AN ANALYSIS OF AGGREGATE DEMAND FOR FOOD AND NONFOOD IN KOREA

Hwang Eui-Gak*

An attempt has been made in this paper to estimate demand functions for food and nonfood products by farmers, nonfarmers and the total population. It is hoped that such classification will be helpful in checking the internal consistency of estimated functions.

I. Economic Model

The problem with which demand analysis is fundamentally concerned is to find out how the demand for a commodity will alter as tcertain specified variables change. This information is usually required for a specified moment in time and for some aggregation of individuals, either for all consumers or for some sub-group. Traditional demand analysis usually assumes a hypothesis that the demand for a commodity is a function of the price of the commodity, the prices of other commodities, including expected future prices, and the disposable income of the consumer.

Of course, other variables such as the introduction of new commodities and change in the consumer's taste attributable to urbanization of the society, increased mobility, and improved means of communication and transportation may also play a significant role in determining the demand relationships.

Consumers' expenditure is the largest item in the gross domestic product of most economies. Therefore, the changing time profile of components of consumers' expenditure in response to increasing income does play a crucial role in changing the structure of industry over time. Also, the knowledge of price responses in relation to consumers' expenditure is an important element in the formulation of fiscal policy or any other type of economic control.

For many practical purposes it may be sufficient to estimate separately a set of single equation models, one for each category of consumers' expenditure. For example, each equation might express the quantity purchased of each good per head of population as a function of average per capita income and the price of the good relative to some overall price index. If needed, a time variable can be included as a "catch-all" for changes in the distribution of income, the introduction of new products and steady

*Associate professor of economics, Yeungnam University, Korea

changes in tastes. If good "j" is supposed to be a close substitute or complement for some other good, then the price of that good will be included in the demand function.

Theoretically, a demand function is derived from the analysis of utility maximization of one or a group of consumers subject to budget constraint. In the case of our two commodities, food and nonfood, consumers' utility function is defined as:

$$U = g(Q_F, Q_N)$$

where Q_F is the quantity of food and Q_N is the quantity of nonfood consumed. The consumers' budget constraint is $Y^0 = P_F Q_F + P_N Q_N$. In order to solve this model we form a Lagrangian function,

$H = g(Q_F, Q_N) + \lambda(Y^0 - P_F Q_F - P_N Q_N)$, which consists of the function to be maximized, budget constraint, and one Lagrange multiplier λ. To obtain the required solution we differentiate H with respect to Q_F, Q_N, and λ, and put each of the derivatives equal to zero. Thus, we obtain

$$g_F(Q_F, Q_N) - \lambda P_F = 0$$

$$g_N(Q_F, Q_N) - \lambda P_N = 0$$

$$Y^0 - P_F Q_F - P_N Q_N = 0$$

This gives us all three equations to be solved for the endogeneous variables Q_F, Q_N, and λ in terms of parameters P_F, P_N, and Y. Solving the system of equations for Q_F and Q_N we obtain explicit demand functions

$$\text{For Food: } Q_F = f(P_F, P_N, Y) \qquad (1.1)$$

$$\text{For Nonfood: } Q_N = f(P_F, P_N, Y) \qquad (1.2)$$

provided the second order condition for the maximum is satisfied.

II. Functional Forms

The basic relationship underlying the regression analysis is assumed to be,

$$\text{For food: } \ln E_F = a_0 + a_1 \ln Y + (1 + a_2) \ln P_F + a_3 \ln P_N \qquad (1.3)$$

$$\text{For nonfood: } \ln E_N = b_0 + b_1 \ln Y + (1 + b_2) \ln P_N + b_3 \ln P_F \qquad (1.4)$$

where ln denotes natural logarithm,

E_F is expenditure on food,
E_N is expenditure on nonfood,
Y is income,
P_F is price of food,
P_N is price of nonfood,
a_1 and b_1 are income elasticities,
a_2 and b_2 are own-price elasticities,
a_3 and b_3 are cross-price elasticities.

Disturbance terms are omitted for simplicity. All the regressions were computed in both linear form[1] and log-linear form. But it is more convenient to discuss the nature of the relationships in the above logarithmic form.

Doing regression computations directly on the equations in the above form would not be expected to give very good results in a highly inflationary situation, because of the high correlations among independent variables.[2] One might think of deflating all the variables by an over-all price index (i.e., a suitable consumer's price index, or weighted average of P_F and P_N), but this procedure tends to result in a very high negative correlation between the deflated P_F and the deflated P_N (as high as U1.0000 to four decimal

[1]The linear quantity dependent forms are:

For food: $E_F/P_F = a_0 + a_1Y + a_2P_F + a_3P_N$ (1.3 a)

For nonfood: $E_N/P_N = b_0 + b_1Y + b_2P_N + b_3P_F$ (1.4 a)

Market demand equations can be written as:

For food: $P_F = A_0 + A_1\ (E_F/P_F) + A_2(E_N/P_N) + A_3Y$ (1.3 b)

For nonfood: $P_N = B_0 + B_1\ (E_F/P_F) + B_2\ (E_N/P_N) + B_3Y$ (1.4 b)

Here P_F and P_N are the index numbers of the two prices, as will be explained later. Accordingly,

$P_T = (W_1P_F + W_2P_N)$, in which $W_1 + W_2 = 1$

[2]As an example, let us look at the linear regression result of our demand function for food by Urban Salary and Wage Earner's Household (1962–1974 periods of time).

$$\left(\frac{E_F}{P_F}\right) = -\ 526.0 + \underset{\substack{(0.07819)\\(1.302)}}{0.10181Y} - \underset{\substack{(0.5327)\\(-\ 0.232)}}{0.1236P_F} + \underset{\substack{(0.7820)\\(1.347)}}{1.0533P_T}$$

