioned earlier, since we have data only in the food subgroup, we modify the Frisch formulae to use the food budget flexibility and food budget elasticities. Table 6

Table 6 — Own-Price Elasticities, 1978 FNRI Survey Frisch Method Estimates[1]

ommodity	Quartile I	II	III	IV
ce and rice products*	−1.449	−1.950	−1.200	−1.000
orn and corn products[2]	—	—	—	−0.025
ther cereal products	−2.248	−1.770	−1.042	−1.202
archy roots and tubers	−0.889	−0.883	−0.801	−0.670
ıgars and syrups*	−2.053	−1.435	−0.853	−0.576
ried beans, nuts and seeds	−2.308	−1.504	−1.563	−0.795
reen leafy and yellow vegetables	−1.564	−0.543	−0.749	−0.223
itamin C rich foods	−3.195	−2.065	−1.689	−1.327
ther fruits and vegetables	−2.548	−1.903	−1.195	−0.802
ish and seafoods	−2.169	−0.876	−0.784	−0.378
leat	−2.402	−2.173	−2.195	−1.583
oultry	−1.328	−0.742	−1.278	−1.067
ggs*	−5.286	−1.599	−1.841	−2.591
lilk and milk products*	−2.884	−5.109	−2.255	−0.706
ats and oils*	−1.388	−0.729	−1.220	−0.465
liscellaneous	−1.319	−0.623	−0.677	−0.518

[1] Estimates for commodities with asterisks are SUR estimates.

[2] The Frisch formula cannot be used since it is valid only if food budget elasti-ities are non-negative.

presents estimates of own-price elasticities obtained using the Frisch method. All the computed elasticities are negative by construction, since this method does not permit inferior goods. The behavior of the Frisch estimates across quartiles is similar to the DL results: most of the elasticities decrease in absolute value as income increases. The Frisch estimates are smaller than DL estimates for other cereals and roots, but are larger than the SBS elasticities. For body-building foods, except for fish, DL and Frisch estimates are generally within the same range. Finally, for regulating foods, only the Frisch estimates for green leafy and yellow vegetables are outside the range of DL results.

However, caution must be taken in accepting the Frisch estimates. First, this method relies heavily on an estimate of the food budget (or money) flexibility. To estimate income-stratum specific w from budget data requires prices to vary by income class. While the choice of quality foods at higher prices by higher income groups may introduce some income-stratum specific price variation, one cannot tell whether this is sufficient to make the estimated food budget flexibility reliable. Other attempts using the wage rates or opportunity cost of leisure (Betancourt, 1971) or household composition effects (Barten, 1964) have been made, but Brown and Deaton (1973) do not hold that this gives reliable results. Second, additivity has been empirically rejected even for broad commodity groupings and is even less plausible for the level of disaggregation required by nutrition-oriented food demand studies.

An Evaluation of Estimation Methods

The absolute values of the price elasticities obtained from the various methods are quite large compared to most of the previous estimates in the Philippines (Table 7), but are similar to results for Brazil, Indonesia and Thailand (Table 8). While differences in the choice of the functional form could be a source of variation, most of it can be traced to the nature of the data.[7] Most food demand studies in the Philippines have been based either on time-series data or on the series of cross-section surveys conducted by the Ministry of Agriculture Special Studies Division (MA-SSD). Covering a longer time period, these sources exhibit greater price variation than quantity variation and would yield smaller elasticity estimates. The Brazil, Indonesia and Thailand studies, on the other hand, are based

[7] Even where the functional form is the same, i.e., single-equation double-log, the elasticities estimated in this study are bigger than those estimated from MA-SSD data. The exceptions are Regalado (1984) for rice and Belarmino (1983) for a number of commodities.

