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JOINT DETERMINATION OF FOOD CONSUMPTION
AND PRODUCTION IN RURAL SIERRA LEONE:
ESTIMATES OF A HOUSEHOLD-FIRM MODEL

by

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Peter Schmidt and William Whelan

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By

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Report No. 6

CONSUMPTION EFFECTS OF ECONOMIC POLICY PROJECT
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I. INTRODUCTION

For persons and bureaus interesting in predicting the effects of certain government policies on nutrient availability to the household it makes a difference whether the household is also a firm. That is if a household is able to adjust its production activities in response to changed circumstances, say to changes in prices, its consumption response will be different than if it is not able to. How different is an empirical question which will depend on the particular set of households and the particular circumstances they face. Working Paper 14 (Strauss, Smith, and Schmidt, 1981), reported the consumption responses of five food items, nonfoods and labor supply to prices, total income and certain demographic variables for rural households in Sierra Leone when their firm profits (hence production) were held fixed. To obtain these responses a Quadratic Expenditure System incorporating household characteristic variables was estimated. A detailed household-firm model was derived and specified for the purpose of estimation. Those details are not repeated in this report. This report extends Working Paper 14 by deriving and reporting the estimation of the production side of the household-firm model and integrates the results from the demand and production sides. Finally the effects of prices and other variables on caloric availability to the household are computed. Households are separated by their total expenditure in deriving these responses so that differential impacts may be examined.

II. THE HOUSEHOLD-FIRM MODEL

Economic models of household-firm behavior are not new. Seminal papers have been written by Nakajima (1969) and Jorgenson and Lau (1969). A further effort was provided by Lau and Yotopoulos (1974). All household firm models have a common structure of maximizing a utility function subject to three constraints: a production function, a time constraint and a budget constraint. Some models (e.g., Nakajima's subsistence model) hypothesize that markets do not exist and others (e.g., Jorgenson and Lau) explore intra-household distribution by using a social welfare function approach. For our purposes, we shall assume that households are semi-subsistence households. That is, they consume part of what they produce and sell the rest.

Derivation of the Model

Our unit of analysis is the household. We assume certainty and abstract from time. A household utility function is assumed with arguments being household consumption of various goods and of leisure. Goods may be bought or sold in the market and produced. Labor may be bought or sold in the market. Goods are produced using labor, land and fixed capital. Land is assumed fixed in total amount but must be distributed between uses. A time constraint exists equating household leisure plus labor time to total time available. Finally, a budget constraint exists equating the value of net product transactions plus exogenous income plus the value of net labor transactions to zero. Product prices and wage are taken exogenously by the household, markets are assumed to be perfectly competitive and family and hired labor are assumed perfect substitutes.

Graphically, for outputs, the household produces on its transformation function between two goods at the point at which the slope of the transformation curve equals relative market prices. Consumption is at the point of tangency between the same market possibilities line and the household indifference curves. Net marketed surpluses are measured by the usual trade triangles. In this case C-B of good j is sold and A-B of good i purchased. Between outputs and labor the same situation holds.

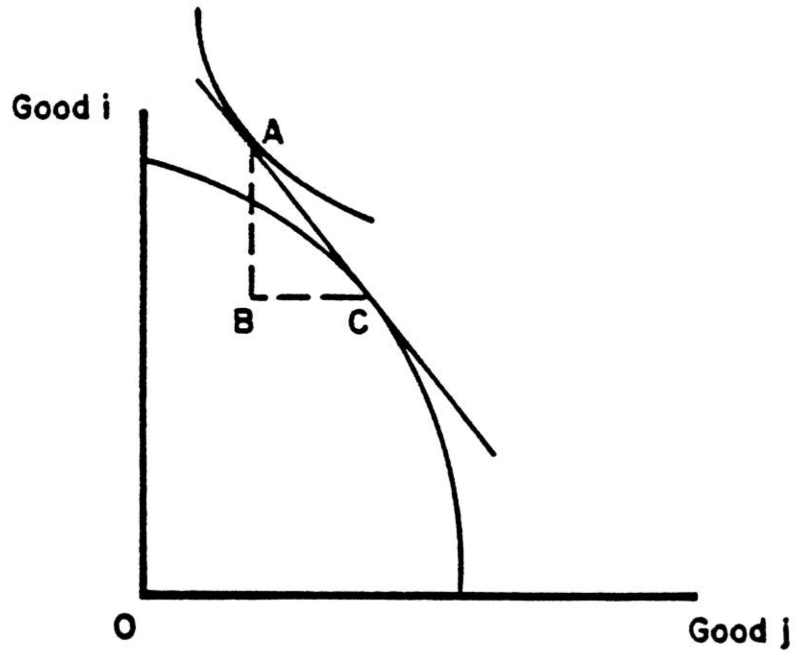

Figure 1

Household Equilibrium: Two Goods

An extremely important property of this model is that it is recursive. The household's production decisions are made first and subsequently used in allocating available "total income" between consumption of goods and leisure. This result is wholly dependent on the existence of markets for goods and labor. Intuitively this allows the family to separate its decisions on goods demanded and household goods supplied, the difference being hired (or sold out). This can be seen graphically in Figure 1.

Conditional on the production decisions the problem becomes the traditional labor-leisure choice problem. This implies that the usual constraints of economic theory apply: zero homogeneity of demand with respect to prices, wage rate and unearned income, and symmetry and negative semi-difiniteness of the Slutsky substitution matrix. Likewise on the production side. The profit function (the profits equation after input demands and output supplies have been solved for in terms of prices of outputs and variable inputs and

and in terms of quantities of fixed inputs) is homogeneous of degree one in all prices and convex in prices.

When we later look at comparative static changes, from p_0-p_0 to p_1-p_1 in Figure 2, we can separate this movement into three parts. The total shift in consumption is from point A to point C. When we hold production fixed at point B, however, the household will be maximizing its utility by consuming at point E. The movement from point A to point E was considered in Working Paper 14. The movement in consumption from point E to point C due to production moving from point B to point D we will later call the "profit effect." Rewriting the budget constraint, we have $A+\pi+p_L T-\Sigma p_i X_i^c-p_L \overline{L}=0$,

where A ≡ exogenous income

p_i ≡ prices

p_L ≡ price of labor

T ≡ total time available to the household

X_i^c ≡ consumption of good i

X_i ≡ production of good i

$\overline{L}$ ≡ leisure

L_T ≡ labor demand and

$\pi=\Sigma p_i X_i-p_L L_T$ can be interpreted as short run profits. When production changes in response to changing prices the effect on consumption will be caused by changing the X_i's and L_T in the budget constraint, that is, by changing profits. The movement from point A to point E is the traditional labor-leisure choice model. It can be broken up into the traditional income and substitution effects (with real total income held constant).

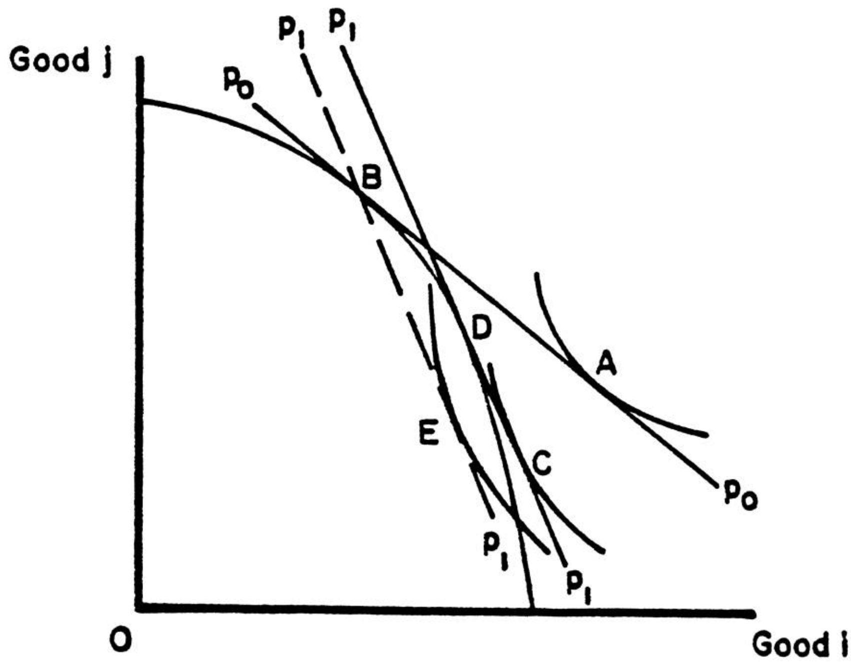

Figure 2

Effect of Price Change on
Household Equilibrium

III. SPECIFYING THE PRODUCTION SIDE

Specifying the production block of the household-firm model will involve a set of factor demand and output supply equations plus a short run profits function. We have initially specified an implicit production function of the form $G(X_i, L_T, D, \overline{K})$, where $D \equiv$ land area cropped and $\overline{K} \equiv$ capital flow are fixed. We could stop at this point, making this function operational (or its associated short run profit function, which we have seen exists) using a flexible form such as the translog. However, we must be conscious of our parameter usage particularly since we are not primarily interested in the production side. The usual way to achieve parsimony in parameters is by using assumptions on the nature of the production function. Two general possibilities suggest themselves. At one extreme, we could assume non-jointness, that is the existence of individual production functions for each output. With fixed land and capital this would insure dependency of those outputs in whose production functions land and capital appeared on the corresponding output prices. However, assuming production functions to differ would entail at least nm parameters, where n is the number of outputs and m the number of inputs. More importantly, there are inadequacies in our data for using this approach (see Section IV). Alternatively, we could assume some form of separability. One logical possibility would be to assume outputs as a group to be separable from inputs as a group. That is, $G(X_i, L_T, D, \overline{K}) = H(X_i) - F(L_T, D, \overline{K})$. We could further assume almost homogeneity of degree $\frac{1}{s}$, that is, $H(\lambda X_i) = F(\lambda^s L_T, \lambda^s D, \lambda^s \overline{K})$. That these assumptions are restrictive in the behavior they permit is true. (For a survey see McFadden, 1978, and for an extension to multiple outputs see Lau, 1978). The question for this research is whether the answers to questions concerning food consumption which we are interested in are robust to assumptions on the production side.

Among the possible functional forms to use for inputs one appealing form is the Cobb-Douglas (CD). Its weaknesses are well known. Its strength for our purposes is its requiring only m+1 parameters. For outputs we might think of the counterpart to the constant elasticity of substitution function, the constant elasticity of transformation (CET) introduced by Powell and Gruen (1968). The function, of the form $H(X_i) = (\Sigma \delta_i X_i^c)^{1/c}$, where $\delta_i > 0$ and $c > 1$ to insure convexity, entails only m+1 parameters. Consequently, a CET-CD system would require n+m+2 parameters which must surely be pushing the lower bound of parameters in any reasonable system. Writing the CD function for inputs as $F(L_T, D, K) = A_o L_T^{B_L} D^{B_D} K^{B_K}$, we have

$$(3.1) \quad (\Sigma_i \delta_i X_i^c)^{1/c} = A_o L_T^{B_L} D^{B_D} K^{B_K}$$

This production system requires one of two normalizations; either $A_0=1$ or $\sum_i \delta_i=1$. This can be seen since we can write the left hand side as $(\sum_i \delta_i)^{1/c}$ $(\sum_i \delta_i^* X_i^c)^{1/c}$ where $\delta_i^*=\delta_i/\sum_i \delta_i$ and $\sum_i \delta_i^*=1$. In this case A_0 and $(\sum_i \delta_i)^{1/c}$ are not distinguishable, so one would estimate $A_0^*=A_0/(\sum_i \delta_i)^{1/c}$ when using the normalization $\sum_i \delta_i^*=1$. Alternatively, we can leave the δ_is as they are and set $A_0=1$, which is what we have done in Chapter 7.

The parameter c can be transformed into $\frac{1}{c-1}$, the elasticity of transformation between outputs. That is, $\frac{1}{c-1}$ is the elasticity of the ratio of two outputs with respect to the marginal rate of transformation, $-\partial X_i/\partial X_j$, between them. Since in a competitive equilibrium, which we assume, the marginal rate of transformation between outputs equals the relative price ratio, the elasticity of transformation between outputs is the elasticity of the ratio of two outputs with respect to their price ratio. For this production function the elasticity of transformation parameter is constant, hence the name CET. Moreover, it is the same for all pairs of outputs. Indeed, one generalization of this functional form would be to write it as a multilevel CET (Mundlak and Razin, 1971) to capture differing transformation elasticities between outputs from different groups.

The δ_i parameters have their meaning in the marginal rate of transformation. It is easily seen that $\frac{-\partial X_i}{\partial X_j} = \frac{\delta_j}{\delta_i}\left(\frac{X_j}{X_i}\right)^{c-1}$. On the input side, the B parameters have the usual meaning for a Cobb-Douglas specification, that is, the percent change in all outputs due to an infinitesimal change in the particular input. The sum of the B's is the degree of almost homogeneity.