$R^2 = 0.9920$

$F(3,8) = 331.850$

where the first parentheses indicate the standard error of estimators and the second paretheses show the corresponding "t" statistics for a_1, a_2 and a_3. By the "t" test we cannot reject the hypothesis that $a_1 = 0$ or $a_2 = 0$ or $a_3 = 0$, and yet by the "F" test we reject the hypothesis that $a_1 = a_2 = a_3 = 0$. The reason is the fact that the separate contributions of Y, P_F and P_T to the explanation of the variation of the dependent variable (E_F/P_F) are weak, whereas their joint contribution, which cannot be decomposed, is quite strong. Note that in this example $r_{YP_F} = 0.9821$, and $r_{YP_T} = 0.99896$, $r_{P_FP_T} = 0.9970$ indicate a high degree of sample correlation between Y and P_F, Y and P_T, and P_F and P_T. A high degree of multicollinearrity is harmful in the sense that the estimates of the regression coefficients are highly imprecise. In general, the relationship between the values of the individual t statistics in the test of

$$H_0:\ \beta_k = 0 \quad (K = 1,2,\ .\ .\ .\ .\ K)$$

and the value of the F statistic in the test of

$$H_0:\ \beta_1 = \beta_2 = \ .\ .\ .\ = \beta_k$$

can be made explicit by expressing the F statistic in terms of the t statistics. For the case of two explanatory variables,

$$F_{2,n-3} = \frac{SSR/2}{SSE/(n-3)}$$

$$= \frac{t_1^2 + t_2^2 + 2t_1t_2r_{12}}{2(1 - r_{12}^2)} \quad \text{where} \quad t_i = \frac{\beta_i}{s_{\beta_i}}\ (i = 1,2)$$

This shows quite clearly that if r_{12}^2 (sample correlation coefficient between X_{i1} and X_{i2}) is not far from unity, the value $F_{2,n-3}$ will be quite large even if both t_1 and t_2 are small.

(See K. Fox, *Intermediate Economic Statistics* (New York: Wiley, 1968), pp. 259–265 for a systematic exploration of this point.)

places, in some of the data).

The procedure adopted here is to impose an assumption that the above functions are homogeneous of degree 1, that is, that if all prices and money income were to rise by the same percentage, then expenditure on each commodity would also rise by the same percentage. This is equivalent to saying that:

$$a_1 + (1 + a_2) + a_3 = 1$$

and

$$b_1 + (1 + b_2) + b_3 = 1$$

and this in turn implies that the above functional forms are respectively equivalent to:

$$\ln(E_F/P_N) = a_0 + a_1 \ln (Y/P_N) + (1 + a_2) \ln (P_F/P_N) \quad (1.5)$$

$$\text{and } \ln(E_N/P_F) = b_0 + b_1 \ln (Y/P_F) + (1 + b_2) \ln (P_N/P_F) \quad (1.6)$$

These are the main logarithmic forms used in the final regression results with some modification in the case of the farmer's demand function (see later discussion). The linear forms also used the same variables. Note that a_1 and b_1 are the income elasticities, holding the price constant; a_2 and b_2 are the elasticities of quantity demanded with respect to price, holding income and the other price constant;and the crossprice elasticities may be obtained, if desired, by the relations,

$$a_3 = -a_1 - a_2 \text{ and } b_3 = -b_1 - b_2$$

The estimated coefficients of the price variables in the regressions are not, of course, direct estimates of the elasticity of quantity with respect to price. The former is obtained by subtracting 1 from the latter.

A number of regressions were also computed using functional forms somewhat different from those given above. Some of these are discussed below, in the section "Some Additional Results".

III. Empirical Analysis

1. Nonfarmers

For urban households, two sets of separate regressions were computed: one for salary and wage earner's household and the other set for the average of all households. Dependent variables are E_F/P_N and E_N/P_F, respectively. Independent variables are Y/P_N, P_F/P_N and Y/P_F, P_N/P_F, respectively. For the nonfarmers, the data on income and expenditures used are from the "Annual Report on the Family Income and Expenditure Survey, 1:74", published by the Bureau of Statistics, Economic Planning Board, Republic of Korea. These are household survey data, giving average monthly expenditure, by years, from a sample of salary and wage earners, and of all households, in cities of 50,000 population or greater income data are obtained, for salary and wage earners, but not for all households. For all households, total consumption expenditure data were used instead of income. The sample does not represent those nonfarmers who did not live in cities of 50,000 or more. The income and expenditure values were obtained from the published data as follows:

Y = "Income" minus "Direct taxes and other Public charges"
E_F = Expenditures on Food and Beverages
E_N = "consumption Expenditure" minus E_F.

The data are available only from 1967 through 1974, or observations. The price data used in the final results were, for 1965–1974, the indices:

P_F = consumer Price Index for Food and Beverages
P_T = consumer Price Index for All Items
P_N = Consumer Price Index for Nonfood, which was calculated by the formula $\frac{(1000.0P_T - 461.0P_F)}{539.0}$, where the weights are those in the construction of P_T.

For 1963–1964, the consumer price indexes for Seoul City were used, linked to the "all cities index" at 1965.[3] All price indexes were based on 1970 = 100. The regression results are given in Table 1.1. Regressions were also computed using a number of different versions of these functions. These are discussed in the section below on "Some Additional Results".

The estimated coefficients appear fairly reasonable. The observed t-ratios vs. the tabled value of t with $n-3 = 9$ degrees of freedom indicate that the estimated coefficients of income, total expenditure and price from logarithmic equations are highly significant at both the five and one percent levels for a two-tail test. So are the coefficients of income and total expenditure from linear equations. All price coefficients obtained from linear equation are significant at the ten percent levels for a one-tail test. All the F statistics are also highly significant, indicating the improvements brought about by fitting the respective regression plans were not due to chance.

2. Total Population

The variables used are:

[3]Two simple regressions (one for all commodities and the other for food and beverages) were run to fit the consumer price indexes for all cities (1965–1974) to the consumer price indexes for Seoul City (1965–1974). The results are

$P_{A1} = -8.012 + 1.073\, P_{s1}$
$P_{A2} = -11.25 + 1.1021\, P_{s2}$

where P_{A1} H the consumer price indexes of all items for all cities
P_{S1} H the consumer price indexes of all items for Seoul City
P_{A2} H the consumer price indexes of food and beverages for all cities
P_{S2} H the consumer price indexes of food and beverages for Seoul City

By linking these results to the corresponding consumer price indexes for Seoul City (1963–1964), we obtained the consumer price indexes for all cities (1963–1964).