Table 7 — Summary of Previous Elasticity Estimates, Selected Food Items, Philippines

a Base/Study	Survey Used	Methodology and Data Used	Commodity	Price Elasticity			Income Elasticity		
MA-SSD Surveys									
.1 Ferrer (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	0.24		
			Fruits and vegetables			−0.75	0.20		
			Fresh fish			−0.60	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	−0.83	−0.53	−0.31	n.s.	−0.03	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	0.30	0.24	0.19
			Fruits and vegetables	−0.88	−0.78	−0.71	0.26	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	0.39	−0.46	−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	0.35	0.29

Table 7 (Continued)

ta Base / Study	Survey Used	Methodology and Data Used	Commodity	Price Elasticity	Income Elasticity			
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	0.3803			
			Fresh fish	−1.5243	0.4589			
			Pork	−1.2851	0.8224			
			Beef — Carabeef	−3.1562	0.7230			
			Poultry	−0.9776	0.4929			
			Eggs	−0.5473	0.6228			
			Dairy products	−0.4452	0.4760			
Snell (1980)	1970-76	Double-log, grouped data, with constraints	(Deflated estimate Model 3.c)		<P400	P400—799	₱800 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	0.58
Bouis (1982b)	1973-76 (15 rounds)	Double-log, original data	Rice	−0.63	0.09			
			Corn	−1.34	−0.27			
			Wheat	−0.78	0.41			

Reference	Data Base	Year	Population Covered	Methodology
1. BRAZIL Gray (1982)	ENDEF	1974-1975	Brazil, 55,000 families	Constant elasticity (double log) demand function; grouped data
2. INDONESIA 2.1 Timmer and Alderman (1979)	SUSENAS V	1976	Indonesia, 3 rounds, 18,000 families per round	Constant elasticity (double log) demand function; grouped data
2.2 Boediono (1978)	SUSENAS V	1976	Indonesia, 3 rounds, 18,000 families per round	Frisch method
3. THAILAND Trairatvorakul 1984	National Socioeconomic Survey	1975-1976	Thailand; Total sample; 12,189 households Sample analyzed: 11,450 households	Constant elasticity (double-log) demand function
4. PHILIPPINES 4.1 Canlas (1983)	Family Income and Expenditure Survey	1965	Philippines	Linear expenditure system Betancourt (1971) procedure, grouped data

Table 8. (Continued)

Reference	Strata	Price Elasticities										
		Rice	Corn	Wheat	Roots	Legumes	Vegetables	Fruits	Fish Meat	Poultry	Milk & Prod.	Fats & Oils
1. BRAZIL												
									(Meat and Fish)			
Gray (1962)	Lowest 30%	−4.31	−1.77	−1.96	−1.36	−0.60	−0.41	−0.90	−0.55	—	−0.27	−0.34
	Middle 50%	−2.95	−1.09	−0.84	−0.76	−0.46	−0.23	−0.57	−0.14	—	−0.64	−0.38
	Highest 20%	−1.15	−0.58	−0.73	−2.23	−0.63	−0.27	−0.38	−0.11	—	−0.84	−0.36
	Average	−0.83	−0.98	−1.10	−0.83	−0.52	−0.46	−0.72	−0.10	—	−0.77	−0.01
2. INDONESIA												
2.1 Timmer and Alderman (1979)	Low (<2000 Rp/mo.)	−1.921	—	—	1.284 0.818							
	Low-Mid (2000-3000 Rp/mo.)	−1.475	—	—	−0.943							
	High-Mid (3000-5000 Rp/mo.)	−1.156										
	High (>5000 Rp/mo.)	−0.743	—	—	−0.760							
	Average	−1.105	—	—	−0.804							
			(corn and roots and tubers)				(vegetables and fruits)					
2.2 Boediono (1978)	Overall (no stratification)	−0.633	−0.255				−0.966	−1.041	−1.135			
3. THAILAND												
								Pork	Beef			
Trair atvorakul (1982)	Lowest 25%	−0.736						−7.215	−7.151	−0.252		
	Middle 50%	−0.714						−0.373	−0.822	−0.852		
	Highest 25%	−0.460						−0.544	−2.250	−0.189		
4. PHILIPPINES												
			(Cereals)									(and miscellaneous)
4.1 Canlas (1983)	Philippines		−0.258		−0.508		−0.382	−0.821	−0.757			−0.503
	Urban		−0.317		−0.617		−0.425	−0.890	−0.578			−0.552
	Manila		−0.289		−0.490		−0.331	−0.648	−0.457			−0.409
	Rural		−0.479		−0.301		−0.333	−0.578	−0.606			−0.337

›n cross-section data from surveys conducted within a one-year ›eriod.