Maximizing profits subject to (3.1) (normalizing $A_0=1$) and to D and K being fixed, we arrive at the output supply and labor demand equations.

$$(3.2)\quad p_iX_i = B_L^{B_L/1-B_L}\ \delta_i^{-1/(c-1)}\ p_i^{c/(c-1)}$$

$$(\sum_k \delta_k^{-1/(c-1)}\ p_k^{c/(c-1)})^{(cB_L-1)/c(1-B_L)}$$

$$(D^{B_D}K^{B_K})^{1/(1-B_L)}\ p_L^{(-B_L/(1-B_L))}$$

$$i=1, \ldots, n$$

$$p_L L_T = (D^{B_D}K^{B_K})^{(\frac{1}{1-B_L})}\ B_L^{(\frac{1}{1-B_L})}\ p_L^{(-B_L/(1-B_L))}$$

$$(\sum_i \delta_i^{\frac{-1}{c-1}}\ p_i^{c/(c-1)})^{(\frac{c-1}{c(1-B_L)})}$$

These equations point out some of the simplifications made by selection of this functional form. Elasticities of value output with respect to fixed input are $\frac{B_i}{1-B_L}$, where i is either D or K. This means these elasticities are the same for all outputs. Also, the elasticities of value output with respect to wage $\frac{B_i}{1-B_L}$ are identical for all outputs. Own price elasticities of value output and of value labor demand are not identical across commodities as seen by

$$(3.3)\quad \frac{\ln p_iX_i}{\ln p_i} = \frac{1}{c-1} + p_i^{\frac{c}{c-1}}\ \delta_i^{\frac{1}{c-1}}\ (cB_L-1)/((1-B_L)(c-1)A)$$

where $A = \sum_i p_i^{c/(c-1)}\ \delta_i^{-1/(c-1)}$ and $\frac{\partial \ln p_L L_T}{\partial \ln p_L} = -B_L/(1-B_L)$.

Thus far we assume the implicit production function to be identical in all regions in Sierra Leone. One way to capture some differences is to allow for fixed regional effects, for instance, on the intercept term on the input function. Indeed, this is pursued in the estimation procedure. Of greater difficulty are possible differences in the remaining parameters.

One could add slope dummy variables but at a large cost in parameters. Alternatively, one could assume that parameters vary randomly around some mean with a disturbance which is identical for households within a region. This is essentially the Swamy (1974) specification for panel data adapted to a regional cross section. Of greater difficulty is the possibility that some outputs are not produced at all in some areas (which is true for our sample, see Sections IV and V).

Estimating the household-firm model by agro-climatic region has appeal in principle. However, separating 138 households into eight regions will not leave sufficient data for estimation, and worse will leave no price variation as that is regional (see Section IV). Compromise may be possible but at the potential cost of having to reduce the parameters to be estimated and reducing observed price and input differentials. Aggregation of outputs or inputs may help some but raises the same issues as on the demand side of the model. Hence, we assume that the production function is identical throughout rural Sierra Leone, but with certain parameters possibly varying with region.

As for the limited number of inputs, this specification is based on Byerlee and Spencer's (1977) extensive study of farm firms in Sierra Leone (also Byerlee, Spencer and Franzel, 1979). Fertilizer purchases are very limited and tractor services are hired by only a few mechanized farms in a particular area, the Bolilands. This study is not concerned directly with changes in farming systems so these factors can reasonably be abstracted from (though they are included in our measure of capital flow--see Section IV.

IV. THE DATA

Sampling procedures and the preparation of the data used in estimating the Quadratic Expenditure System are discussed in Working Paper 14. Quantities of foods consumed were derived from quantities purchased and quantities consumed from home production. The latter were derived as a residual. Sales, wages in kind paid out and rice seed were subtracted from production. In kind wages received and rice seed purchased were added. Net charge in storage from the beginning to the end of the cropping year was assumed to be nil. Consumption prices were calculated for each of the eight agro-climatic regions. They are arithmetically weighted averages of farm gate sales and market purchase prices with the weights being the proportion of the value of regional consumption coming from home production and from market purchases. Foods were aggregated into five groups. These plus non-foods and labor are the seven commodities used in the study. A listing appears in Table A.1.

Values of production were derived by multiplying quantities produced by farm gate sales price, and then added into the appropriate groups. Production of raw products was used; processed product production was not added in order to avoid double counting. For example for fish, only estimates of fresh production were used. Production of dried fish was not added to that.

Household labor demanded was measured in terms of male equivalents. Spencer and Byerlee (1977) found that wages for females over 15 were .75 of wages for males over 15, and children aged 11-15 had wages .5 of male adult wages. Under the assumption that relative wages reflect relative marginal productivities, hours of labor supplied were weighted by these factors and then summed. Labor demand includes work on all agricultural and nonagricultural activities in the household exclusive of processing agricultural products. Both family and hired labor are included.

Farm sales prices for the 128 foods were aggregated into the same groups as the weighted sales and purchase prices. In this case the weights were the proportion of value of regional sales for the group represented by each of its component foods. These were the prices used in estimating the system of output supplies and labor demands. There is room for disaggrement as to whether these weighted sales prices or the weighted "consumption" prices used in the QES estimation ought to have been used on the production side. On the one hand, the household-firm model does not distinguish between the two prices; indeed it assumes they are equal. From this point of view, we should use the same set of prices for each component of the model. However, looking at the dichotomous nature of the model, we first maximize short run profits subject to a production function. If this is done as a separate study sales prices are the appropriate ones to use.

Wage was taken directly from Byerlee and Spencer's earlier work. It is expressed as Leones per hour worked for males over 15 years old.

Calculation of Production Inputs

Land is measured as total land area cropped, in acres. It includes land in perennial as well as annual crops. It is a simple sum of acres. No weighting to reflect different qualities (for example of swamp and of upland lands) was made because no such data were available. For a very few households, data on this variable were missing. Since these households had usable data for all other variables, they were not dropped. Byerlee and Spencer had classified households into many different farm types. From the production sample of 328 households we computed average land-labor use ratios for each farm type. Knowing the farm type and the labor used for these households we were able to estimate total land cropped.

Capital is measured as the value of its flow. For variable capital this represents no problem. However, variable capital for our sample is minuscule, mostly rice seed. Only a very little fertilizer is used and a little machinery hired, and these were added into the total. Since there are some values for variable capital, which is a flow, it was necessary to convert the stock of fixed capital into the equivalent flow in order to add the two. This raises many problems, but follows the lead of Spencer and Byerlee (1977, p. 46). In their work they used the formula

$$(4.1) \quad K = \frac{rV}{1-(1+r)^{-n}}$$

where K≡annual service user cost, V≡acquisition cost of capital, and n≡expected life of capital in years. In a perfect market the acquisition cost of the asset equals the discounted sum of its annual flows. Assuming the annual flows to be constant in real value, and assuming the flows start in year one, we obtain equation 4.1. Spencer and Byerlee use a discount rate of .1 and expected lives that were different for different types of capita (1977, pp. 47-48). The types of capital included are farm tools, animal equipment (including fishing equipment), nonfarm equipment, livestock and tree crops. The coefficients $\frac{r}{1-(1+r)^{-n}}$ used are 1/5, 1/6, 1/13, 1/3.8, and 1/30 respectively.

Sample Characteristics

Production characteristics of the sample of 138 households are shown in Table IV-1. For reporting average values, the sample is divided into the ten households in Enumeration Area 13 (EA13) and the remainder. The former are mostly commercial fishermen who also grow and sell a large amount of vegetables to the Freetown market. In their production characteristics they

Table IV.1

Mean Values of Production-Related Data, EA 13 and Other Households

Variable	EA 13	Non-EA 13	Entire Sample
Value of Production[1]			
Rice	62.7	283.5	267.5
Root crops & other cereals	27.9	64.4	61.8
Oils and fats	20.6	104.2	98.1
Fish and animal products	733.5	23.0	74.5
Miscellaneous foods	331.8	53.3	73.5
Nonfoods	82.8	25.0	29.2
Value of Labor Demand	954.7	367.5	410.0
Prices[2]			
Rice	.19	.22	.22
Root crops & other cereals	.25	.14	.15
Oils and fats	.37	.41	.41
Fish and animal products	.17	.52	.49
Miscellaneous foods	.15	.29	.28
Nonfoods	2.23	1.25	1.32
Labor	.15	.08	.08
Household Characteristics			
Cultivated land[3]	1.6	6.8	6.4
Capital[4]	214.3	35.1	48.1
Proportion of households in EA 13	1.00	0.00	.07

[1]In Leones. Valued by weighted sales prices.

[2]Weighted sales prices. In Leones per kilogram for foods and per hour of male equivalent for labor.

[3]In acres.

[4]Annual flow in Leones.

are quite different from the rest of the households, as will be confirmed in Section V. (This is not so true of their consumption characteristics). The fishing households cultivate much less land than the other households (an average of 1.6 rather than 6.8 acres), but have considerably more capital in the form of boats and the like. Prices are also different, with the price of fish and animal products being considerably lower in EA13.

Table IV.2 presents the quantities of production, total consumption and the difference, net marketed surplus, by expenditure group. Expenditure group was found to be a useful classification of households for the demand side of the study, and it will be used in presenting the results of the complete model. The expenditure groups are formed by separating households according to whether their total expenditure on goods is under 350 Leones, between 350 and 750 Leones, or over 750 Leones. Except for rice the high expenditure group tends to sell more or buy more than do lower expenditure groups. The only groups for which net purchases from the market are made are nonfoods, labor for middle and high expenditure groups and fish and animal products for low and middle expenditure groups. We have to remember, however, that these are net figures. A household may hire labor during peak season and sell labor in the offpeak season. The figures reported here combine these two transactions.

Finally, and not surprisingly, households specialize in production more than in consumption. Using our commodity definitions we have three households which do not produce rice, 19 which have no production--of root crops and other cereals, 24 for oils and fats, 35 for fish and animal products, 12 for miscellaneous foods, and 59 for nonfoods. The relatively large number of zero outputs gives rise to statistical problems will be considered in Section V.

Table IV.2

Quantities[1] Produced, Consumed, and Marketed by Expenditure Group

Commodity	Expenditure Group	Produced	Consumed	Marketed
Rice	Low	902.8	232.8	670.0
	Middle	1,164.3	544.3	620.0
	High	1,622.2	973.7	648.5
	Mean	1,227.5	586.8	640.7
Root crops and other cereals	Low	69.0	29.7	39.3
	Middle	335.8	49.1	286.7
	High	744.6	194.9	549.7
	Mean	422.1	111.5	310.6
Oils and fats	Low	85.5	26.3	59.2
	Middle	242.0	60.0	182.0
	High	447.2	186.1	261.1
	Mean	242.2	86.7	155.5
Fish and animal products	Low	18.0	49.4	-31.4
	Middle	48.3	103.2	-54.9
	High	508.7	303.3	205.4
	Mean	151.5	128.7	22.8
Miscellaneous foods	Low	93.0	50.0	43.0
	Middle	191.3	113.4	77.9
	High	515.3	165.0	350.3
	Mean	262.3	110.5	151.8
Nonfoods	Low	10.8	145.2	-134.4
	Middle	19.4	297.0	-277.6
	High	33.9	432.0	-398.1
	Mean	22.1	302.9	-280.8
Labor[2]	Low	3,963.8	3,800.3	163.5
	Middle	4,286.7	4,425.1	-138.4
	High	5,687.8	6,141.4	-453.6
	Mean	4,670.2	4,829.7	-159.5

[1]In kilograms for foods, hours for labor.

[2]Produced and Consumed correspond to supply and demand.

V. ESTIMATION

Estimation with Censored Data

For estimating the system of output supply and input demand equations we begin with equation 3.2, derived from a Constant Elasticity of Transformation-Cobb-Douglas (CET-CD) multiple output production function. Following the discussion in Section IV of Working Paper 14, we add error terms which are distributed as $N(0,\Sigma)$ to these equations, which are in quantity form. If there were no other considerations, we could obtain our maximum likelihood estimates easily. However, we saw in Section IV that for several of our six goods many households have no production. In particular, for production of nonfoods, oils and fats and fish and animal products this is so. If it is physically possible for households to produce these goods then the first order conditions from the maximization of profits subject to the production function are the Kuhn-Tucker conditions.

$$(5.1) \quad p_i - \mu\frac{\partial G}{\partial X_i} \leq 0,\ X_i(p_i - \mu\frac{\partial G}{\partial X_i}) = 0 \qquad i=1, \ldots, n$$

$$-p_L - \mu\frac{\partial G}{\partial L_T} \leq 0,\ L_T\ (-p_L - \mu\frac{\partial G}{\partial L_T}) = 0$$

$$G \leq 0,\ \mu G = 0$$

Assume no technical inefficiencies, so that $G=0$, and assume that labor is always demanded, which is true for our sample, so that $p_L + \mu\frac{\partial G}{\partial L_T} = 0$. Then $\frac{p_i}{p_L} \leq \frac{-\partial G/\partial X_i}{\partial G/\partial L_T},\ \forall_i$. The right hand side is the reciprocal of the marginal product of labor in producing good i. We have then that the value or marginal product of labor for good i is less than or equal to the price of labor. When this holds as an equality the good is produced and when it is an inequality the good is not produced.

This is the deterministic situation. Randomness can be accounted for in two ways. One can append error terms to the Kuhn-Tucker first order conditions. This was done for a system of demand equations by Wales and Woodland (1979).