Table 1.1 Regression Results from Urban Household Survey Data, Annual Averages

(Prices = All cities and Seoul CPI, no. of observation = 12; 1963–1974)

Demand Function	Estimated Elasticities: Logarithmic Equation: Income	Logarithmic Equation: Total Expenditure[2]	Logarithmic Equation: Price[3]	Linear Equation: Income	Linear Equation: Total Expenditure[2]	Linear Equation: Price[3]	Estimated Regression Coefficient from Linear Equation: Income	Total Expenditure[2]	Price[4]	Logarithm $\bar{R}^2$ and (R^2)	Linear $\bar{R}^2$ and (R^2)
Food Salary & Wage Earners	.2968 (.05560)		—.68355 (.1560)	.3184		—.71385	.1365 (.02577)		32.883 (17.74)	.8439 (.8092)	.8527 (.8200)
Food All Households		.39320 (.05638)	—.66674 (.1312)		.41378	—.68312		.18564 (.02721)	38.199 (15.66)	.8954 (.8722)	.8984 (.8758)
Nonfood Salary & Wage Earners	1.3549 (.03661)		—1.20390 (0.1236)	1.28288		—.76567	.66167 (.02541)		32.140 (15.40)	.9935 (.9920)	.9869 (.9840)
Nonfood All Households		1.5912 (0.05652)	—1.20390 (0.1236)		1.46786	—1.32809		.80819 (0.2744)	—35.264 (14.550)	.9888 (.9863)	.9897 (.9875)

[1] Standard errors of regression coefficients are shown in parenthesis where appropriate. Standard errors are given rather than the corresponding "t-ratios," because in most cases we are not especially interested in testing the null hypothesis that the true coefficient is zero, but we are interested in some idea of the sampling error in the estimate.

[2] For all households, income data are not provided, so the elasticities are with respect to total consumption expenditure instead of income.

[3] This is the elasticity of quantity with respect to price. For the logarithmic equations, the standard error of this estimate is the same as the standard error of the estimate of elasticity of expenditure with respect to price, since the difference between the two elasticities is the constant 1.

[4] This is the coefficient of expenditure with respect to price. The elasticity of expenditure with respect to price (from Linear Equation) was calculated as the means of the variables, from this coefficient, and then the elasticity of quantity with respect to price was obtained by subtracting 1. Note that if this coefficient were zero, the elasticity of quantity with respect to price would be -1.

Dependent	*Independent*
E_F/P_N	Y/P_N, P_F/P_N
E_N/P_F	Y/P_F, P_N/P_F

where Y = Personal Disposable Income
E_F = Private Consumption Expenditure on Food and Beverages
E_N = Private Consumption Expenditure minus E_F
P_F = Implicit Price Deflator for Private Consumption Expenditure on Food
P_T = Implicit Price Deflator for Total Private Consumption Expenditure
P_N = Implicit Price Deflator for Non food Private Consumption Expenditure, wh·ch is calculated on the basis of proportionate expenditures on nonfood out of total expenditures in 1970.

Income and expenditure values were obtained from the National Income Statistics, 1975, published by the Bank of Korea. The prices are the GNP-Sectoral Implicit Deflators based on 1970 = 100.

The regressions were computed for data from 1956–1974 (See Table 1.2), and from 1963–1974 (See Table 1.3). The latter set was computed to see if there might be any differences from the overall period, and also for more direct comparability with the household survey results.

The point estimates given in the section on "A Summary of Main Results" below are those from the longer time period.

The estimated results were consistent with each other for data from 1956–1974 and from 1963–1974. However, the above functional forms did not produce very satisfactory results for per capita data, possibly due to either identification problem or some unidentified source of errors in the variables used. The best results from per capita data were obtained by using P_T as deflator in place of other price indexes.

Autocorrelation of Residuals: The analysis of time-series data by least-squares regression method depends on the assumption that the errors in the regression model are serially uncorrelated, that is, $E(U_i, U_{i+s}) = 0$ for all i and all $s \neq 0$. When this assumption does not hold, the least-squares estimates of the regression coefficients can be inefficient and the estimates of variance of the estimated coefficients can be biased. Thus, if autocorrelation goes undetected, confidence intervals for the parameters tend to be incorrectly stated to be shorter than they really are.

Durbin and Watson (1950–51) proposed a test based on the residuals $Z^1 = (Z_1, \ldots, Z_T)$ from the fitted regression. It was shown in their study that the distribution of d depends on the particular set of regressors in the data under analysis and therefore varies from sample to sample. Bounding random variables d_L and d_U, were derived such that $d_L \leq d \leq d_U$ and their significance points were tabulated. If, for a test against positive serial correlation, the observed value of d is less than the tabulated value of d_L, the null hypothesis of independence is rejected. Similarly, if d is greater than the

Table 1.2 Regression Results[1] From National Income Consumption Data

(1956–1974)

(Prices = Implicit Deflators) (No. of Observations = 19)

Demand Function	Estimated Elasticities				Estimated Coefficients, Linear Equation		Logarithm	Linear	Logarithm	Linear	Logarithm	Linea
	Logarithmic Equations		Linear Equations				R^2 and ($\bar{R}^2$)	R^2 and ($\bar{R}^2$)	F(2, 16) Statis-tics	F(2, 16) Statis-tics	D-W[5]	D-W[5]
	Disposable Income	Price[2]	Disposable Income	Price[2]	Disposable Income	Price[3]						
FOOD												
Total Population	.77030 (.05659)	—.54775 (.05659)	.78027	—.610	.41757 (.01112)	3.1751 (.5851)	.9957 (.9952)	.9939 (.9931)	1853.653	1296.212	2.27	2.07
Per Capita[4]	.66312 (.02548)	—.29225 (.1204)	.67345	—.268	.36370 (.01364)	.20414 (.03649)	.9873 (.9857)	.9877 (.9861)	621.029	639.922	2.11	2.15
NONFOOD												
Total Population	1.1584 (.03305)	—.57648 (.08759)	1.09596	—.711	.46383 (.01343)	1.7309 (.5121)	.9878 (.9862)	.9882 (.9867)	645.796	667.282	1.60	1.27
Per Capita[4]	1.1945	—.21271	1.13306	—.420	.47703	.12114	.9720	.9774	277.623	346.213	1.30	1.11

[2] This is elasticity of quantity with respect to price (See footnote 3, Table 1)

[3] This is the coefficient of expenditure with respect to price (See footnote 4, Table 1)

[4] The Per Capita Income and Expenditure values were obtained from the total population values by dividing by population at mid-year. In case of per capita data, the best results were obtained by using P_T as deflator index in place of the other price implicit deflators.