Cross-section elasticities are usually larger than those estimated rom time-series data.These typically reflect long-run adjustments of ıouseholds to regional differences in prices and to expected seasonal ›rice movements, and hence are not likely to be accurate predictors ›f short-run response. Elasticities obtained from annual time series vill tend to reflect shorter-run variation and are expected to be maller in absolute value than cross-section estimates. The results of his study are therefore consistent with expectations regarding the ize of cross-section coefficients.

The choice between alternative methods should probably be based on the plausibility of the price elasticity estimates. Engel coefficients are easily estimated from budget data, but the estimation of price elasticities with little price variation has always been a problem. This has led to the use of alternative methods which use restrictions on demand parameters and separability assumptions to reduce the number of parameters to be estimated.

Comparison of the elasticities estimated using various methods reveals that the direct methods (i.e., DL) yielded the most stable price elasticities across income groups, followed by the Frisch and ACS methods. This is because the additivity assumption imposes a structure on price effects which may be independent from actual price effects. Additivity is not empirically tenable for detailed commodity breakdowns with a high degree of substitutability. Since there is substantial substitutability between calorie and protein sources, the assumptions of additivity and a constant elasticity of substitution (in the S-branch system) are not warranted.

A general conclusion is that the less restrictions imposed on the structure of preferences, the more stable the behavior of the coefficients. However, the use of direct methods is dependent upon an extensive data base, either a cross-sectional panel of consumers whose consumption expenditures are recorded over time, or a sample drawn over enough geographical and temporal diversity to capture significant variance in the relevant variables (Timmer and Alderman, 1979).

The next section presents a market intervention model which uses the estimated DL elasticities as demand parameters.

4. Estimating the Nutritional Effects of Food Policy

Food policy instruments generally fall into one or a combination of three basic types: supply shifters, demand shifters, and price wedges. To analyze the nutritional effect of food policies, we use a model describing the price and quantity equilibrium displacement effects of each of the three basic types of food policy instruments, for an n commodity economy with m income strata. Given the nutrient content of the commodities, we estimate the effect of the policies on equilibrium nutrient intake.[8] Since the model takes into account differential responses in price and income changes by different strata, we are able to estimate the distributional impact of alternative food policies.

The Basic Model

Consider the n-demand curves for the consuming population as a whole. Changes from the initial equilibrium levels of consumption of commodity i must result from either a shift in demand for that commodity or from a change in the price of either commodity or one of the other commodities. The percentage change in quantities demanded can be expressed as:

$$(16)\quad Eq_i = \sum_{j=1}^{n} e_{ij}\, E^d_{p_j} + \gamma_i\, Ey \qquad i = 1, \ldots, n$$

where:

E : percentage change operator

e_{ij}: the direct and cross-price elasticities of demand

γ_i : the income elasticity of demand

y : income.

The effect of food stamp or nutritional educational programs can be represented by a reinterpretation of the demand shift in $(\gamma_i Ey)$.

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[8] Due to the importance of calorie consumption as a limiting factor in nutrition, emphasis must be given to gains in calorie intake. While optimum health depends on the correct balance of a multiple of nutrients (Scrimshaw and Young, 1976 in Morgan, 1981) at the level of the vulnerable groups, calorie adequacy should override all other nutritional considerations (Florencio, 1982). In cases where protein consumption is adequate but calorie consumption is low, for example, consumed protein would be used for energy instead of body-building mechanisms. In actuality, severe protein deficiency seldom occurs if energy needs are met, particularly if the energy sources are cereals rather than tubers (Florencio, 1982:16).