Alternatively, one can add error terms directly to the reduced form of output supply and input demand equations, as done for a demand system by Wales and Woodland (1978). This is akin to the Tobit model $y^*=g(x,\beta) + \varepsilon$, $y=\max(0,y^*)$, where y^* is not observed but y is. If $\varepsilon \sim N(0,\sigma^2)$ then $E(y) = E(y/y>0) \cdot P(y>0) + E(y/y=0) \cdot P(y=0)$, where $E(\cdot)$ is the expectations operator and $P(\cdot)$ is probability. Of course, $E(y/y=0)=0$ so $E(y) = E(y/y>0) \cdot P(y>0)$. $E(y/y>0) = g(x,\beta) + E(\varepsilon/y>0)$ and from Johnson and Kotz (1970) we have $E(\varepsilon/y>0) = E(\varepsilon/\varepsilon>-g(x,\beta)) = E(\varepsilon/\frac{\varepsilon}{\sigma}>\frac{-g(x,\beta)}{\sigma}) = \sigma f(g(x,\beta)/\sigma)/F(g(x,\beta)/\sigma)$, where $f(\cdot)$ is the standard normal density and $f(\cdot)$ is the standard normal distribution function. In particular, $E(\varepsilon/y>0) \neq 0$ so that regression using only observations with positive y's leads to inconsistent parameter estimates. This last implies that the mean of the disturbances using all observations on $y, E(\varepsilon/y>0) \cdot P(y>0)$ is also not zero, so these OLS parameter estimates are inconsistent also. For the linear in parameters model Greene (1981) has shown $E(\hat{\beta}_{OLS}) = \beta F(\overline{X}\beta/\sigma)$, so that the lower the probability of a positive observation the greater is the bias. What is happening in this model is that the entire normal distribution of ε is not being observed. The lower tail in which $\varepsilon<-g(x,\beta)$, corresponding to $y=0$, is piled up at $-g(x,\beta)$, providing we observe y when it is equal to zero. This is so because we observe y, not y^*. If y is not observed when it is zero, the distribution of ε is simply cut off or truncated at $\varepsilon=-g(x,\beta)$. The former situation (y observed), which we have in our data, is called censored data; the latter is called truncated data.

The foregoing applied to a single equation model. The output supply and input demand equations are a system but the same model is applicable. In this case ε is an n+1 vector with covariance matrix Σ. Also, there exist cross equation parameter restrictions, for instance that c is the same in all equations. The system can be estimated consistently using maximum likelihood techniques. The probability density for each household involves evaluating multiple integrals, one for each good not produced. In our data there are many households not producing one or two goods and a few households not producing as many as four goods. For these households the corresponding density involves evaluating a quadruple integral. This is not only extremely messy to program, but expensive to compute as well. Indeed, in their two papers, Wales and Woodland used only three commodities, one of which was always consumed.

One way around this difficulty would be to aggregate to, say, three outputs plus labor. Since one output is always produced and labor always demanded, this would involve at most double integrals, which would still be expensive, but perhaps manageable. An alternative not involving more aggregation is to assume Σ, the covariance matrix of ε, to have zeroes in certain places. If Σ were block diagonal then the multivariate density would be a product of densities of the outputs (and input) corresponding to each block. This would reduce the dimension of the multiple integrals to be evaluated. In the extreme case of assuming independence between each of the error terms, the household density would be the product of 7-K normal densities and K standard normal distribution functions. If K outputs were not produced, only a single integral would have to be evaluated, but one for each of the normal distribution functions corresponding to the K outputs not produced. However, evaluating a single integral K times is a much less costly and less difficult procedure than evaluating a K- dimension integral once. Although one need not go so far as assuming independence between all of the error terms, to choose which error terms are correlated in such a way as to result in block diagonality for Σ would seem to involve as much arbitrariness as assuming complete independence. Since the latter results in a considerably simpler estimation procedure, it was chosen.

It should be noted that one reason why this would be an unreasonable assumption for a demand system does not hold for output supplies and input demands. As we have seen for the demand side expenditures on goods plus value of household leisure equal total income, resulting in error terms summing to zero. Hence, the covariance matrix is singular, which it could not be if it were diagonal. However, this is not true for the values of output supply less value of input demand. On the other hand, one can argue that the probability of producing rice conditional on the household not producing any other commodity but demanding labor is not equal to the unconditional probability of producing rice. Clearly, in this case, the conditional probability is one, but the unconditional probability is not. Yet independence of the error terms implies these probabilities are equal. Still, assuming independence does make the computation problem manageable. Moreover, ignoring cross-equation restrictions, maximum likelihood estimates assuming independence retain their consistency even if the assumption is violated. Hence, the assumption remains attractive statistically. All that would be sacrificed is asymptotic efficiency. The likelihood function to be maximized is thus

$$(5.2)\quad L = \prod_t \Big[\prod_{i \in P} \frac{1}{\omega_i} f(g_{ti}(\beta)/p_i\omega_i) \prod_{j \in NP} F(-g_{tj}(\beta)/p_j\omega_j) \Big]$$

where f(·) is the standard normal density, F(·) the standard normal distribution function, ω_i is the standard error of the ith equation, P corresponds to goods produced, NP to goods not produced, and t to households.

To justify use of the multivariate Tobit model one has to be convinced that there is positive probability of producing non-produced outputs. Looking at the data, many of the zero outputs are spread throughout all regions. That is, some households within an enumeration area will be producers and others not. In these cases, there is evidently no environmental reason why the particular good cannot be produced. There do exist some cases in which the zero observations are clustered geographically so that none of the particular output is produced by our sample of 138 in a particular enumeration area. This occurs for root crops and other cereals in EA 72, for oils and fats in EAs 52 and 53, for fish and animal products in EAs 32 and 72, and for nonfoods in EA 72. To get a better idea of whether there exist environmental constraints on production of those goods in these enumeration areas, we examined the larger sample of 328 households for which production data were considered reliable by Spencer and Byerlee. In all cases except oils and fats in EAs 52 and 53, and fish and animal products in EA 72, there was some production of the good in question. For EAs 52 and 53, the 1970/71 Agricultural Survey of Sierra Leone showed that oils and fats were indeed produced in the Bombali areas in question. For EA 72 the Agricultural Survey indicated that game was captured. Since fish and animal products includes wild game, it was concluded that it was possible to produce this "good" in the area in question.

Another potential problem in using the Tobit model is misspecification of the production function. Instead of separability of all outputs and all inputs in the implicit production function, it can be argued that there are separate production functions for some outputs, perhaps for nonfoods, oils and fats and fish and animal products. As an example, one might assume nonfood production to be a function of nonfood labor and nonfood capital. With capital fixed, either a Cobb-Douglas or a CES function implies zero supply of output if there is no capital. Hence, if households have no nonfood capital, the probability of producing nonfood output is zero. This approach runs into severe data problems with our sample. For example, there are households reporting no capital or labor use for fishing and animal product activities, yet reporting positive outputs. Many households reporting zero production of nonfoods report positive labor use to produce nonfoods. When inputs are aggregated, as we have done, into total labor, total capital and total land, there is a greater chance than for using disaggregated inputs that such errors cancel each other out.

Another advantage in the CET-CD specification is that the supply of any output is a function of all output prices. A separate production function for nonfood, if it did not include land as an input, would make nonfood supply a function of only nonfood price, wage and nonfood capital. This is a result of assuming labor can be freely sold and purchased, so that labor supply to the firm is not fixed.

Variable Selection

Variable selection is largely specified by choice of outputs, inputs and production function. It bears repeating here that land is not adjusted for quality as labor and capital flows are. The rental market for land is too small and influenced importantly by nonmarket factors such as whether the household is a member of the community or not (Spencer and Byerlee, 1977, pp. 21-23), so cannot be used to adjust acreage for quality. No other data bearing on this question were available. Acreage disaggregated by crop use was available but there may be different quality lands within each crop use. Moreover, the same data problems which exist for disaggregated capital exist for disaggregated land use. There is some room for variable selection after the outputs, inputs and production function have been specified providing one hypothesizes parameters of the production function to be a function of other variables. In production function analysis this has a time honored tradition when using cross-section, time series data (see Mundlak, 1961) as firm and time effects. This amounts to using shift dummies corresponding to firm or time when estimating the production function. More recently Mundlak (1980) has made slope parameters functions of certain variables. From their work studying production and labor use using the larger production sample of 328 households, Byerlee and Spencer concluded that one could group households by the two large regions, north and south, the same grouping which was used when estimating the quadratic expenditure system. Fitting completely different production functions for each region would reduce both sample size and price variation.

If one can assume that the overall functions are the same but that certain parameters differ by region, then advantage may be taken of pooling the regions in estimation. Suppose one lets the shift parameters of the CET-CD production function vary by region. As we saw in Section III, this function requires normalization by either the δ_i parameters summing to one or the shift parameter being unity. We have chosen the latter method. However, let $A_0=a_0+a_1D$, where $D\equiv$dummy variable. Dividing both sides of equation 3.1 by A_0 gives the normalization which we use of the shift dummy equaling one. Now, however, the δ_i's are each divided by A_0 and the new coefficient will take on different values for each region. The coefficients thus derived $\delta_i/(a_0+a_1D)$ are a bit cumbersome. A simpler way to achieve this result and to maintain the normalization that $A_0=1$ is to make each δ_i depend linearly on the dummy variable $\delta_0=\delta_{i0} + \delta_{i1}D$. This introduces n new parameters rather than just one, where n is the number of outputs. However, it presumably allows somewhat more flexibility. In principle, all the coefficients might be allowed to vary with region. However, to keep matters simpler, only the equivalent to a shift dummy was permitted.

Estimates of CET-CD System in Quantity Form

The system of output supplies and labor demand was estimated in quantity form.[2] Numerical maximum likelihood techniques were used. Parameter estimates and their asymptotic standard errors are given in Table A.2. The first sixteen parameters correspond to the production function coefficients in equations 3.2. The last seven parameters are the standard errors from the likelihood function in equation 5.2. Nine out of sixteen production function parameters have absolute values of coefficients greater than their standard errors, with four having this ratio greater than two. For the δ_i parameters we use the one-tailed test since they are constrained to be positive. One parameter (for rice) is significant at a probability level less than .1 (corresponding to a standard normal statistic of greater than 1.29) and two have probability levels of roughly .11. For the $\delta_{i0} + \delta_{i1}$ parameters (which correspond to EA13 households), two have coefficients absolute values greater than 1.29 their standard errors. Wald test statistics of the joint significance of the δ_i parameters are low as is seen in Table A.3.

The coefficient c is 4.25, corresponding to an elasticity of transformation between outputs of .31. The production function is almost homogeneous of degree .78, significantly less than one. The estimate of the coefficient for land .07, is low. This is very different from the usual single agricultural output Cobb-Douglas results in which land has the largest coefficient. Two reasons suggest themselves for this. First, some of our outputs such as fishing and animal products, oils and fats and nonfoods are not going to be much affected directly by land cultivated by the household. Capital and labor are far more important inputs for these activities. Perhaps, had the production function specification been to allow separate functions for these activities, the land coefficient might have been higher for the remaing crop activities. Be that as it may, this was not possible due to the data inadequacies described earlier. In any case, given the output detail and function specification used, these coefficients may not be unreasonable. A second potential reason is the absence of any quality adjustments in defining the land variable. This misspecification affects all coefficients. Had the model been linear in parameters, however, and if increasing size of farm was associated with lower quality land, then land's estimated coefficient would be lower than the true value. Whether this result applies given that the model is highly nonlinear in parameters is not clear.

Output Elasticities with Respect to Prices and Final Inputs

Price elasticities of quantity of output supply and labor demand are given in Table V.I for EA 13 households, the remaining households and the sample average. The elasticities are evaluated at average values for these three groups. This is done rather than using only the sample mean values and setting the dummy to one for EA 13 households and to zero for the rest. The reason is that predicted quantities for EA 13 households using sample

Table V.1

Elasticities of Expected Quantities of Outputs Supplied and Labor Demanded with Respect to Price From CET-CD System in Quantity Form[1]

With Respect to Price of	Household Group	Rice	Root Crops and Other Cereals	Oils and Fats	Fish and Animal Products	Miscellaneous Foods	Nonfoods	Labor
Rice	EA 13	.08	.02E-1	.03E-2	.06E-1	.06E-1	.03E-1	.03
	Non-EA 13	.36	.03	.04	.02	.05	.01	.53
	Mean	.11	.01	.03E-1	.01	.02	.06E-1	.14
Root Crops and Other Cereals	EA 13	.08E-1	.12	.01E-1	.03	.03	.01	.18
	Non-EA 13	.03	.09	.01	.07E-1	.01	.04E-1	.16
	Mean	.02	.10	.04E-1	.01	.03	.08E-1	.20
Oils and Fats	EA 13	.02E-2	.04E-2	.02	.01E-1	.01E-1	.04E-2	.06E-1
	Non-EA 13	.02	.08E-1	.13	.06E-1	.01	.03E-1	.14
	Mean	.02E-1	.02E-1	.02	.02E-1	.03E-1	.09E-2	.02
Fish and Animal Products	EA 13	.04	.05	.07E-1	.45	.14	.06	.83
	Non-EA 13	.03	.01	.02	.08	.02	.05E-1	.20
	Mean	.02	.02	.05E-1	.09	.03	.09E-1	.23
Miscellaneous Foods	EA 13	.01	.02	.02E-1	.05	.35	.02	.27
	Non-EA 13	.02	.06E-1	.09E-1	.05E-1	.14	.03E-1	.11
	Mean	.01	.01	.03E-1	.01	.15	.05E-1	.13
Nonfoods	EA 13	.03E-1	.04E-1	.05E-2	.01	.01	.13	.06
	Non-EA 13	.04E-1	.01E-1	.02E-1	.09E-2	.02E-1	.04	.02
	Mean	.03E-1	.02E-1	.05E-2	.02E-1	.04E-1	.04	.03
Labor	EA 13	-.14	-.20	-.03	-.54	-.54	-.23	-1.37
	Non-EA 13	-.47	-.15	-.21	-.12	-.23	-.07	-1.17
	Mean	-.17	-.14	-.03	-.13	-.24	-.07	-.75

[1]Calculated at mean values for each household group using $\frac{p_j}{E(X_i)} \frac{\partial E(X_i)}{\partial p_j}$. Uses EA 13 - Non-EA 13 dummy.

mean prices are wild. Prices faced by these ten households, particularly for fish and animal products, are very different (lower) than sample average prices, causing this aberrant behavior.