[5] The value of Durbin-Watson statistic (d) is given by $\dfrac{\sum_{t=0}^{n} (e_t - e_{t-1})^2}{\sum_{n=1} e_t^2}$

where the e's represent the ordinary least squares residuals. If the alternative hypothesis is that of positive autoregression, the decision rules are: (1) Reject if $d < du$. (2) Do not reject if $d > du$. (3) The test is inconclusive if $d_L \leq d \leq du$. If the alternative hypothesis is a two-sided one, the decision rules for the Durbin-Watson test are: (1) Reject if $d_L > d$, or if $d > 4-d_L$. (2) Do not reject if $du < d < 4-du$. (3) The test is inconclusive if $d_L \leq d \leq du$, or if $4-du \leq d \leq 4-d_L$.

Table 1.3 Regression Results[1] From National Income Consumption Data
(1963–1974)

(Prices = Implicit Deflators) (No. of observations = 12)

Demand Function	Estimated Elasticities: Logarithmic Equations, Disposable Income	Estimated Elasticities: Logarithmic Equations, Price[2]	Estimated Elasticities: Linear Equations, Disposable Income	Estimated Elasticities: Linear Equations, Price[2]	Estimated Coefficients, Linear Equation: Disposable Income	Estimated Coefficients, Linear Equation: Price[3]	Logarithm: R^2 and ($\bar{R}^2$)	Linear: R^2 and ($\bar{R}^2$)	Logarithm: F(2, 9)	Linear: F (2,9)	Z[5] Statistic
FOOD											
Total Population	.76353 (.02713)	—.47536 (.08917)	.78071	—.571	.40773 (.01617)	4.0095 (.9917)	.9923 (.9906)	.9905 (.9884)	578.249	470.380	.6896
Per Capita[4]	.68578 (.03164)	—.04232 (.01772)	.7027	—.163	.36825 (.01853)	.25353 (.06070)	.9866 (.9836)	.9847 (.9814)	331.032	290.482	.6896
NONFOOD											
Total Population	1.1208 (.04074)	—.52302 (.1229)	1.06381	—.631	.45378 (.01688)	2.8449 (.8784)	.9883 (.9854)	.9878 (.9851)	378.720	365.845	—.7042
Per Capita[4]	1.1386 (.04874)	—.04537 (.02152)	1.08292	—.247	.46074 (.01966)	.18875 (.05164)	.9838 (.9802)	.9842 (.9807)	273.075	280.164	—.7042

Footnote 1 through 4: See Table 2

[5] Chi-square runs test statistic: $Z = R - E(R)\sqrt{V(R)}$, where $R =$ the number of residual sign changes plus 1, $E(R) = (2n_1n_2/n_1+n_2)+1$, and $V(R) = 2n_1n_2(2n_1n_2-n_1-n_2)/(n_1+n_2)^2(n_1+n_2-1)$. Here n_1 is the number of residuals with plus signs and n_2 is the number of residuals with minus signs. Assume serial correlation is present if $Z < -1.645$ for $\alpha=0.05$ or $Z < -1.28$ for $\alpha = 0.10$.

tabulated value of d_U, the hypothesis is accepted. If d lies between the two, the result of the bound test is regarded as inconclusive.

As reported in Table 2, the Durbin-Watson statistic for 1956–1974 data shows evidence of nonautocorrelation in case of food and test inconclusive in nonfood demand function. For $n = 19$, $k = 2$, and significance level 0.05 (one-sided test), the value of d_L is 1.08, and $d_U = 1.53$.

For 1963–1974 period data (n is less than 15), the less powerful but often satisfactory chi-square runs test was used, and null hypothesis of independence is accepted.

The formula for chi-square runs test is as follows:

$$Z = \frac{R - E(R)}{\sqrt{V(R)}}$$

where R is the number of residual sign changes plus 1.

$E(R)$ is the expected number of runs assuming no serial correlation.

$V(R)$ is the variance of "number of runs (R)" assuming no serial correlations.

3. Farmers

For the farmers, the data on income and expenditures are from the "Report on the Results of Farm Household Economy Survey and Production Cost Survey of Agricultural Products," 1974, Ministry of Agriculture and Forestry, Republic of Korea. The income and expenditure values are:

Y = Farm Household Income
E_F = Living Expenses for Food
E_N = Living Expenses for Nonfood

The prices are indexes from "Prices of Household Goods Paid by Farmers" obtained from Agricultural Year Book, National Agricultural Cooperation Federation, and Economic Statistics Yearbook published by the Bank of Korea, and are defined as:

P_F = Prices of Foods which include (1) grain and noodles, (2) seaweed and fish, (3) meat, (4) seasonings and (5) stimulants.
P_T = Price of Total Farm Household Goods paid by Farmers.
P_N = Price of Nonfood Living Expenditure paid by Farmers. The formula for the calculation of P_N is as follows:

$$P_N = \frac{603.2P_T - 153.9\,P_F}{449.3}$$

where the weights are those in the construction of P_T. Data are available for 1962–1973, or 12 observations.

There is always a question pertaining to the problems of choosing deflators in the estimation process. When estimating an individual, "partial equilibrium" type behavior relation, the usual "natural" choice of deflator is that price index which seems to best approximate a measure of the "value money" to the people or firms whose behavior is being analyzed.

An alternative procedure which might be considered would be to estimate all individual behavior relations from the beginning using the same deflator.

The first set of regressions were attempted to estimate the farmers' demand relations using the same deflator P in the following:

Demand Function	*Dependent Variable*	*Independent Variables*
Food (Expenditure Dependent)	E_F/P_T	$Y/P_T{}'\ P_F/P_T$
Food (Price Dependent)	P_F/P_T	$Y/P_T{}'\ E_F/P_T$
Nonfood	E_N/P_T	$Y/P_T{}'\ P_N/P_T$

Using variables in this form, the coefficient of P_F/P_T or P_N/P_T in the logarithmic equations is still equal to the price elasticity plus one; however, the price elasticity is now defined holding income and P_T constant instead of income and the other price. The results, for the logarithmic equations, were as follows:

Function	*Income*	*Estimated Coefficients*[a] *Price*	R^2	*F-value*	*SEE*
Food	0.31491	0.45956	0.4742	4.058	0.1116
(Expend. Dep.)	(0.2857)	(0.7352)			
Food	0.27488	0.09054	0.6778	9.464	0.04955
(Price Dep.)[b]	(0.09926)	(0.1448)			
Nonfood	0.87108	0.52101	0.7391	12.746	0.1091
	(0.2950)	(2.352)			

[a]Standard errors of regression coefficients are shown in parentheses. Note that the coefficients of the price variable are estimates of the elasticity of expenditure, which is equal to the price elasticity of quantity plus one.