Supply changes can be represented as

$$(17)\quad Eq_i = \sum_{j=1}^{n} S_{ij} E_{p_j}^{S} + \delta_i \qquad i = 1, \ldots, n$$

where S_{ij} are supply elasticities and δ_i is a supply shift caused by some policy.

To incorporate the possibility of price subsidies, we specify the following equilibrium relationship between supply prices and demand prices:

$$(18)\quad Ep_i^S = Ep_i^d + E\beta_i \qquad i = 1, \ldots, n$$

where $E\beta_i$ is the size of the subsidy wedge for commodity i, measured as a percentage of initial equilibrium price.

The three sets of n equations each can be expressed in matrix form as

(19)

$$\begin{bmatrix} -H & O & I \\ O & -S & I \\ -I & I & O \end{bmatrix} \begin{bmatrix} EP^d \\ EP^s \\ EQ \end{bmatrix} = \begin{bmatrix} \Gamma Ey \\ \Delta \\ EB \end{bmatrix}$$

where:

H : an nxn matrix of demand elasticities, e_{ij}

S : an nxn matrix of supply elasticities, S_{ij}

P^d : an nxl vector of demand prices, P_i^d

P^s : an nxl vector of supply prices, p_i^s

Q : an nxl vector of quantities, q_i

Γ : an nxl vector of income elasticities of demand, γ_i

Δ : an nxl vector of supply shifts, δ_i

EB : an nxl vector of price subsidies, $E\beta_i$

The solution to the system of equations (2.44) expresses changes in equilibrium prices and quantities as functions of the policy variables, E_y, Δ and EB:

$$(20) \quad \begin{bmatrix} EP^d \\ EP^S \\ EQ \end{bmatrix} = \begin{bmatrix} (S\text{-}H)^{-1} & (\Gamma Ey - \Delta - SEB) \\ (S\text{-}H)^{-1} & (\Gamma Ey - \Delta - HEB) \\ H(S\text{-}H)^{-1} & (SH^{-1} \; \Gamma Ey - SEB) \end{bmatrix}$$

Given these changes in the equilibrium consumption of commodities, the percentage change in the equilibrium level of nutrient consumption is

$$(21) \quad EN = KEQ = KH(S\text{-}H)^{-1} \; (SH^{-1} \; \Gamma Ey - \Delta - SEB)$$

where K is a lxn vector of K_i, the fraction of initial total nutrient consumption provided by commodity i.

Equation system (20) can then be stratified to consider different income strata; basically, this involves specifying separate demand equations for each income group and solving for the equilibrium stratum-specific quantities. Equation (21) then is modified using the result of the stratum-specific change in quantities and the stratum's corresponding nutrient weights. The details of this derivation can be found in Quisumbing (1985).[9]

In the next few pages, we present an application of a modified model to the analysis of the nutritional effects of the use of modern rice varieties (MV).

Nutritional Consequences of the New Rice Technology

Substantial increases in rice production have been realized throughout Asia with the development and diffusion of modern varieties (MV) of rice. In the context of our model, the adoption of new varieties and its accompanying technology results in an outward shift of the agricultural supply curve. While the market intervention model can incorporate effects of supply shifts in the shift parameter vector Δ in Equation (17), the simple model does not adequately describe the effects of a supply shift in a subsistence crop. According to Hayami and Herdt (1978), in developing economies, a major fraction of a subsistence crop is consumed in the producers' households. Hence, producers' and consumers' gains or losses through market price changes will apply to only a portion of total produce. A major portion of economic gain due to technical progress is thus internalized by producers, especially small subsistence ones.

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[9] The derivations in Quisumbing, 1985 were extensions of an unpublished appendix to Perrin and Scobie (1981). I wish to thank Richard K. Perrin for providing me a copy of that Appendix.