The formula used is $\frac{p_j}{E(X_i)} \frac{\partial E(X_i)}{\partial p_j} = \frac{p_j}{E(X_i)} (F(\frac{g_i(\beta)}{p_i \omega_i}) \frac{\partial}{\partial p_j} (\frac{g_i(\beta)}{p_i}))$.

All the output elasticities are less than .5. In general, the more important the activity to the group of households, the more price responsive it is. For EA 13 households, fish and animal products and miscellaneous foods (remember vegetables production is important for these households), have own-price elasticities of .45 and .35 respectively. For non-EA 13 households rice is the most price responsive, having an elasticity of .36. For these households root crops and other cereals, oil and fats and miscellaneous foods have own-price elasticities ranging from .09 to .14. Labor is much more elastic than outputs for all households, being -1.37 and -1.17 for EA 13 and non-EA 13 households respectively.

For oils and fats (which includes palm kernels), a cash crop, the own-price elasticity of .13 for non-EA 13 households is at first glance surprisingly low. However, it should be remembered that exogenous variables are averaged over households of which only some are major producers of oils and fats. This may bring price responsiveness down. More importantly, the stock of oil palm trees of bearing age is fixed so the major response to price can come only by varying labor, that is, by varying the amount of fruit picked and processed.[4]

At the sample means own-price responsiveness tends to be low. The largest elasticities are for miscellaneous foods, .15, and for rice, .11. Except for rice and oils and fats, the elasticities are close to those for the non-EA 13 households, which is not surprising since they carry the larger weight in forming the sample means. The algebraic reason this is not so for rice and palm products is that the parameter $\delta_{i0} + .0725 * \delta_{i1}$ is closer to $\delta_{i0} + \delta_{i1}$, the parameter for EA 13 households, than to δ_{i0}, that for non-EA 13 households (.0725 is the proportion of sample households in EA 13). That is, δ_{i1} has a much larger value than δ_{i0} for rice and oils and fats. In the expression $\frac{\partial}{\partial p_i}\left(\frac{g_i(\beta)}{p_i}\right)$, $\delta_i = \delta_{i0} + \delta_{i1}D$ raised to the -1/(c-1) power multiplies the remaining terms. Since the power is negative, the larger is δ_i the smaller this term tends to be.

Cross price elasticities of outputs tend to be low except with respect to wage rate. The latter is not surprising since labor demand is reasonably price responsive. The cross price elasticity with respect to wage can be written as the product of the own price elasticity of labor demand and the output elasticity of labor, where the latter is written $\frac{E(L_T)}{E(X_i)}\frac{\partial E(X_i)}{\partial E(L_T)}$. Cross price elasticities of labor demand are also not negligible. As with own-price output elasticities, the more important the activity corresponding to the price changing, the more responsive labor demand is. The signs of the output cross elasticities are positive. That is, increasing price of output i leads to increased production of output j. As output price changes, there is a substitution effect, that is movement along a production transformation frontier. This should be negative. There is also an output effect, a shift of the transformation frontier, due to changes in outputs other than i and j, and more importantly, due to changes in labor demand. An increase in price i should increase labor demand as well as output i, shifting the transformation frontier between goods i and j outward. Whether the outward shift of the transformation frontier is sufficient to outweigh the substitution effect is an empirical question. For the CET-CD production function, it turns out that sign $\left(\frac{\partial E(X_i)}{\partial p_j}\right)$ = sign $(c\beta_L - 1)$, which is positive for our estimates.

The price elasticities derived all assume that quantities, not prices, of land and of capital are fixed to the household. In the longer run, the reverse should be true, which should increase the price responsiveness of both outputs and labor. In the short run, a possibly interesting question is what are the expected output elasticities with respect to fixed inputs. If the data were not censored, the formula, given the production function used, would be $\beta_D/(1-\beta_L)$ for land and $\beta_K/(1-\beta_L)$ for capital. With our data, the formula is $F(g_i(\beta)/p_i\omega_i)\ \frac{g_i(\beta)}{p_i}\ \beta_D/((1-\beta_L)E(X_i))$ for land, and the same for capital with β_K replacing β_D. The former is the same for all outputs and labor. The latter is not, although the ratio of the land to capital elasticities is β_D/β_K for each output and for labor. These elasticities are presented in Table V.2. The elasticities with respect to capital are roughly five times greater than those with respect to land. Again, the magnitudes are largest for those activities which are more important, for which $Fg_i/p_iE(X_i)$ is larger. These are fish and miscellaneous foods outputs for EA 13 households and rice for non-EA 13 households, and labor demand for both.

VI. TOTAL PRICE EFFECTS

Having estimated separately the demand system and production system components of the household-firm model we can now examine the model in its entirety. Consumption demand may be written $X_i^c = f(p,\eta,p_L T(m)+\pi(p,z))$, where $p\equiv$prices, $\eta\equiv$household characteristic variables, $T\equiv$time available to the household, $m\equiv$household characteristic variables, $z\equiv$fixed inputs and $\pi\equiv$profits.

Table V.2

Elasticities of Expected Quantities of Outputs Supplied and Labor Demand with Respect to Fixed Inputs[1]

Commodity	Household Group	With Respect to	Land	Capital
Rice	EA 13		.03	.14
	Non-EA 13		.09	.49
	Mean		.04	.18
Root Crops and Other Cereals	EA 13		.04	.20
	Non-EA 13		.03	.15
	Mean		.03	.15
Oils and Fats	EA 13		.05E-1	.03
	Non-EA 13		.04	.21
	Mean		.07E-1	.04
Fish and Animal Products	EA 13		.11	.56
	Non-EA 13		.02	.13
	Mean		.02	.13
Miscellaneous Foods	EA 13		.11	.56
	Non-EA 13		.05	.24
	Mean		.05	.25
Nonfood	EA 13		.05	.24
	Non-EA 13		.01	.07
	Mean		.01	.07
Labor	EA 13		.10	.50
	Non-EA 13		.08	.42
	Mean		.05	.27

[1]Using CET-CD system with EA 13 - Non-EA 13 dummy. Calculated at mean values for each household group using $\frac{Z_j}{E(X_i)} \frac{\partial E(X_i)}{\partial Z_j}$.

In Working Paper 14 we examined the price elasticities holding profits constant. If we now allow profits to vary we can write

$$\frac{\partial X_i^c}{\partial p_j} = \frac{\partial X_i^c}{\partial p_j} \Big|_{d\pi=0} + \frac{\partial X_i^c}{\partial \pi} \frac{\partial \pi}{\partial p_j} .$$

In elasticity form,

$$(6.1) \quad \frac{p_j}{X_i^c} \frac{\partial X_i^c}{\partial p_j} = \frac{p_j}{X_i^c} \frac{\partial X_i^c}{\partial p_j} \Big|_{d\pi=0} + \frac{p_j \partial X_i^c \partial \pi}{X_i^c \, \partial \pi \partial p_j}.$$

The first term is simply the usual uncompensated elasticity of demand of good i with respect to price j. The second term is what we might call the "profit effect" in elasticity form. It can be simplified by noting that by Hotelling's Lemma $\frac{\partial \pi}{\partial p_j} = X_j$. (This derivative is taken allowing outputs and inputs to vary; see Varian (1978), pp. 31-31). The term $\frac{\partial X_i^c}{\partial \pi}$ is easily gotten from the marginal total income expenditures in Table VI.1.

Two complications arise when implementing equation 6.1 with our data. First, $\pi=E(\pi)+u$, where u is an error term with mean zero, independent of price and fixed inputs. Then $\frac{\partial \pi}{\partial p_j} = \frac{\partial E(\pi)}{\partial p_j}$. However, due to the censoring in our data, Hotelling's lemma no longer holds. We can write $\pi = \sum_{i=1}^{6} p_i X_i - p_L L_T$. From Section V we know that when using our parameter estimates from the quantity form of the production system $E(p_i X_i) = F(\frac{g_i(\beta)}{p_i \omega_i})\, g_i(\beta) + p_i \omega_i\, f(\frac{g_i}{p_i \omega_i})$, and likewise for $E(p_L L_T)$. Hotelling's lemma asserts that $\sum_{i=1}^{6} \frac{\partial g_i(\beta)}{\partial p_j} - \frac{g_L(\beta)}{p_j} = \frac{g_j(\beta)}{p_j}$, which is in fact true of the CET-CD production function. Then if the data were uncensored, so that the error terms had mean zero conditional on positive outputs, the lemma would apply. However, we have seen that

Table VI.1

Marginal Total Income Shares[1]
by Expenditure Group

Commodity	Low	Expenditure Group Middle	High	Mean
Rice	.15	.11	.01	.09
Root crops & other cereals	.02	.04	.09	.05
Oils and fats	.09	.14	.26	.16
Fish and animal products	.09	.08	.05	.07
Miscellaneous foods	.06	.05	.03	.05
Nonfoods	.27	.27	.28	.28
Leisure	.31	.31	.29	.30

[1]Partial derivative of commodity expenditure with respect to total income. Evaluated at expenditure group means.

$\frac{\partial E(p_i X_i)}{\partial p_j} = F(\frac{g_i}{p_i \omega_i}) \frac{\partial g_i}{\partial p_j}$ and $\frac{\partial E(p_i X_i)}{\partial p_i} = F(\frac{g_i}{p_i \omega_i}) \frac{\partial g_i}{\partial p_i} + \omega_i f(\frac{g_i}{p_i \omega_i})$. Using this we have

$$(6.2) \quad \frac{\partial E(\pi)}{\partial p_j} = \sum_{i=1}^{6} F(\frac{g_i}{p_i \omega_i}) \frac{\partial g_i}{\partial p_j} + \omega_j f(\frac{g_j}{p_j \omega_j}) - F(\frac{g_L}{p_L \omega_L}) \frac{\partial g_L}{\partial p_j} \qquad j=1, \ldots, 6$$

$$\text{and} \quad \frac{\partial E(\pi)}{\partial p_L} = \sum_{i=1}^{6} F(\frac{g_i}{p_i \omega_i}) \frac{\partial g_i}{\partial p_L} - F(\frac{g_L}{p_L \omega_L}) \frac{\partial g_L}{\partial p_L} - \omega_L f(\frac{g_L}{p_L \omega_L}) \qquad j=7$$

Since we have estimates for the necessary parameters, $\frac{\partial E(\pi)}{\partial p_j}$ can be constructed from our data.

Relation between Sales Prices and Purchase Prices

A second complication arises because our study uses sales prices when estimating the production system, and a weighted average of sales and purchase prices when estimating the consumption system. Using superscripts of c for weighted consumption prices and s for sales prices, we have $\frac{\partial X_i^c}{\partial p_j^c} = \frac{\partial X_i^c}{\partial p_j^c} \mid d\pi=0 + \frac{\partial X_i^c}{\partial \pi} \frac{\partial \pi}{p_j^s} \frac{\partial p_j^s}{\partial p_j^c}$. We need to make some assumption about $\frac{\partial p^s}{\partial p^c}$.

What relationship would hold over time is unclear because it depends partly on the source of the price changes, i.e., shifts in the supply schedule of marketing services versus autonomous increases in retail demand. What little evidence is in our data is inconclusive. Since an assumption must be made it was assumed that sales prices and purchase prices are proportional. Two reasons can be offered for making this assumption. First, our entire analysis assumes fixity of firm capital and total land. This is a short or medium run situation. In such a short time period it should be less likely that the marketing services supply schedule is horizontal than for the long run. That is, one would expect some upward slope of this supply schedule for the time horizon considered here. The second reason is that the elasticity calculations which follow will be much more understandable if both weighted consumption and sales prices move by the same infinitesimal percent. This would not be true if we assumed a constant marketing margin.[5]

Profit Effects

When deriving profit effects we need the marginal expenditures out of total income. They come from the QES estimates and are given in Table VI.I. A discussion of these results may be found in Working Paper 14. Table VI.2 reports the "profit effects" in elasticity form, the second term in equation 6.1, for low, middle, high and mean expenditure households assuming proportional changes in sales and purchase prices. In most cases the effects are larger, often much larger, for the lowest expenditure households, declining with higher expenditure. Two reasons exist for this tendency to decline. First, for some goods marginal expenditures out of total income decline with higher expenditure. Second, mean consumption of all goods and of labor supply increases with higher expenditure level. Indeed even for root crops and oils and fats, for which marginal expenditures out of total income rise with total expenditure level, the profit effect, which is in an elasticity form, falls. Goods having higher marginal expenditures, such as oils and fats and nonfoods, tend to have larger profit effects. This factor is also responsible for many of the cross profit effects being large. A change in total income generated by a changing price is distributed over all commodities according to the marginal expenditure out of total income.