[b]Unadjusted. Only in case of $R^2 = 1$, demand elasticity is exact reciprocal of price flexibility, except for rounding.

The above results are not very satisfactory.

Alternatively, the first set of distributed lag type equations was tried in the following form. The underlying assumption is that "desired" quantity consumed is a function of past year's real income and real prices, and there is also a lag in adjustment from the previous period's quantity consumed.

For food: $\ln(E_{Ft}/P_{Ft}) = ca_0 + ca_1 \ln(Y_{t-1}/P_{T,t-1}) +$

$$ca_2 \ln(P_{F,t-1}/P_{T,t-1}) + (1-c)\ln(E_{F,t-1}/P_{F,t-1}) + a_4 t$$

For Nonfood: $\ln(E_{Nt}/P_{Nt}) = cb_0 + cb_1 \ln(Y_{t-1}/P_{T,t-1}) +$

$$cb_2 \ln(P_{F,t-1}/P_{T,t-1}) + (1-c)\ln(E_{N,t-1}/P_{N,t-1}) + b_4 t$$

where the subscript "t" denotes the year and "c" is the "expectations" coefficient assumed to be the same for income and prices.

The results are as follow:

$$\text{Food: } \ln(E_{Ft}/P_{Ft}) = \underset{(2.02)}{-\ 1.269} + \underset{(0.5366)}{1.3413} \ln\ (Y_{t-1}P_{T,t-1})$$

$$\underset{(0.5366)}{-1.3084} \ln(P_{F,t-1}/P_{T,t-1}) - \underset{(0.4856)}{0.2788} \ln(E_{F,t-1}P_{F,t-1})$$

$$\underset{(0.02265)}{-0.044708t}$$

$$R^2 = 0.7776$$

$$\bar{R}^2 = 0.6239$$

$$F = 5.243$$

$$\text{SEE} = 0.0675$$

$$\text{Nonfood: } \ln(E_{Nt}/P_{Nt}) = \underset{(2.58)}{6.255} + \underset{(0.1544)}{0.47527} \ln(Y_{t-1}/P_{t-1})$$

$$+ \underset{(0.9173)}{0.47212} \ln(P_{N,t-1}/P_{T,t-1}) - \underset{(0.4590)}{0.56763} \ln(E_{N,t-1}/P_{N,t-1})$$

$$\underset{(0.02106)}{+\ 0.070824t}$$

$$R^2 = 0.9823$$

$$\bar{R}^2 = 0.9705$$

$$F = 83.126$$

$$\text{SEE} = 0.03221$$

The results show that income elasticities are 1.34 for food and 0.48 for nonfood while price elasticities are -2.3 for food and -0.52 for nonfood.

The high price elasticity of food suggests that if the prices of farm food products were higher in the previous year, then the farmer's desired sale of food would increase this year. Also the elastic income elasticity of food explains that higher farm income tends to reduce farmers' desired sale (or production). But the inclusion of the trend variable tends to make the coefficient of the lagged dependent variable (or its equivalent) turn out to be negative.

Finally, a number of alternative distributed lag type equations were also tried, based on various assumpt·ons about the nature of the adjustment and/or the expectations. There were, in fact, many possible different formulations which would allow for the current as well as the past values of explanatory variables including lagged dependent variables to affect the dependent variable.

In each case, we start out with the variables in the form:

E_N/P_N, Y/P_N, P_F/P_N for the food equation,

and E_N/P_F, Y/P_F, P_N/P_F in the nonfood equation.

Also, these same equations were computed with "Value Added in Agriculture" per farm household used as an alternative to Household Income. Based on the earlier results, it was also decided to included a trend variable in these equations.

None of these attempts was entirely successful; in fact, in many of them, presumably bacause of the inclusion of the trend variable, the coefficient of the lagged dependent variable (or its equivalent) turned out to be negative. However, in general, the trend variable tended to be quite significant statistically in all of these equations. The most reasonable (or the least unreasonable) of the results were those based on the simplest of the equation, namely the equations in the form:

$$\ln (E_{Ft}/P_{Nt}) = ca_0 + ca_1 \ln (Y/P_{Nt}) + c(1 + a_2) \ln (P_{Ft}/P_{Nt})$$
$$+ (1 - c) \ln (E_{F,t-1}/P_{F,t-1}) + a_4 t \text{ for food, and}$$
$$\ln (E_{Nt}/P_{Ft}) = cb_0 + cb_1 \ln (Y/P_{Ft}) + c(1 + b_2) \ln (P_{Nt}/P_{Ft})$$
$$+ (1 - c) \ln (E_{N,t-1}/P_{N,t-1}) + b_4 t \text{ for nonfood consumption.}$$

The assumption underlying these forms is that "desired" quantity consumed is a function of current income and prices, but there is a lag in adjustment from the previous period's quantity consumed:

$$\ln (E_{Ft}/P_{Ft}) = c \ln (E_{Ft}*/P_{Ft}*) + (1 - c) \ln (E_{F,t-1}/P_{F,t-1}), \text{ and}$$
$$\ln (E/_{Nt}P_{Nt}) = c \ln (E_{Nt}*/P_{Nt}*) + (1 - c) \ln (E_{N,t-1}/P_{N,t-1})$$

where $E_{Ft}*/P_{Ft}*$ and $E_{Nt}*/P_{Nt}*$ are desired quantities consumed (not observable) respectively. As it turned out, the estimates of $(1 - c)$ were very small and statistically negligible (t-ratios less than 0.30), so that the variation in the dependent variable is almost entirely explained by current income, current price, and trend in the case of food, and by current price and trend in the case of nonfood. The computed regressions are as follows (standard errors in parentheses).