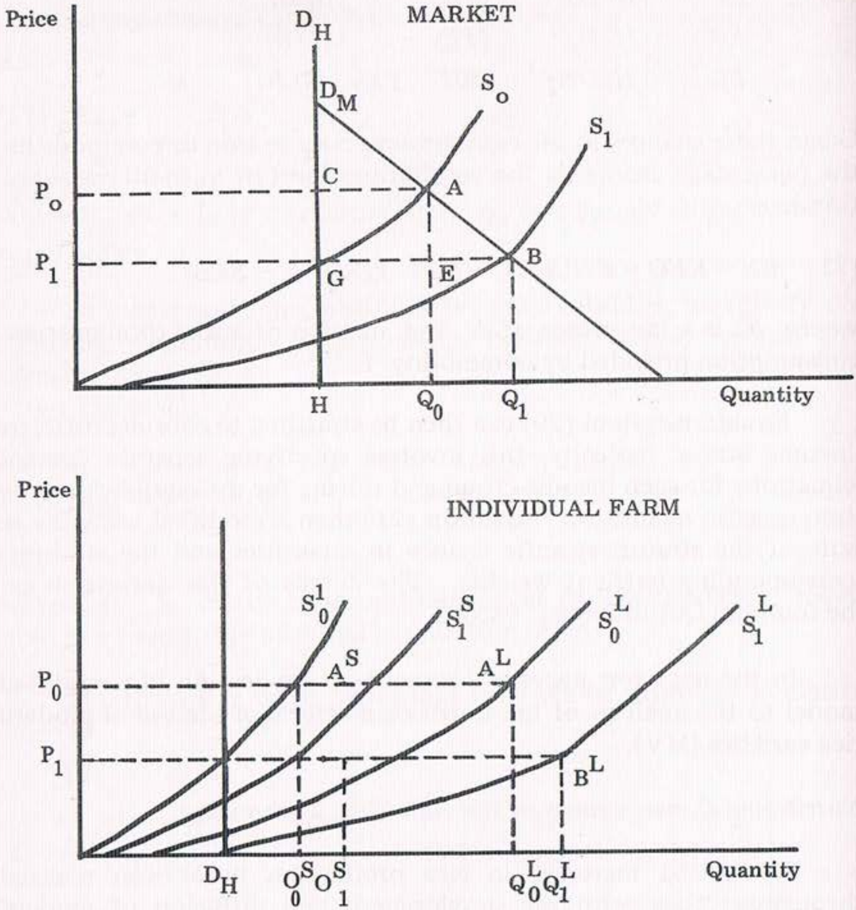

Figure 1 — The Impact of Technological Change in a Subsistence Crop

Hayami and Herdt's (1978) diagram of the process is as follows:

Consider the market diagram of Figure 1. The vertical line $D_H H$ is the demand curve of producers for home consumption. $D_M D$ represents the market demand for the product while the horizontal differences between $D_M D$ and $D_H D$ measure the quantity purchased by nonfarmer households.

$S_o O$ and $S_l O$ are the supply curves before and after a technical change. After the supply shift, the equilibrium moves from A to

B. Consumers' surplus increases by $ADGB$ and producers' cash revenue changes from $ADHQ_o$ to $BGHQ_1$, while producers' home consumption stays the same. Production cost changes from AOQ_o to BOQ_1. Assuming that the "real income value" of home consumption is represented by the quantity consumed, changes in producers' income are reflected in cash income, or revenue minus cost.

On the level of the individual farm, changes in equilibrium points corresponding to the shift in the small farm supply curve and the large farm supply curve from $S_o S$ to $S_1 S$ and $S_o L$ to $S_1 L$, respectively, are shown by movements from A^S to B^S and A^L to B^L. Home consumption is assumed to be the same for both small and large farmers, a reasonable assumption considering the nature of subsistence crops. Changes in cash income are calculated in a similar fashion. The net effect on producers' income depends on relative changes in revenue and cost, which in turn depend on the price elasticities of individual elasticities of producers' supply relative to the aggregate demand elasticity.

In the light of this study, it is therefore necessary to specify the supply shift (which may or may not differ between small and large farms) and the change in the food budget of the different strata resulting from a change in producers' cash incomes.