The largest own profit effect, at the sample mean, is .27 for fish and animal products. Oils and fats has an effect of .24. The other own effects

Table VI.2

Profit Effects in Elasticity Form by Expenditure Group

With Respect to Price of	For Expenditure Group OF	Rice	Root Crops and Other Cereals	Oils and Fats	Fish and Animal Products	Miscellaneous Foods	Nonfoods	Household Labor
Rice	Low	.82	.63	1.44	.91	.66	.94	-.32
	Middle	.11	.15	.46	.16	.10	.18	-.11
	High	.05E-1	.08	.26	.05	.03	.11	-.07
	Mean	.08	.09	.35	.14	.09	.17	-.10
Root crops and other cereals	Low	.49	.38	.86	.54	.40	.56	-.19
	Middle	.14	.19	.56	.19	.12	.22	-.13
	High	.01	.16	.58	.12	.07	.24	-.15
	Mean	.12	.16	.55	.21	.14	.27	-.15
Oils and fats	Low	.36	.28	.63	.40	.29	.41	-.14
	Middle	.08	.11	.31	.11	.06	.13	-.07
	High	.03E-1	.04	.17	.03	.02	.07	-.04
	Mean	.05	.07	.24	.09	.06	.12	-.06
Fish and animal products	Low	.71	.54	1.24	.78	.58	.81	-.28
	Middle	.25	.35	1.05	.35	.22	.41	-.24
	High	.09E-1	.13	.45	.10	.06	.19	-.12
	Mean	.16	.21	.73	.27	.18	.36	-.20
Miscellaneous foods	Low	.23	.18	.40	.25	.19	.26	-.09
	Middle	.08	.11	.33	.11	.07	.13	-.08
	High	.05E-1	.06	.22	.05	.03	.09	-.06
	Mean	.06	.07	.25	.10	.06	.13	-.07
Nonfoods	Low	.12	.10	.22	.14	.10	.14	-.04
	Middle	.04	.06	.18	.06	.04	.08	-.04
	High	.02E-1	.04	.12	.02	.02	.06	-.04
	Mean	.04	.04	.14	.06	.04	.08	-.04
Labor	Low	-.56	-.43	-.99	-.62	-.46	-.64	.22
	Middle	-.13	-.19	-.56	-.19	-.11	-.22	.13
	High	-.08E-1	-.11	-.38	-.08	-.05	-.15	.10
	Mean	-.10	-.13	-.43	-.17	-.11	-.21	.12

[1] Calculated as $\frac{p_j}{X_i^c} \frac{\partial X_i^c}{\partial \pi} \frac{\partial E(\pi)}{\partial p_j}$ at expenditure group means, using parameter estimates from the CET-CD system in quantity form, and assuming proportional sales and purchase prices.

effects at the mean household level are all lower than .17.

For the low expenditure group the largest own profit effect is .82 for rice, followed by .78 for fish and animal products and then .63 for oils and fats. In addition to the reasons previously advanced the profit effect for rice is large because the term $\frac{\partial E(\pi)}{\partial p}$ rises substantially when computed for the low expenditure group.

The signs of the profit effects with respect to goods prices are positive except for household labor supply. This is due to the marginal expenditures out of total income being positive for all goods. The sign in household labor is the opposite of the sign on household "leisure." Since "leisure" is a normal good for these households, labor supply is lowered as total income increases due to rising goods prices. With respect to wage rate the signs for effects on goods are negative, for the same reason. Profits are reduced as wage increases so expenditures fall. Household labor, however, increases in this case.

Total Price Elasticities of Consumption

Having derived the profit effects we can add these to the uncompensated elasticities with respect to price, which hold profit constant, to arrive at the total price elasticities of quantities of goods demanded and of labor supplied. The former are computed for Working Paper 14 and are reproduced here as Table VI.3. The latter correspond to the movement from point A to point C in Figure 2 and are presented in Table VI.4. The own total price effects for commodities remain negative when profit effects are added except for root crops and other cereals at the low expenditure group. The fact that root crops and other cereals consumption responds positively to own price for low expenditure households is reflective of the lack of responsiveness of consumption to own price holding profits constant and of

Table VI.3

Uncompensated Quantity Elasticities with Respect to Price[1] by Expenditure Group

With Respect to Price of	For Expenditure Group	OF Rice	Root Crops and Other Cereals	Oils and Fats	Fish and Animal Products	Miscellaneous Foods	Nonfoods	Household Labor
Rice	Low	-1.26	-.16	-.23	.02	.03	-.01	.01E-1
	Middle	-.78	-.13	-.31	.02	.02	-.02	.04E-1
	High	-.45	-.12	-.38	.05	.07	-.04	.01
	Mean	-.74	-.10	-.29	.03	.03	-.03	.01
Root crops and Other cereals	Low	-.02	-.15	-.02	-.02	-.02	-.02	.01
	Middle	-.02	-.26	-.04	-.02	-.01	-.02	.01
	High	-.01	-.31	-.02	-.01	-.01	-.01	.01
	Mean	-.01	-.22	-.02	-.02	-.01	-.02	.01
Oils and Fats	Low	.04	.04	-.82	.05	.03	.05	-.02
	Middle	.01E-1	.04E-1	-1.10	.02E-1	.01E-1	.04E-1	-.02E-1
	High	-.01E-1	.05E-1	-1.25	.02E-1	.01E-1	.01	-.03E-1
	Mean	.04E-1	.01	-.97	.01	.01	.01	-.01
Fish and Animal Products	Low	.02	-.08	-.12	-1.29	.01	-.01	.01E-1
	Middle	.03	-.06	-.15	-.92	.01	-.01	.03E-1
	High	.06	-.05	-.15	-.81	.04	-.03E-1	-.04E-1
	Mean	.04	-.04	-.12	-.95	.02	-.01	.01E-3
Miscellaneous Foods	Low	.01	-.06	-.10	-.03E-1	-.99	-.01	.04E-1
	Middle	.01	-.06	-.14	-.03E-1	-.60	-.02	.01
	High	.04	-.04	-.14	.02	-.63	-.02	.01
	Mean	.02	-.04	-.11	.03E-1	-.71	-.02	.01
Nonfoods	Low	.10	-.16	-.21	.06	.06	-1.17	-.01
	Middle	.07	-.16	-.36	.02	.03	-.90	.01
	High	.14	-.12	-.38	.07	.08	-1.05	-.04E-1
	Mean	.09	-.11	-.30	.04	.05	-1.01	-.04E-1
Labor	Low	1.30	.72	1.81	1.38	1.03	1.39	-.06
	Middle	.56	.48	1.53	.71	.44	.74	.09
	High	.20	.31	1.16	.43	.31	.65	.28
	Mean	.47	.34	1.25	.67	.47	.78	.14

[1] Calculated at mean for each expenditure group. Uses QES with regional dummy.

Table VI.4

Total Quantity Elasticities with Respect to Price[1] by Expenditure Group

With Respect to Price of	For Expenditure Group OF	Rice	Root Crops and Other Cereals	Oils and Fats	Fish and Animal Products	Miscellaneous Foods	Nonfoods	Household Labor
Rice	Low	-.44	.47	1.21	.93	.69	.93	-.32
	Middle	-.67	.02	.15	.18	.12	.16	-.11
	High	-.44	-.04	-.12	.10	.10	.07	-.06
	Mean	-.66	-.01	.06	.17	.12	.14	-.09
Root crops and other cereals	Low	.47	.23	.84	.52	.38	.54	-.18
	Middle	.12	-.07	.52	.17	.11	.20	-.12
	High	.01E-1	-.15	.56	.11	.06	.23	-.14
	Mean	.11	-.06	.53	.19	.13	.25	-.14
Oils and fats	Low	.40	.32	-.19	.45	.32	.46	-.16
	Middle	.08	.11	-.79	.11	.06	.13	-.07
	High	.02E-1	.05	-1.08	.03	.02	.08	-.04
	Mean	.06	.08	-.73	.10	.07	.13	-.07
Fish and animal products	Low	.73	.46	1.12	-.51	.59	.80	-.28
	Middle	.28	.29	.90	-.57	.23	.40	-.24
	High	.07	.08	.30	-.71	.10	.19	-.12
	Mean	.20	.17	.61	-.68	.20	.35	-.20
Miscellaneous foods	Low	.24	.12	.30	.25	-.80	.25	-.09
	Middle	.09	.05	.19	.11	-.53	.11	-.07
	High	.05	.02	.08	.07	-.60	.07	-.05
	Mean	.08	.03	.14	.10	-.65	.11	-.06
Nonfoods	Low	.22	-.06	.01	.20	.16	-1.03	-.05
	Middle	.11	-.10	-.18	.08	.07	-.82	-.03
	High	.14	-.08	-.26	.09	.10	-.99	-.05
	Mean	.13	-.07	-.16	.10	.09	-.93	-.05
Labor	Low	.74	.29	.82	.76	.57	.75	.16
	Middle	.43	.29	.97	.52	.33	.52	.22
	High	.19	.20	.78	.35	.26	.50	.38
	Mean	.37	.21	.82	.50	.36	.57	.26

[1] Sum of uncompensated quantity elasticities and profit effects in elasticity form. Assumes proportional sales and purchase prices.

the higher profit effect for these households. In the other cases the short run responsiveness, holding profits constant, to own price is much greater and overwhelms the profit effect. However, the profit effect does have the interesting consequence that the total own price elasticities for several commodities such as rice, oils and fats, and fish and animal products no longer drop in absolute value with higher expenditure levels. Indeed, for rice the total own price elasticity is as low for low expenditure households as for high expenditure households. For root crops and other cereals, the negative response of consumption to own price is greater for high than for middle expenditure households. As seen in Table VI.3 this is mostly a result of the uncompensated (profits constant) price elasticities being higher in aboslute value for the high expenditure group. Secondarily, the profit effects are slightly higher for the middle than for the high expenditure group. For household labor supply the response to wage is now positive at all expenditure levels, rising to almost .4 for high expenditure households and being roughly .25 at the sample mean. The fact that this still rises with the higher expenditure group is due to the classical demand substitution effects rising with expenditure as explained in Working Paper 14, p. 27.

In general, the total cross price effects are positive. Negative classical demand income effects are reversed in sign by the profit effects. The exceptions are for root crops and other cereals and oils and fats consumption with respect to nonfoods price, and for those two commodities with respect to rice price for the high expenditure group (and sample mean for root crops and other cereals). Some of the positive cross price elasticities are of large magnitude, for example, oils and fats consumption with respect to the price of root crops and other cereals. However, in general the cross price responsiveness declines with higher expenditure, as the profit effects do, and is not large when evaluated at the sample mean. For labor supply the cross price effects are negative, due to the profit effect. The cross effects with respect to wage rate are cut substantially from the effects when profits are held constant, but remain positive and non-negligible. Rises in the wage rate increase total income by increasing the value of time available to the household, but decrease total income by decreasing the profit component. Evidently, the former effect is the dominant one because the positive income effect, found by subtracting the income compensated from the uncompensated elasticities, is larger in absolute value than the negative profits effect.

Effects of Fixed Inputs

Prices are not the only exogenous variables in our household-firm model in which we are interested. The effect of changes in household characteristic variables on consumption was examined in Working Paper 14. Since these variables do not enter into the production side those are the total effects. On the production side, we can look at changes in consumption due to the profit effect of changes in fixed inputs. In elasticity form we have $\frac{Z_j}{X_i^c}\frac{\partial X_i^c}{\partial \pi}\frac{\partial E(\pi)}{\partial Z_j}$, where z_j is either total land acreage or value of capital flow. These elasticities are reported in Table VI.5. The elasticities with respect to capital flow are larger than those with respect to land because the term $\frac{Z\partial E(\pi)}{\partial Z}$ is larger for capital than for land. This is a reflection of the higher expected quantity output elasticities with respect to capital as was reported in Section V. As with the profit effects due to changes in prices, those profit effects are larger at lower expenditure levels, and for the same reasons. Also, they tend to be larger for commodities having

Table VI.5

Quantity Elasticities with Respect to Fixed Inputs[1] by Expenditure Group

Commodity	Expenditure Group	With Respect To	Total Land Cultivated	Value of Capital Flow
Rice	Low		.08	.43
	Middle		.01	.06
	High		.01E-1	.04E-1
	Mean		.01	.04
Root Crops and Other Cereals	Low		.06	.33
	Middle		.02	.08
	High		.01	.05
	Mean		.01	.06
Oils and Fats	Low		.15	.76
	Middle		.04	.23
	High		.04	.19
	Mean		.04	.20
Fish and Animal Products	Low		.09	.48
	Middle		.02	.08
	High		.08E-1	.04
	Mean		.01	.07
Miscellaneous Foods	Low		.07	.35
	Middle		.01	.05
	High		.04E-1	.02
	Mean		.01	.05
Nonfoods	Low		.09	.50
	Middle		.02	.09
	High		.01	.08
	Mean		.02	.10
Household Labor	Low		-.03	-.17
	Middle		-.01	-.05
	High		-.01	-.05
	Mean		-.01	-.05

[1]Calculated as $\frac{Z_j}{X_i^c} \frac{\partial X_i^c}{\partial \pi} \frac{\partial E(\pi)}{\partial Z_j}$, where Z_j is either acres of total land cultivated or Leones of capital flow.

larger marginal expenditures out of total income. The magnitudes of the elasticities are low, all being less than .05 at the sample mean with respect to land, and .20 or less with respect to capital. It should be remembered that these elasticities reflect an autonomous change in these variables. In the longer run in which capital and total land can be varied, the elasticities of consumption with respect to price of capital and to price of land will not correspond to these short run figures.