Food, Logarithmic Equation[a]:

$$\ln(E_F/P_N) = \underset{(1.27)}{-1.572} + \underset{(0.2167)}{1.0954} \ln(Y/P_N) - \underset{(0.4053)}{0.27956} \ln(P_F/P_N)$$
$$+ \underset{(0.1768)}{0.22035} \ln(E_{F,t-1}/P_{F,t-1}) - \underset{(0.009817)}{0.041899}t$$
$$R^2 = 0.9564$$
$$\bar{R}^2 = 0.9274$$

[a]Note that the coefficient of the price variable is, as usual, an estimate of the elasticity of expenditure with respect to price; to get the elasticity of quantity with respect to price, subtract 1. The elasticities given in the later section, "A Summary of the Main Results," were obtained by dividing the estimated coefficients from this equation by the estimate of C, or 1 − 0.22035 = 0.97965. This adjustment, while fairly minor, may be somewhat questionable, in view of the lack of significance in the estimate of 1 − c.

$$F(4,6) = 32.938$$

$$\text{SEE} = 0.0402$$

Food, Linear Equation:

$$(E_F/P_N) = \underset{(374)}{397.8} + \underset{(0.08310)}{0.42364}(Y/P_N) - \underset{(3.987)}{1.6454}(P_F/P_N)$$

$$+ \underset{(0.1972)}{0.08957}(E_{F,t-1}/P_{F,t-1}) - \underset{(11.36)}{50.372}t$$

$$R^2 = 0.9545$$

$$\bar{R}^2 = 0.9242$$

$$F(4.6) = 31.482$$

$$\text{SEE} = 44.61$$

Nonfood, Logarithmic Equation:

$$\ln(E_N/P_F) = \underset{(1.79)}{0.8203} + \underset{(0.1161)}{0.2688} \ln(Y/P_F) + \underset{(0.1489)}{0.74631} \ln(P_N/P_F)$$

$$+ \underset{(0.1872)}{0.030175} \ln(E_{N,t-1}/P_{N,t-1}) + \underset{(0.01049)}{0.040448}t$$

$$R^2 = 0.9832$$

$$\bar{R}^2 = 0.9720$$

$$F(4,6) = 87.779$$

$$\text{SEE} = 0.02528$$

Nonfood, Linear Equation:

$$(E_N/P_F) = \underset{(245.)}{-328.8} + 0.12232(Y/P_F) + \underset{(1.669)}{6.8290}(P_N/P_F)$$

$$+ \underset{(0.2483)}{0.056974}(E_{N,t-1}/P_{N,t-1}) + \underset{(11.44)}{35.713}t$$

$$R^2 = 0.9762$$

$$\bar{R}^2 = 0.9603$$

$$F(4,6) = 61.497$$

$$\text{SEE} = 30.09$$

In all four equations, the trend term (t) appears quite significant (t-ratios of 3.12 or higher), and the other coefficients appear quite reasonable. Food as a "necessity" good is generally considered to have an income elasticity less than one (Engel's law), but our results from farm household data support the argument that food elasticities are close to unity for the average poor farm family in developing counties, contrasted with values as low as one third for the average higher income urban family. The coefficients of "t" in the logarithmic equations indicate that, for given prices and income, farm households have been decreasing their consumption of food by 4.2% a year, and increasing their consumption of nonfood by about 4.1% a year, during the sample period (1962–1973). The most likely explanation of these trends seem to be "sociological" such as changes in tastes attributable to the urbanization of rural areas, improved means of communication and transportation. How long such trends might be expected to continue is, of course, question able. In 1970, farm household's food expenditures were about 45.9 % to total consumption expenditures, having declined from about 60.3% in 1963, while urban household's food expenditures were about 40.5% of total consumption expenditures as compared with 54.2% in 1963. In 1974, food occupied about 47% of total farm living expenses, while urban households spent about 42% of total consumption expenditures on food.

IV. Summary of Main Results

These "bare numbers" for elasticities were obtained by taking mean elasticities from the results of logarithmic and linear equations in the case of nonfarmers and total population, while they are from logarithmic equation in the case of farmers.

	Nonfarmers (per household)	Farmers (per household)	Total Population (per capita)
	Income Elasticities		
Nonfood	1.31	0.28	1.16
Food	0.31	1.12	0.67
	Marginal Propensity (MPC)		
Nonfood	0.67	0.12	0.48
Food	0.14	0.42	0.36
	Price Elasticities		
Nonfood	—0.98	—0.26	—0.32
Food	—0.70	—1.31	—0.28

The income and price elasticities for nonfarmers and farmers appear fairly reasonable, even if many previous studies of demand for food in advanced countries indicate that price elasticity and income elasticity are less than one. (See G.S. Tolley, Y. Wang· and R.G. Fletcher (1969) for U.S. estimates). Ideally, income elasticities are declining functions of income. The tendency to declining elasticity might indeed more accurately be related to the increasing level of the consumption of the commodity in question than to income. This elasticity declines as consumption increases, whether as the effect of increasing income, decreasing price, or simply as a trend in preferences. The estimated results explain that farmers' consumption of their own products (food) have not reached a saturation level as income increases at a given price. Indeed the saturation level is itself a function of price, which, in turn, affects the income level.

Unless farmers' consumption level of food is saturated, the consumption continues to increase as their income goes up. On the other hand, if their income is not high enough to meet all living expenses, farmers have to tighten their belts by not consuming enough of their product (food) if the price of food goes up. That is partially demonstrated by the farmer's higher response to food prices.

V. Some of Additional Results

1. Cross-Sections, Urban Household

For each year, 1963–1974, a regression was done on the Salary and Wage Earners data, taking expenditures on nonfood as dependent, and income and persons per household as independent. The purpose was to compare the cross section income elasticity estimates with time series, and also to see whether there appeared to be any change in income elasticity over time. Income and persons per household are very likely correlated cross-sectionally, and the coefficients of the latter variable are not very reliable, but it was felt that including it in the regressions would provide more useful estimates of the coefficients of income.

The values of the variables are the means for the income classes into which the published data are divided. The number of observations ranges from 7 to 10.

It must be noted that the cross section survey data do not include "Estimated Rental Value of Owner-Occupied Housing" as a part of income, although the times series data do. This means, of course, that the two sets of estimates are not directly comparable.

The regression results are summarized in Table 1.4. The results for 1964 are clearly in error, for some unknown reason, and should be ignored.