We used Evenson and Flores' (1978) estimates of the supply shift parameters, with a high estimate of 24.42 per cent and a low estimate of 8.61 per cent. We then estimated the percentage change in farmers' cash incomes using the methodology of Hayami and Herdt (1978) for large and small farmers. We assume that large and small rice farmers have the same price elasticity of supply, the long-run elasticity of 0.5. We use two alternative assumptions regarding technical progress: 1) the same rate of technical progress K for different-sized farms, and 2) the rate of technical progress of the larger farmers twice that of the smaller farmers $(k^L > k^S)$. Furthermore, we assume a fixed marketable surplus ratio of 0.2 in small farms and 0.8 for large farms. Cash income changes were assigned to the different strata from the sample distribution of large and small farmers, assuming that these were evenly distributed throughout the sample. Finally, we computed the resulting percentage change in the food budget as a result of the income change (using an estimate of the income elasticity of food expenditure) and used it as an input arameter Ey in the model.[10]

The estimates of the nutritional impact of adopting modern ırieties of rice under alternative assumptions of technical progress ıd Philippine supply elasticity conditions are shown in Table 9.[11]

The results of the simulations show that significant gains in utrient consumption can be achieved by a shift in the agricultural ıpply curve for a staple food and that these gains are greater for the ɔwest income groups. The gains for all groups are, as expected, reater if one assumes a higher cumulative shift in the supply curve. 'he shift in the supply curve, after accounting for income effects, enerates close to an equal percentage increase in calorie consumpion by the lowest income group. The percentage gains in protein onsumption are a little over half of the calorie gain. Using the

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[10] Note that we have to convert income changes into the corresponding hange in the food budget because the elasticities were obtained using the food udget as an independent variable, not income. Since this study did not compute he income elasticity of food expenditure directly, indirect estimates were obained by adjusting Grey's (1982) estimates of the income elasticity of total alorie consumption.

The income elasticity of the food budget is simply the percentage change in the food budget EF divided by the percentage change in income EY. Alternatively,

$$\frac{EF}{EY} = \frac{EC}{EY} : \frac{EC}{EF}$$

where $\frac{EC}{EY}$ is the income elasticity of total calorie consumption and

$\frac{EC}{EF}$ is the food budget elasticity of total calorie consumption.

[11] The supply elasticity matrix was defined as follows:

Rice $S_{1,1} = 0.5$ (own-price) (Mangahas, 1966)
Corn $S_{2,2} = 0.79$ (own-price)(IAPMP, 1980)
$S_{2,1} = 0.87$ elasticity with respect to rice price
Sugar $S_{5,5} = 0.68$ (own price) (World Bank, 1984)
Fish $S_{10,10} = 0.22$ (own-price) (IAPMP, 1980)
Pork $S_{11,11} = 0.90$ (own-price) (World Bank, 1984)
Poultry $S_{12,12} = 0.80$ (own-price) (World Bank, 1984)
Copra $S_{15,15} = 0.60$ (own-price) (World Bank, 1984)

All other $S_{i,j}$ $i=j$ were set to 0.5 and $S_{i,j}$ $i \neq j$ were set to zero, in the absence of supply elasticity estimates for other commodities.

Table 9 — Estimated Nutritional Impact of Adoption of Modern Rice Varieties Alternative Demand Elasticity Estimates

Alternative Supply Shift Assumptions[a]	Percentage Change in Total Calorie Consumption				Percentage Change in Total Protein Consumption			
	Quartile				Quartile			
	I	II	III	IV	I	II	III	IV
Original Demand Elasticities								
Case 1 $k = 24.42$ $k_S = k_L$	23.80	11.84	6.93	6.94	12.74	8.06	6.71	4.43
Case 2 $k = 24.42$ $k_L > k_S$	22.24	12.02	6.98	7.00	12.04	8.22	6.75	4.48
Case 3 $k = 8.61$ $k_S = k_L$	8.40	4.17	2.44	2.45	4.49	2.84	2.37	1.56
Case 4 $k = 8.61$ $k_L > k_S$	7.59	4.27	2.44	2.47	4.14	2.93	2.36	1.59