Marketed Surplus Price Elasticities

We now have the total price elasticities of consumption of commodities and of labor supply. There are many questions which can be explored using these. One such is what happens to quantities sold or bought on the market when price changes and households have had a chance to adjust their production patterns as well as consumption. The response to price of marketed surplus, which can be either positive or negative, is an important question to governments interested in supplies to urban areas and to other rural areas. There is a very large literature on this both theoretical (for example, Krishna, 1962; and Dixit, 1969) and empirical (e.g., Behrman, 1966; and Medani, 1975, 1980). A review is provided by Newman (1977).

Some empirical studies have not had data on consumption and production available separately. They used a reduced form and found the marketed surplus of subsistence crops negatively related to own price. In doing so many simplifications were made. For example, Behrman (1966) assumed zero expenditure and price elasticities of demand and Haessel (1975) assumed that production was fixed. Our data permit direct derivation of the elasticities of marketed surplus.

The only previous study to compute these elasticities from a structural household-firm model is by Lau, Lin and Yotopoulos (1978) they used only one aggregate agricultural commodity. Let $MS_i \equiv$ marketed surplus of commodity i. We have $MS_i = X_i - X_i^c$. Given our data construction marketed surplus includes net sales plus wages paid in kind minus wages received in kind. Then $\frac{\partial MS_i}{\partial p_j} = \frac{\partial X_i}{\partial p_j} - \frac{\partial X_i^c}{\partial p_j}$ and in elasticity form

$$(8.3) \quad \frac{p_j}{|MS_i|}\frac{\partial MS_i}{\partial p_j} = \frac{X_i}{|MS_i|}\frac{p_j}{X_i}\frac{\partial X_i}{\partial p_j} - \frac{X_i^c}{|MS_i|}\frac{p_j}{X_i^c}\frac{\partial X_i^c}{\partial p_j}$$

The elasticity of marketed surplus is then a weighted difference of output elasticities and of total price elasticities of quantities consumed. The weights are the ratio of quantity produced to surplus, for production, and quantity consumed to surplus, for consumption. Given our Tobit estimation of the production side, we use $\frac{\partial E(X_i)}{\partial p_j}$ in the first term. Also, the divisor is the absolute value of marketed surplus. This is used so that one can easily tell the sign of $\frac{\partial MS_i}{\partial p_j}$, that is whether production increases more or less than consumption.

In the sign of the elasticity is positive and the net surplus is positive, then an increase in price will result in more being sold on the market. If the elasticity is positive and the household is a net purchaser (a negative surplus), then an increase in price will lead to less being purchased on the market. A negative elasticity and a positive surplus will lead to less being sold to the market and negative elasticity and a negative surplus means more will be purchased. We continue to assume proportional sales and purchase prices.

As Krishna pointed out, the magnitudes of the own price marketed surplus elasticites may be a good deal higher than the output elasticities if production is very much larger than surplus. Providing the total own price elasticities of consumption are negative, these will reinforce the effect of increasing production, further increasing the marketed surplus elasticity. Indeed, the only way in which this measure can be negative is for the total own price elasticity to be sufficiently positive and the ratio of consumption to marketed surplus be large enough so that their product outweighs the effect of increasing production. Given our total price elasticities this will only be possible for root crops and other cereals for low expenditure households.

The matrix of marketed surplus price elasticities is shown in Table VI.6. All the own price elasticities are positive and reasonably high. There is a tendency for the price responsiveness of marketed surplus to decline at higher expenditure levels. In large part this is due to the absolute value of marketed surplus, part of the denominator, increasing with higher expenditure levels (see Table IV.2). The marketed surplus being low is the reason for the high magnitude of the own price elasticity for root crops and other cereals for low expenditure households. If absolute changes in kilograms marketed due to a one-percent increase in price were shown they would be roughly equal for the low and middle expenditure groups, rising for the high expenditure group. For household labor the large values of the marketed surplus elasticity with respect to wage rate are also caused by the small values of marketed surplus in the denominator.

The cross price elasticities of marketed surplus tend to be negative because of the strong profit effect in the cross total price elasticity of demand. The latter term is generally positive and often large. Since it is subtracted, after being weighted appropriately, from a generally small positive cross price effect on production, the difference will usually be negative. For example, an increasing price of root crops and other cereals will lead to a decrease in the marketed surplus of oils and fats. That is, sales of oils and fats will decrease. Also, a decrease in the marketed

Table VI.6

Price Elasticities of Marketed Surplus[1] by Expenditure Group

With Respect to Price of	For Expenditure Group OF	Rice	Root Crops and Other Cereals	Oils and Fats	Fish and Animal Products	Miscellaneous Foods	Nonfoods	Household Labor
Rice	Low	.89	.66	-.32	-1.05	-.47	-1.00	-18.45
	Middle	.73	.05	-.04	-.23	-.09	-.17	-5.74
	High	.75	.04	.09	-.12	-.03	-.08	-1.31
	Mean	.71	.06	-.03	-.72	-.05	-.15	-4.42
Root crops and other cereals	Low	-.11	3.10	-.31	-.70	-.34	-.58	-7.53
	Middle	-.09	.37	-.17	-.23	-.09	-.21	-5.54
	High	.02	.39	-.40	-.10	.02	-.25	-3.09
	Mean	-.08	.46	-.29	-.73	-.04	-.27	-6.61
Oils and fats	Low	-.08	.06	.79	-.58	-.27	-.50	-7.09
	Middle	-.07	-.01	.29	-.19	-.07	-.14	-2.56
	High	-.02E-1	-.01	.78	-.04	-.07E-1	-.09	-.58
	Mean	-.05	-.02	.44	-.44	-.04	-.14	-2.35
Fish and animal products	Low	-.18	.04	-.41	2.15	-.56	-.86	-10.84
	Middle	-.22	.03	-.29	1.81	-.22	-.43	-10.56
	High	-.09	.02	-.21	1.33	-.01	-.21	-2.56
	Mean	-.16	.02	-.33	5.94	-.08	-.38	-8.80
Miscellaneous foods	Low	-.05	.11	-.09	-.32	1.97	-.27	-4.22
	Middle	-.06	.03	-.06	-.13	1.29	-.12	-3.77
	High	-.06	.03	-.05	-.07	.49	-.08	-1.36
	Mean	-.06	.04	-.08	-.34	.81	-.12	-3.44
Nonfoods	Low	-.07	.08	.03E-1	-.30	-.17	1.12	-1.59
	Middle	-.09	.02	.06	-.14	-.09	.88	-1.24
	High	-.21	.04	.19	-.12	-.04	1.08	-.80
	Mean	-.12	.04	.09	-.52	-.06	1.01	-1.85
Labor	Low	-1.22	-9.45	-1.49	-3.30	-2.37	-.83	27.41
	Middle	-.58	-.60	-.37	-2.02	-1.29	-.56	16.41
	High	-.42	-.54	-.58	-.93	-.44	-.55	8.57
	Mean	-.49	-.72	-.51	-5.82	-.78	-.62	17.18

[1]Calculated as $\frac{X_i}{|MS_i|} \frac{p_j}{X_i} \frac{\partial E(X_i)}{\partial p_j} - \frac{X_i^c}{|MS_i|} \frac{p_j}{X_i^c} \frac{\partial X_i^c}{\partial p_j}$ and assuming proportional sales and purchase prices.

surplus of nonfoods will take place. However, since nonfoods are purchased on the market (the surplus is negative) the decrease in marketed surplus means that more will be purchased on the market.

Some positive cross price elasticities exist. For example, the surplus for root crops and other cereals responds positively to all prices except for oils and fats and the wage rate. Also, the surplus for oils and fats responds positively to nonfoods price.

Some of the magnitudes of the cross price elasticities are fairly large. Again this is caused by the strong profit effect on consumption. The magnitudes do tend to fall with the higher expenditure groups, as they do for the own price elasticities. They are not negligible, however, so it is not wise to ignore them as most past studies have done.

Effects of Prices and Expenditure on Caloric Availability

This study is concerned ultimately with determinants of food consumption. This can be further translated into effects of prices and other variables in our model on availability to the household of different nutrients. Of greatest interest to development economists recently is caloric availability. Sukhatme's (1970) work indicating that sufficient caloric intake is usually accompanied by sufficient protein intake and caloric deficiencies with protein deficiencies is partly responsible for this attitude.

More germane to this study, UCLA's (1978) study of the nutritional situation in Sierra Leone, based on anthropometric data, found that chronic malnutrition (underweight for age) was the principal nutritional problem of children aged 0-5 years. The little evidence which exists for other groups, principally pregnant and lactating women, also suggests that being underweight is the major problem. In view of these findings, only the impact on calories will be examined here, although one can in principle use our results to examine the impact of socio-economic variables on many nutrients.

We want to calculate $\frac{\partial cal}{\partial p_j} = \sum_{i=1}^{5} \frac{\partial cal}{\partial X_i^c} \frac{\partial X_i^c}{\partial p_j}$, where cal≡calories and 1-5 are our food groups. In elasticity form we want $\frac{p_j}{cal} \frac{\partial cal}{\partial p_j} = \frac{1}{cal} \sum_{i=1}^{5} \frac{\partial cal}{\partial X_i^c} \frac{p_j \partial X_i^c}{\partial p_j}$. We calculate effects on calories of price changes both when profits are constant and when they are variable. The difference will point out clearly the effect of allowing families to adjust their production patterns. In addition, the results from holding profits constant will be useful since they correspond to a short run situation which might be found at times.

Elasticities of caloric availability with respect to total expenditure are reported in Table VI.7.[6] Total expenditure, as opposed to total income, is endogenous in our model, but the results will still be of interest. The magnitudes are around .85 with little variation among expenditure groups. That the elasticity for the high expenditure group is slightly higher than for the low expenditure group is because the marginal total expenditure share of oils and fats, an important contributor of calories, rises with the expenditure group. This apparently offsets the declining total expenditure share on rice. The elasticity magnitudes we report compare to a range of .15 to .30 used by Reutlinger and Selowsky (1976). They believed .15 and .3 to be bounds on the calorie elasticity with respect to income.

TABLE VI.7

Elasticities of Calorie Availability with Respect to Total Expenditure[1] by Expenditure Group

Expenditure Group			
Low	Middle	High	Mean
.85	.83	.93	.86

[1]Calculated as $\frac{TEXP}{CAL} \Sigma \frac{\partial Cal}{\partial X_i^c} \frac{\partial E(X_i^c)}{\partial TEXP}$ (see Table VI.1 for $\frac{\partial E(p_i X_i^c)}{\partial TEXP}$).

Our estimates of the total expenditure elasticity of calorie availability are much closer to those of Pinstrup-Anderson and Caicedo (1978). They estimate Engel curves from cross section household data in Colombia and find a calorie elasticity with respect to income of over .5 ranging to over .6 for low income households.

Tables VI.8 and VI.9 report caloric elasticities with respect to prices with profits held constant (VI.8) and allowed to vary (VI.9). In the very short run, profits being constant, increases of commodity prices results in decreased caloric availability, except with respect to nonfoods price at the low expenditure group. There is no general pattern of elasticities across expenditure group, but the absolute change in caloric availability often increases with expenditure group. For commodity prices the largest response of caloric availability is for changes in the price of rice, the major staple. These range from -.58 to -.28. This is a rather large impact, suggesting short run nutritional vulnerability of rural households to rice price increases.

For absolute changes in caloric availability the largest annual change, of -19,000 calories, occurs for an average household when rice price changes.

Table VI.8

Elasticities of Calorie Availability with Respect to Price, Profits Constant[1] by Expenditure Group

With Respect to Price of:	Expenditure Group	Change in Calories[2] (x 1000)	Elasticity
Rice	Low	-11.9	-.58
	Middle	-18.5	-.38
	High	-23.2	-.28
	Mean	-19.1	-.38
Root Crops and Other Cereals	Low	-0.7	-.03
	Middle	-2.1	-.04
	High	-5.2	-.06
	Mean	-2.3	-.05
Oils and Fats	Low	-1.5	-.07
	Middle	-6.0	-.12
	High	-20.9	-.25
	Mean	-7.4	-.15
Fish and Animal Products	Low	-3.9	-.19
	Middle	-4.0	-.08
	High	-6.9	-.08
	Mean	-4.2	-.08
Miscellaneous Foods	Low	-1.5	-.07
	Middle	-4.4	-.09
	High	-6.3	-.08
	Mean	-4.2	-.08
Nonfoods	Low	0.2	.08E-1
	Middle	-1.1	-.02
	High	-1.9	-.02
	Mean	-0.9	-.02
Labor	Low	23.0	1.12
	Middle	28.0	.57
	High	36.5	.45
	Mean	28.1	.56

[1]Calculated as $\frac{p_j}{cal} \sum_i \frac{\partial cal}{\partial X_i^c} \frac{\partial E(X_i^c)}{\partial p_j} \Big|_{d\pi=0}$ at expenditure group means.

[2]Change in kilocalorie availability due to infinitesimal percentage change in price, $\frac{p_j}{100} \sum_i \frac{\partial kcal}{\partial X_i^c} \frac{\partial E(X_i^c)}{\partial p_j} \Big|_{d\pi=0}$.