2. Comparison of "Quantity-Dependent with "Expenditure-Dependent Functional Forms

A few regressions were computed on the "Ouantity Dependent" forms
$E_F/P_F = F(Y/P_T, P_F/P_T)$
to be compared with the corresponding "Expenditure-Dependent" forms
$E_F/P_T = F(T/P_T, P_F/P_T)$
As would be expected, the income elasticity estimates are not much different in the two cases, while the price elasticity estimates are a little higher numerically using the "Ouantity-Dependent" form only in case of all urban households. The relationship between these two forms can be shown as follows:

Table 1.4 Urban Household Cross-Sectional Income Elasticities For Nonfood[1]

Year	No. of observations	Estimated Coefficients[2]: Logarithmic Equations: Income[4]	Logarithmic Equations: Persons per Household	Linear Equations: Income	Linear Equations: Persons per Household	R^2 and ($\bar{R}^2$): Logarithmic Equation	R^2 and ($\bar{R}^2$): Linear Equation
1963	8	1.4120*	—2.0424	0.5393	—460.27	0.9886	0.9908
		(0.2259)	(1.026)	(0.04860)	(246.8)	(0.9841)	(0.9871)
1964[3]	8	0.55747	2.4421	0.73912	—1294.1	0.9965	0.9944
		(0.4626)	(1.812)	(0.06795)	(319.1)	(0.9951)	(0.9922)
1965	8	1.3440*	—0.41496	0.54067	—447.95	0.9994	0.9989
		(0.09534)	(0.3217)	(0.01782)	(81.38)	(0.9991)	(0.9984)
1966	8	1.2239*	—0.084147	0.55849	—567.86	0.9993	0.9997
		(0.1150)	(0.4771)	(0.01114)	(82.81)	(0.9991)	(0.9996)
1967	10	1.0417*	—0.29733	0.46230	—260.95	0.9988	0.9977
		(0.06064)	(0.3034)	(0.01971)	(332.5)	(0.9984)	(0.9970)
1968	10	1.0295*	0.089461	0.55151	—203.39	0.9961	0.9945
		(0.1302)	(0.6311)	(0.03730)	(673.2)	(0.9950)	(0.9929)
1969	10	1.1301*	—0.69284	0.59796	—1226.2	0.9952	0.9969
		(0.1258)	(0.5892)	(0.03346)	(617.1)	(0.9939)	(0.9961)
1970	7	0.99281*	0.21973	0.60050	—1037.9	0.9976	0.9954
		(0.1083)	(0.3344)	(0.05034)	(947.2)	(0.9965)	(0.9931)
1971	7	1.5083*	—2.3545	0.72877	—6688.9	0.9875	0.9900
		(0.4401)	(2.080)	(0.08916)	(3048.0)	(0.9813)	(0.9850)
1972	8	1.6060*	—2.1008	0.72010	—5751.1	0.9973	0.9947
		(0.1868)	(0.7853)	(0.03927)	(1261.0)	(0.9962)	(0.9963)
1973	8	0.94581*	0.55955	0.68978	—5792.5	0.9882	0.9966
		(0.4130)	(1.797)	(0.04972)	(1633.0)	(0.9834)	(0.9952)
1974	9	0.87321*	0.642837	0.641231	1163.74	0.99593	0.99146
		(0.092158)	(0.0447557)	(0.052189)	(2093.56)	(0.99458)	(0.98862)

[1]Excluding "Estimated Rent of Owner Occupied Housing."
[2]Standard errors shown in parentheses.
[3]These results seem to be clearly in error.
[4]*indicates "significant" at the 5% level or above.

$$\ln (E_F/P_F) = \alpha_0 + \alpha_1 \ln (Y/P_T) + \alpha_2 \ln (P_F/P_T) \qquad \text{(a)}$$

$$\ln (E_F/P_T) = \beta_0 + \beta_1 \ln (Y/P_T) + \beta_2 \ln (P_F/P_T) \qquad \text{(b)}$$

Equation (a) can be rewritten as:

$$\ln (E_F) = \alpha_0 + \alpha_1 \ln (Y/P_T) + \alpha_2 (\ln P_F - \ln P_T) + \ln (P_F) \qquad \text{(a)}$$

Subtracting $\ln(P_T)$ from both sides and rearranging gives:

$$\begin{aligned}\ln(E_F/P_T) &= \alpha_0 + \alpha_1 \ln (Y/P_T) + (1 + \alpha_2) \ln P_F - (1 + \alpha_2) \ln P_T \\ &= \alpha_0 + \alpha_1 \ln (Y/P_T) + (1 + \alpha_2) \ln (P_F/P_T) \qquad \text{(a)}\end{aligned}$$

Compare equation (b) with (a)". The price elasticity of quantity demanded is equal to the price elasticity of expenditure minus 1.

The estimated results from urban households are given below:

Food: Salary and Wage Earner's Household:

$$\ln(E_F/P_F) = \underset{(2.38)}{13.47} + \underset{(0.05249)}{0.30654} \ln(Y/P_T) - \underset{(1.2686)}{1.0972} \ln(P_F/P_T)$$

$$R^2 = 0.8178$$

$$F(2,9) = 20.194$$

$$\text{SEE} = 0.04590$$

$$\ln(E_F/P_T)^a = \underset{(2.38)}{4.262} + \underset{(0.05249)}{0.30654} \ln(Y/P_T) - \underset{(0.2686)}{0.097247} \ln(P_F/P_T)$$

$$R^2 = 0.8001$$

$$F(2,9) = 18.009$$

$$\text{SEE} = 0.04590$$

Food: All Urban Households:

$$\ln(E_F/P_F) = \underset{(2.06)}{11.40} + \underset{(0.05366)}{0.39998} \ln(Y/P_T) - \underset{(0.2284)}{0.9977} \ln(P_F/P_T)$$

$$\ln(E_F/P_T)^a = \underset{(2.06)}{2.189} + \underset{(0.05366)}{0.39998} \ln(Y/P_T) + \underset{(0.2284)}{0.040229} \ln(P_F/P_T)$$

$$R^2 = 0.8671$$

$$F(2,9) = 29.349$$

$$\text{SEE} = 0.03988$$

3. Deflating with P_T vs. Deflating with the Price of the "Other Commodity

A number of regressions were computed using the form

$$E_F/P_T = f(Y/P_T, P_F/P_T) \tag{1}$$

(and similarly for nonfood). In this form, the income elasticity has the same meaning as in the form

$$E_F/P_N = f(Y/P_N, P_F/P_N) \tag{2}$$

but the price elasticity has a quite different meaning. In (2) the price elasticity is defined as holding Y and P_N constant, while in (1) it is defined as holding Y and P_T constant. Or, alternatively, the price elasticity in (1) might be thought of as approximately the elasticity with respect to (P_F/P_T) holding "real income" (Y/P_T) constant.