Alternative Supply Shift Assumptions	Percentage Change in Total Calorie Consumption				Percentage Change in Total Protein Consumption			
	Quartile				Quartile			
	I	II	III	IV	I	II	III	IV
Deflated Demand Elasticities[b]								
Case 1 $k = 24.42$ $k_S = k_L$	8.65	7.61	3.95	5.47	17.08	4.04	10.03	2.84
Case 2 $k = 24.42$ $k_L > k_S$	7.77	7.61	4.04	5.50	13.79	4.19	10.37	2.97
Case 3 $k = 8.61$ $k_S = k_L$	3.05	2.68	1.39	1.94	6.03	1.42	3.54	1.05
Case 4 $k = 8.61$ $k_L > k_S$	2.74	2.68	1.43	1.93	4.87	1.48	3.66	1.00

[a] K stands for the supply shift; K_s and K_L, the supply shift on small and large farms, respectively.

[b] These refer to the *DL* estimates divided by adjustment factors used to scale down the *DL* values which lie within the same range as reference Philippine estimates. This should be treated as a conservative result using different input parameters.

deflated elasticities, we see that the calorie consumption gains are smaller and the protein gains larger compared to the undeflated case.

Comparing the effects of different rates of technical progress between large and small farms, the gains of quartile I are greater under assumption of equal rates of technical progress. This is not surprising since 40 per cent of quartile I are employed in small farms. The difference in the gains of the other quartiles is quite small (about 0.2 and 0.01 percentage points) and does not exhibit any systematic pattern.

The results of this case study suggest that a supply shift for a staple foodcrop whose consumption is more or less equally distribued across income groups will have favorable distributional effects on nutrition. This is similar to the results of Pinstrup-Andersen, de Londoño and Hoover (1976). For a supply-oriented policy to have a favorable impact on nutrient deficit groups, a substantial portion of the additional nutrients must be consumed by the deficit groups.

It must be emphasized that gains from a supply shift policy will be maximized only if there are income increases among deficit groups. In addition, we must stress that the simulations present *potential* results of a supply shift policy. The actual nutritional effect, and the actual production and income effects, will depend on how the expansion in agricultural supply is realized as well as the presence of complementary policies.

5. Concluding Remarks

This study has attempted to estimate the distributional impact of food policy on nutrition. Essential to this was the estimation of income-stratum specific demand parameters. These were used in a market equilibrium model which can be modified for various applications, in this case, the nutritional consequences of the adoption of modern rice varieties. In this section, we point out some of the directions for further research arising from the study's findings.

With regard demand parameter estimation, we found that the direct method (DL) which did not impose any *a priori* restrictions yielded more stable results than those which assumed want independence (Frisch) and weak separability within the food group (S-branch). A general conclusion seems to be that the less restrictions imposed on the structure of preferences, the more stable the behavior of coefficients. This conclusion, however, seems to imply that demand parameters will not necessarily satisfy the axioms of demand theory, or if they do, this will be purely on an *ad hoc* basis. Fortunately, an alternative to the restrictive LES-based systems and the *ad hoc* pragmatic methods of estimation now exists, in the form of flexible demand functions derived from an indirect utility function. These flexible forms have been shown to perform well on Indian data by Swamy and Binswanger (1984); future work on this topic in the Philippines will test the use of flexible forms in demand parameter estimation.

It is also desirable to include data on expenditure items other than food, as well as to estimate total expenditure elasticities in future work. This will enable us to study the impact of policies which not only affect food prices and the food budget, but also more general policies like tax, wage or subsidy policies.

The inclusion of more general policies in nutrition policy analysis necessitates that the partial equilibrium model be expanded to consider general equilibrium effects. A general equilibrium model would make the determination of price, employment, and income changes endogenous. Considering the macroeconomic importance of the food sector in the Philippines, it is in this direction that future work must go.

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