Table VI.9

Elasticities of Calorie Availability with Respect to Prices, Profits Variable[1] by Expenditure Group

With Respect to Price of:	Expenditure Group	Changes in Calories[2] (x 1000)	Elasticity
Rice	Low	3.9	.19
	Middle	-11.7	-.24
	High	-16.7	-.20
	Mean	-12.8	-.26
Root Crops and Other Cereals	Low	8.8	.43
	Middle	6.4	.13
	High	8.6	.11
	Mean	7.5	.15
Oils and Fats	Low	5.5	.27
	Middle	-1.4	-.03
	High	-16.9	-.21
	Mean	-3.0	-.06
Fish and Animal Products	Low	9.8	.48
	Middle	11.5	.23
	High	3.9	.05
	Mean	8.8	.18
Miscellaneous Foods	Low	2.9	.14
	Middle	0.6	.01
	High	-0.8	-.01
	Mean	0.3	.07E-1
Nonfoods	Low	2.6	.12
	Middle	1.5	.03
	High	1.1	.01
	Mean	1.9	.04
Labor	Low	12.2	.59
	Middle	19.8	.40
	High	27.3	.33
	Mean	20.3	.41

[1]Calculated as $\frac{p_j}{cal} \sum_i \frac{\partial cal}{\partial X_i^c} \frac{\partial E(X_i^c)}{\partial p_j}$ assuming proportional sales and purchase prices.

[2]Change in kilocalorie availability due to one percent change in price, $\frac{p_j}{100} \sum_i \frac{\partial kcal}{\partial X_i^c} \frac{\partial E(X_i^c)}{\partial p_j}$.

This change translates into a change of slightly under -52 calories per household per day, or roughly -8 calories per capita per day, (using the mean household size of 6.5 persons).

When profits can vary the situation changes substantially. Now most of the commodity price elasticities of calories are positive. Increasing price may result in decreased consumption of that good, but the expected increase in total income is distributed on increases in consumption of other foods, enough so to increase total caloric availability. The exceptions to this are for rice and oils and fats prices at all but the low expenditure group, and for the price of miscellaneous foods at the high expenditure group. The magnitudes of the positive elasticities are not high for the sample mean, but some are sizable for the low expenditure group. Even absolute changes in calorie availability tend to decline as expenditure group rises except for changes in the prices of rice, oils and fats, and labor.

For all commodities the positive effect of a change in price with profits variable is greatest for low expenditure households, reflecting the fact that for every commodity own-price profit effects are greatest among such households. For rice and for oils and fats it is _only_ for low expenditure households that the profit effect is large enough to dominate the negative own-price effects upon calorie availability with profits constant. (This is partially because in the middle and high expenditure households the negative own-price effects--profits constant--are stronger for rice and for oils and fats than for other commodities.)

While caloric availability increases for low expenditure households, with changes in rice and in oils and fats prices, it decreases for middle and high expenditure households, and at the sample mean. For rice price the elasticities for the two higher expenditure groups are still sizably negative, between -.2 and -.25. Hence, when profit effects are accounted for, rice price increases seem to lessen the discrepancy in calories available to the rural expenditure groups. They increase availability for very low expenditure households and decrease availability for higher expenditure households. From Table B.1 we see that the mean daily caloric availability per capita for high expenditure households is quite high (2600 calories). Although some households in this group will have caloric availability lower than the mean, it may be that lower availability will still allow these households to have available sufficient calories for weight maintenance under "normal" activity levels.

These results have significant implications for the development process in Sierra Leone and for future modeling of this kind. First, we state the obvious: prices and total income affect household caloric availability, although the ability of the household adapt its production pattern mitigates this effect. Response by the households in its role as a firm does make a difference. Secondly, for the representative low expenditure household to have caloric availability even at the level of 1900 calories per capita per day (see Table B.1) would require increases in income of a magnitude not likely to occur anytime soon. With prices and household characteristics constant, an average low expenditure household would need an increase in annual total income of about 270 Leones to reach the availability level of 1900 calories per capita per day. This new level of total income would result in total expenditures of roughly 445 Leones. That figure is 88 percent higher than the existing expenditure level of the representative low expenditure household--237 Leones. Assuming, optimistically, an annual growth rate in total expenditures of three percent, it would take nearly 22 years for an average low expenditure family to reach this point. Of course, if family size grew along with total expenditure, which is likely, even longer would be needed.

Caution is needed here. Caloric availability at the household level says little about intake of individuals. For example, one of the variables in our model is household labor supplied, of which one part is labor supplied by lactating women. If, with increasing household total income, lactating women spend more time at home breastfeeding infants, the caloric intake of infants may increase more than suggested by total household availability. As another example, food waste may be influenced by variables such as total income.

Trade-Off between Secular Growth and Short Run Nutritional Status

The price responsiveness, especially with respect to rice price, of food availability and ultimately of calorie availability implies that there is a trade-off to be made between long run output growth and short run nutritional status. A secularly rising price of rice may lead to increased output levels, and possibly to increased growth rates if technical change is endogenous, but will lower caloric availability of many rural households. Very low expenditure households may enjoy some nutritional benefits from such a rise. Of course, in the long run households may invest in more capital (some embodying technical progress perhaps) and in more land. This would presumably be one result of a secular rise in rice price. As shown in Table VI.5 this will increase quantities of food availability, hence of calorie availability. Whether this would offset the decreasing caloric availability due to increasing price will depend on how much capital and land increase. At the sample mean the elasticity of caloric availability with respect to quantity of capital flow is .07. This is roughly one fourth the elasticity with respect to rice price. However, when both change there is an interaction effect and both elasticities will change also. Nevertheless, it would seem that capital (or a combination of capital and technical change if the latter is capital augmenting) would have to increase more relatively than price for there not to be a net negative effect on caloric availability for a representative rural household.

In the longer run, rice price may be lower than otherwise if production growth has been stimulated. Distributional impacts of technical change have long been debated. Questions of access to technology cannot be addressed by these research results. However, differential price effects of technical change may be addressed. Most producers in rural areas would seem to be helped nutritionally by rice price being lower than if otherwise might be. However, those lowest expenditure households who are nutritionally worst off (see Table B.1) may be hurt unless they participate in the technical change sufficiently so that the autonomous increase in total income due to the technical change is enough to offset the lowered caloric availability due to a rice price lower than otherwise. These effects of price changes due to technical change are somewhat different from those generally postulated in the literature. Distributional impacts have been limited to examining the impact on pure consumers and on pure producers. Hayami and Herdt (1974) examine the impact on each with producers selling a portion of the crop (rice) to the market. However, consumption out of home production is assumed to be completely price inelastic and since purchases are ignored, total consumption of rice is assumed price inelastic. This enables them to examine the impact only on cash income. In their model a decline in rice price reduces cash income, hence welfare, but differentially depending on the proportion marketed. In our model total income, not cash income, matters, and consumption of rice is affected by price changes, though the decomposition of changes on consumption of home produced versus changes in consumption of purchased rice is not identified. Nevertheless, the price impact of technical change can now be positive on rural rice producing households, and is for representative households of all but the lowest expenditure group.

Rice Self-Sufficiency Impact on Caloric Availability

Another major policy thrust which may involve long run versus short run trade-offs is attempting to obtain self-sufficiency in rice. Whether this policy is wise using static comparative advantage criteria is not at issue here. If, however, domestic rice prices are raised over c.i.f. Freetown plus transportation cost levels, there would seem to be an adverse short run impact on calorie availability for all but very low expenditure rural households (and a presumably adverse impact on urban households also). If, in the longer run, a higher domestic rice price is only temporary and promotes an increasing level (and possibly growth rate) of rice production, then this adverse short run nutritional impact may lead to a positive long run impact. Exactly what the magnitudes might be will depend upon how much domestic prices are raised, and what effect that has on future supplies.

Export Promotion and Relation between Market Orientation and Calorie Availability

A related trade policy question is to what extent to promote exports of cash crops such as palm oil, coffee and cocoa. Some have argued that increasing the production of cash crops at the expense of subsistence crops will have an adverse impact on nutritional status. Such persons argue that less orientation toward the market will result in better nutrition. In our household-firm model marketed surplus is endogenous, being simultaneously determined with production and consumption. As an endogenous variable it is affected by many exogenous variables. Hence, it stands to reason that one exogenous variable will affect marketed surplus and consumption differently than another, so that the relationship between marketed surplus and consumption should not be of only one kind. Hence in principle it need not be true that increased reliance on the market leads to worse nutritional status.

Looking at our results, if we examine oils and fats, of which palm products are the lion's share in value, an increase in own price results in decreased calorie availability for high and middle expenditure groups but increased availability for the low expenditure group. Marketed surplus increases for all groups. Hence increased reliance on the market for oils and fats as a consequence of a rise in oils and fats price results in higher caloric availability for a typical low expenditure household, but lower caloric availability for typical middle and high expenditure households.

As another example, an increase in capital flow actually decreases the marketed surplus of oils and fats for the sample mean, and as seen from Table VI.5 it increases consumption for all foods. Hence calorie availability is increased in this case.

Alternatively, an increase in rice price decreases the marketed surplus of oils and fats for the low and middle expenditure groups (Table VI.6.) Such an increase in rice price will lead to increased calorie availability for the low expenditure group and decreased availability for the middle expenditure group. Hence for an increase in rice price, lower reliance on the market for oils and fats is accompanied by lower calorie availability for a representative middle expenditure household. This is contrary to the relationship of ten hypothesized. However for low expenditure households decreased market reliance is associated with higher calorie availability when the source of the change is an increase in rice price. Note that the relationships for low and middle expenditure households between the direction of change of marketed surplus of oils and fats and of calorie availability are different when they are a result of changed rice price than when they result from a changed price of oils and fats. This is in accordance with the general proposition advanced earlier that the relation between two endogenous variables will depend upon what exogenous variable is changed.

When the expected relationship of greater market reliance coinciding with reduced caloric availability does occur, the sources of this relationship turn out to be the opposite of the sources which have heretofore been suggested. More, not less, is consumed of rice and root crops and other cereals when the price of oils and fats increases (Table VI.4). This is primarily due to the profit effect in increasing total income. As a result, less is marketed of these foods, while less, not more, is consumed of oils and fats. It is that reduction in consumption which is the source of lowered caloric availability. In addition, more is produced of rice and of root crops and other cereals (see Table V.1), not less, when the price of oils and fats increases. This occurs because land area cannot be productively switched in the short run to oil palm production since it takes time for palm trees to grow. Labor can be reallocated to harvesting fruit from wild trees, but an increase in output prices increases the total amount of labor used in production, and some of this is allocated to increasing rice and root crop and other cereal production. Even in the longer run when more land reallocation takes place, perhaps reducing subsistence crop production, total income increases even more and some of that will be allocated to increased consumption of foods, increasing caloric availability.

When the price of rice increases, oils and fats consumption goes up and

and rice consumption decreases. For the low expenditure group a reduction in reliance on the market for the oils and fats due to rice price changes results in the expected increase in caloric availability, but again for different reasons than commonly assumed. In this case calorie availability increases because enough additional oils and fats, as well as other commodities, are consumed to offset the reduced consumption of rice.

VII. RELATIONSHIP OF RESEARCH TO PAST EMPIRICAL WORK

Lau, Lin and Yotopoulos (1976) estimated a profit function and input demand function using a Cobb-Douglas production function for an aggregate agricultural output. Their data were averages in each of two years of household data grouped by size of operation in Taiwan. They then used these data to estimate a Linear Logarithmic Expenditure System (1978) using aggregate agricultural (in kind) and nonagricultural (in cash) commodities, and leisure, as commodity definitions. This system assumes homogeneity of degree minus one in the indirect utility function resulting in expenditure elasticities with respect to total income being one for each group. They estimate the system using seemingly unrelated regressions with cross equation restrictions. In this case, which is not maximum likelihood estimation, parameter estimates are not invariant to the equation not estimated. Using both sets of estimates, they compute elasticities of marketed surplus as well as of quantities consumed.

Barnum and Squire (1979) use a Linear Expenditure System on the demand side with rice, a nonagricultural good and leisure as commodities. (The households practiced monoculture). On the production side, they use a Cobb-Douglas production function for a single agricultural commodity, which they estimate directly. Their data were from a cross section of households in Malaysia, exhibiting price variation only for labor. Their procedure in obtaining the LES parameter estimates is unusual and the statistical properties of their estimates aside from consistency are unclear.[7]

Singh and Squire (1978) pursue the results of Barnum and Squire. In addition, they propose using linear programming for the production side of the model, to extend it to multicrop households. Ahn, Singh and Squire (1980) do so using cross section household data from South Korea. They use six commodities, including four foods: rice, barley, other farm produce and market purchased foods. They use an LES, using the same estimation procedure as did Barnum and Squire. Use of linear programming on the production side allows more easily for commodity disaggregation on that side. Also, it easily handles the problem of specialization since it is a deterministic model. Further, risk can easily be incorporated into it. One disadvantage stems from its determinateness; statistical tests cannot be performed. In addition, one cannot get income group specific results without redoing the analysis for representative farms from each group. Nevertheless, the idea is worth exploring further.

The empirical results from these studies are reported only at the sample mean. Lau, Lin and Yotopoulos report an own price elasticity of -.72 for their agricultural commodity, profits being held constant, and a total own price elasticity of .22. They find that the marketed surplus of the agricultural good responds positively to own price with an elasticity of about 1. The Malaysian and Korean studies find a very small own price elasticity for rice holding profits constant -.04 and -.18 respectively. The total own price elasticities--profits variable--reported in these two studies are .38 and .01 respectively. Hence, all these studies find that for the agricultural good profit effects outweigh negative own price effects holding profits constant. This is not generally confirmed for our data. The magnitudes of own price elasticities found in the Malaysia and Korean studies are much lower than we find, except for root crops and other cereals. The Malaysian figure seems particularly low.

The average income of farmers studied in Korea and Taiwan is much higher than that of farmers studied in Sierra Leone. That higher income farmers should have smaller own price elasticities for staples is not so surprising; indeed, it is confirmed in our results for rice.

On the production side, this is the first work to apply the Tobit model to a multiple output production function. Heretofore, the only method used to account for specialization was mathematical programming. On the demand side Wales and Woodland (1978, 1979) have used the multivariate Tobit model without assuming independent error terms, but only for three commodities.

In sum, our research has shown that cross section household data can be successfully used to estimate price as well as income relationships of demand. This can be done using functional forms allowing for a wide variety of behavior, and it can be done for several commodities. The same holds true for the production side with the addition that zero outputs can be statistically handled in a proper way, provided certain simplifying assumptions are made. We have further shown that accounting for a household's ability to change its production patterns in response to changing prices makes an important difference in predicting its consumption behavior.

NOTES

[1]The rental markets are very thin and rental prices reflect a household's standing in the community as much as the economic value of the land, Spencer and Byerlee, 1977, pp. 21-24.

[2]The system was also estimated in value form. If the error terms appended to the quantity form are homoskedastic, then those added to the value form are not; and vica versa. Tests of homoskedasticity were performed for each form of the system estimates. For the value form homoskedastic error terms were clearly rejected. For the quantity form the evidence is mixed. In addition, the own price supply response can be negative when computed from estimates of the system in value form. This is so despite the fact that the CET-CD functional form constrains such responses to be positive. The reason is that the expected quantity of output is a function of the standard error as well as the mean of the uncensored distribution (see Note 3). If the standard errors of the error terms on the value form are σ_i, then on the quantity form they are σ_i/p_i. As p_i increases σ_i/p_i decreases. If this term decreases fast enough the response of expected output to own price can be negative. Indeed this was so for our estimates. (For details see Strauss, 1981, Chapter 7).

[3]This is so since $E(X_i) = F(\frac{g_i(\beta)}{p_i\omega_i})\ \frac{g_i(\beta)}{p_i} + \omega_i f(\frac{g_i(\beta)}{p_i\omega_i})$.

[4]The palm products produced by the sample households came almost entirely from wild oil palm trees. (Spencer, Byerlee and Franzel, 1979, p. 30.)

[5]For instance, the mean ratio of consumption to sales price for root crops and other cereals is 3.8. The meaning of these ratios for our purposes is that if we alternatively assume a constant marketing margin, then a one

percent increase in consumption price would mean that sales price increases by more than one percent. For root crops and other cereals an increase of one percent in average consumption price for the middle expenditure group would imply a 5.5 percent increase in sales price for that group. This would result in a rather large profit effect. Worse yet, the percentage increases in sales prices would be different for different groups so that reading a table of profit effects as elasticities would be quite misleading.

[6]Conversion factors from Kilograms of foods into calories are reported and discussed in Appendix B.

[7]For details see Strauss (1981). Chapter 9.

APPENDIX A

TABLES

Table A.1

Components of Commodities

Commodity-Subgroup	No.	Components
Rice	1	
Root crops and other cereals	2	
Root crops		Cassava (including gari, foofoo and cassava bread), Yam, Water Yam, Chinese Yam, Cocoyam, Sweet potato, Ginger, Unspecified
Other cereals		Benniseed, Fundi, Millet, Maize (shelled), Sorghum, Agidi,[1] Biscuits (Natco)[1]
Oils and Fats	3	Palm oil, Palm kernel oil, Palm kernels,[2] Groundnut oil,[1] Coconut oil, Cocoa butter, Margarine,[1] Cooking oil,[1] Unspecified[1]
Fish and animal products	4	
Fish		Bonga (fresh), Bonga (dried),[1] Other saltwater (fresh), Other saltwater (dried),[1] Frozen fish,[1] Freshwater (fresh),[1] Tinned fish[1]
Animal products		Beef, Pork,[1] Goats and sheep (dressed), Poultry (dressed), Dear (dressed), Wild bird (dressed), Bush meat (dressed), Cow milk, Milk (tinned),[1] Eggs, Honey bee output, Unspecified[1]
Miscellaneous foods	5	
Legumes		Groundnuts (shelled), Blackeyed bean (shelled), Broadbean (shelled), Pigeon pea (shelled), Soybean (shelled), Green bean (in shell), Unspecified (shelled)
Vegetables		Onions, Okra, Peppers and Chillies, Cabbage, Eggplant, Greens, Jakato, Pumpkin, Tomato, Tomato paste,[1] Watermelon, Cucumber, Egusi, Other
Fruits		Orange, Lemon, Pineapple, Banana, Plantain, Avocado, Pawpaw, Mango, Guava, Breadfruit, Coconut, Unspecified
Salt and other condiments		Salt,[1] Sugar,[1] Maggicubes,[1] Unspecified[1]
Kolanut		
Nonalcoholic beverages		Coffee, Tea,[1] Soft drinks (bottled),[1] Ginger beer (local)[1]
Alcoholic beverages		Palm wine, Raffia wine, Beer (Star and Heineken),[1] Omole,[1] Gin (local), Liquor (Rum, etc.)[1]
Nonfoods	6	Clothing, Cloth, Fuel and light, Metal work, Woodwork, Other household and personal goods, Transport, Services and ceremonial, Education, Local saving, Tobacco products, Miscellaneous
Household labor	7	All farm and nonfarm production and marketing activities (for labor demand, work on processed agricultural products excluded), Labor sold out.[1] Excludes household activities such as food preparation, child care and ceremonies

[1]Commodity is not included in production figures for use in estimating system of output supplies and labor demand either because it is only purchased or because it is a more processed form of a commodity already counted.

[2]Not included in consumption data but included in production data.

Table A.2

Coefficients and Asymptotic Standard Errors of CET-CD System in Quantity Form[1]

Parameter[2]	Coefficient	Standard Error[3]
δ_{10}	.14E-5	.96E-6
δ_{11}	.26E-2	.13E-1
δ_{20}	.96E-5	.95E-5
δ_{21}	.29E-4	.92E-4
δ_{30}	.16E-2	.15E-2
δ_{31}	12.7	134.8
δ_{40}	.131223E-2	.15E-2
δ_{41}	-.131218E-2	.15E-2
δ_{50}	.7319E-3	.60E-3
δ_{51}	-.7307E-3	.60E-3
δ_{60}	90.8	107.7
δ_{61}	-78.8	108.5
c	4.25	.3
β_D	.69E-1	.3E-1
β_K	.36	.29E-1
β_L	.35	.17E-1
ω_1	1,008.4	63.1
ω_2	2,635.2	171.5
ω_3	512.7	34.7
ω_4	1,066.5	95.9
ω_5	504.0	32.4
ω_6	88.1	7.3
ω_7	2,924.2	184.4
Value of log-likelihood function	-6,071.0	

[1]Uses EA 13 - Non-EA 13 dummy variable.

[2]Single subscripts refer to commodity number listed in Figure 4.1. Double subscripts refer to commodity number and 1 for dummy coefficient, 0 if not.

[3]From information matrix calculated from second derivatives of log-likelihood function.

Table A.3

Chi-Square Statistics From Wald Tests Using Estimates From CET-CD System in Quantity Form

Test of	Statistics	Degrees of Freedom
1. CET parameters for non-EA 13 households, δ_{i0}	3.6	6
2. CET dummy parameters, δ_{i1}	2.2	6
3. CET parameters for EA 13 households, $\delta_{i0} + \delta_{i1}$	2.4	6
4. Degree of almost homogeneity, $\beta_D+\beta_K+\beta_L$	37.6	1

APPENDIX B. CALORIC EQUIVALENTS OF FOOD GROUPS

Having determined the quantities available for consumption from home production and from market purchases, nutrient availabilities may be calculated by using conversion rates available from food composition tables. This was done by William Whelan using the FAO tables prepared for Africa (FAO, 1968). For this purpose, quantities purchased and available from home production were added without value weights for each of the 128 foods in our data. The nutritional composition of a food was thus assumed to be identical from either source. The conversion into nutrients accounted for the inedible portion of each food (using figures available from the food composition tables). What was derived, then, was the nutrients available from each food at the farm gate or retail level, taking out the inedible portion. Left in, however, is whatever part of the edible portion is wasted by the household before ingestion. This will vary greatly by household and by food. The FAO, in its calculations, assumes this to average 10 percent (FAO, 1973, pp. 87-8).

Table B.1 reports total caloric availability expressed per capita per day, and its sources by our five food groups for each of the expenditure groups. For this purpose caloric availability by food was summed into the five food groups and then totaled. Not surprisingly, caloric availability increases dramatically with expenditure group, particularly between the low and middle groups. The sample mean of 2109 cal/cap/day compares to an estimated availability of 2090 cal/cap/day computed by FAO from food balance sheets for the entire country for a 1972-74 average and a 1975-77 average (FAO, 1980, pp. A41). The availability calculated from food balance sheets covers urban as well as rural areas. It is formed by taking production,

Table B.1

Calorie Availability and Its Components
by Food Group by Expenditure Group

	Expenditure Group			
Calories from:	Low	Middle	High	Mean
Rice	.44	.45	.43	.44
Root crops & other cereals	.17	.17	.15	.16
Oils and fats	.12	.12	.20	.16
Fish and animal products	.17	.10	.10	.11
Miscellaneous foods	.11	.15	.11	.12
Total calories per cap per day	1,188	2,132	2,608	2,109

subtracting net exports, seed, feed, waste (storage and marketing), and net change of storage. The remaining figures are converted into units sold at retail level by further adjusting for processing. The FAO food balance sheet availability figures are comparable to ours, as is their caloric availability figure (which takes account of the inedible portion; FAO, 1972, p. 45).

To obtain the conversion from kilograms of our five food groups into calories, $\frac{\partial cal}{\partial X_i^c}$, we use the conversion factors available for each of our 128 foods from food composition tables. Within each food group we obtain the calories available for each household from each food in the group, by multiplying those conversion ratios by the sum of consumption out of home production and consumption from purchases. These figures are then summed over households and over all foods in the group. The sums are then divided by the total quantity consumed of each of the five food groups, where quantity is defined as total value of consumption divided by group price. These group quantities are weighted sums of quantities in straight kilograms. The weights are the ratio of the sales or purchase price of an individual food (depending on whether it was purchased or not) to the consumption price of the group. This weight will, of course, vary among the eight agro-climatic regions to which prices correspond. The numerator, calorie availability, will also vary by household, because the components consumed within each food group vary. In other words, from a nutritional perspective, the aggregated commodity groups correspond to different commodities depending on the region and on the household. Heretofore, we have assumed that the commodities were identical for all households. For our previous economic analysis this last assumption makes sense. Now, however, it does not. Since we want to apply the caloric conversions to low, middle and high expenditure household groups separately, we calculate separate conversions for each group. The conversions may differ between groups for two reasons. First, the weights in calculating quantities for the denominator differ by region, particularly for root crops and other cereals. Second, the proportion of calories available for each food group from each of its components will differ by expenditure group. If we want to ask what would the effect of price changes be on caloric availability for a "typical" low expenditure household in our sample it makes sense to use caloric conversions specific to that group.

Caloric conversion rates are reported in Table B.2. The magnitudes for rice and for oils and fats do not require explanation, but the rest do. Comparing these rates to rates available for disaggregated foods in food composition tables shows large differences. For root crops and other cereals, cassava was assumed to have 1490 calories per kilogram and sorghum, 3420. These are the two major components of this group, yet both their calorie conversion rates are substantially below the sample mean group rate of 7506 calories per kilogram. The reason for this follows: The numerator in our calculation is the best estimate of actual calories available for our sample from the particular group. If we had divided this by the simple sum of kilograms consumed of the components of the root crops and other cereals group (e.g., kilograms of cassava plus kilograms of sorghum, etc.) the conversion rate would look reasonable. It would then be a weighted average of food composition conversion rates, with weights being the proportion of unweighted group quantities for each component. For root crops and other cereals the dominant quantity weight is for cassava. Over 300 kilograms of cassava per household are consumed in our sample, while only about

Table B.2

Calorie Conversion Rates of Food Groups[1]
by Expenditure Group

Food	Expenditure Group			
	Low	Middle	High	Mean
Rice	3,759.1	3,848.6	3,664.6	3,743.3
Root crops and other cereals	8,679.4	10,270.6	5,956.1	7,505.6
Oils and fats	9,909.1	9,241.1	9,001.0	9,143.6
Fish and animal products	5,647.3	3,770.1	2,485.2	3,196.4
Miscellaneous foods	2,430.2	5,184.5	4,748.9	4,430.7

[1]In calories per kilogram of weighted quantity.

50 kilograms of sorghum are consumed. However, in deriving weighted quantities, the large quantity of cassava, most of which comes from home production, is multiplied by the ratio of cassava sales price to group consumption price. This price ratio is generally very small. While the sorghum quantities are multiplied by ratios which are generally a little greater than one, those quantities are not large. The result is that the weighted quantity of root crops and other cereals is much smaller than the unweighted quantity. Hence, the large calorie conversion rate. Since the quantity units used in our model are weighted quantities, we use calorie conversion rates which are in terms of the same weighted quantities.

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