[a]The elasticity of quantity with respect to price must be obtained by subtacting 1 from the elasticity of expenditure with respect to price.

The income elasticity estimates using (1) were somewhat higher for food and slightly lower for nonfood, than they were using (2) on the Urban Household Data, and the price elasticity estimates were substantially higher (numerically) for food and lower for nonfood using (1) than they were using (2).

Similar comparisons to those described for the Urban Household data were also made for the National Income Accounts Consumption data.

The regressions of the National Income Accounts data were also computed with the "price" P_F, P_N, and P_T represented by the Wholesale Price Indexes instead of the Implicit Consumption Expenditure Deflators. The reason was that the thought that relative changes in average prices paid by urban and rural consumers might be better approximated by the relative changes in wholesale prices than by those in the implicit deflators. Some of these results are given in the Appendix 1

VI. Problems and Further Research

There are many problems, and much further research that could be done.

(A) An over-riding question is that pertaining to the validity of the data. We have little to say about this, except that it seems likely that the household survey expenditures data are reasonably valid. The price data and the national aggregate consumption data, an the other hand, are fairly widely suspected of being somewhat distorted, for policy reasons. For example, whenever a government attempts to control prices, the real prices are not likely to be fully reflected in the official price indices. For another example, if aggregate product·on data on certain commodities are inflated to satisfy policy "goals," the corresponding aggregate consumption data may tend to be similarly inflated.

(B) The next research should be to thoroughly explore the household survey data cross-sectionally, and then combine the cross section and time series analyses to fully exploit the available data.

(C) To find what is happening in the national aggregate consumption statistics, the simpler simultaneous equations estimation such as two stage least squares to the aggregate data will be useful, since the single-equation ordinary regression method we have used does, in a simultaneous-equations model setting, give biased estimates, of course.

(D) The Final Problem is a question pertaining to the problems of choosing deflators in the estimation process. When estimating an individual, "partial equilibrium" type behavior relation, the usual "natural" choice of deflator is that price index which seems to best approximate a measure of the "value of money" to the people or firms whose behavior is being analyzed; for example, the Consumer's Price Index in the case of estimating consumer's demand for a particular commodity, or a Prices Paid by Farmer Index in the case of estimating the supply of a particular farm product. However, the choice is not always clear cut.

Different deflators give different elasticity estimates, particularly in price elasticities. A good example of the exploratory attempt to check out the total bias in elasticity estimates due to incorrect deflation is the study of food demand by Tolley, Wang and Fletcher (1:6:).

Appendix

A. Urban Household Data: P_T *vs. Other Prices as Deflators*

For Food:

(a) Salary and Wage Earner's Household:

$$\ln (E_F/P_T) = \underset{(2.38)}{4.262} + \underset{(0.05249)}{0.30654} \ln (Y/P_T) - \underset{(0.02686)}{0.9724} \ln (P_F/P_T)$$

$$R^2 = 0.8001$$
$$F(2,9) = 18.009$$
$$SEE = 0.04590$$

$$\ln (E_F/P_N) = \underset{(1.35)}{0.1777} + \underset{(0.05557)}{0.29683} \ln (Y/P_N) + \underset{(0.1560)}{0.31645} \ln (P_F/P_N)$$

$$R^2 = 0.8439$$
$$F(2,9) = 24.32$$
$$SEE = 0.04879$$

(b) All Household:

$$\ln (E_F/P_T) = \underset{(1.35)}{2.189} + \underset{(0.05557)}{0.39998} \ln (Y/P_T) + \underset{(0.2284)}{0.04023} \ln (P_F/P_N)$$

$$R^2 = 0.8671$$
$$F(2,9) = 29.349$$
$$SEE = 0.03988$$

$$\ln (E_F/P_N) = -\underset{(1.14)}{0.4708} + \underset{(0.05638)}{0.3932} \ln (Y/P_N) + \underset{(0.1312)}{0.33326} \ln (P_F/P_N)$$

$$R^2 = 0.8954$$
$$F(2,9) = 38.535$$
$$SEE = 0.04177$$

For Nonfood:

(a) Salary and Wage Earner's Household:

$$\ln (E_N/P_T) = -\underset{(1.81)}{10.71} + \underset{(0.03437)}{1.3400} \ln (Y/P_T) + \underset{(0.1917)}{0.88397} \ln (P_N/P_T)$$

$$R^2 = 0.9941$$
$$F(2,9) = 761.46$$
$$SEE = 0.03099$$

$$\ln (E_N/P_F) = -\underset{(0.902)}{4.918} + \underset{(0.03661)}{1.3549} \ln (Y/P_F) + \underset{(0.09456)}{0.24524} \ln (P_N/P_F)$$

$$R^2 = 0.9935$$
$$F(2,9) = 685.630$$
$$SEE = 0.03214$$

(b) All Household:

$$\ln (E_N/P_T) = -6.305 + 1.5839 \ln (Y/P_T) + 0.26347 \ln (P_N/P_T)$$
$$(2.22) \quad (0.05088) \qquad (0.2359)$$

$$R^2 = 0.9908$$
$$F(2,9) = 485.976$$
$$SEE = 0.03851$$

$$\ln (E_N/P_F) = -2.044 + 1.5912 \ln (Y/P_F) + 0.20390 \ln (P_N/P_F)$$
$$(1.167) \quad (0.05652) \qquad (0.1236)$$

$$R^2 = 0.9888$$
$$F(2,9) = 396.534$$
$$SEE = 0.04188$$

B. National Income Accounts Consumption Data[1]: P_T *vs. Other Prices Represented by Implicit Price Deflators*

For Food:

(a) Total Population

$$\ln (E_F/P_T) = -3.017 + 0.75595 \ln (Y/P_T) + 0.91011 \ln (P_F/P_T)$$
$$(0.832) \quad (0.02688) \qquad (0.1896)$$

$$R^2 = 0.9911$$
$$F(2,9) = 503.555$$
$$SEE = 0.02829$$

$$\ln (E_F/P_N) = -1.297 + 0.76353 \ln (Y/P_N) + 0.52464 \ln (P_F/P_N)$$
$$(0.378) \quad (0.02713) \qquad (0.08917)$$

$$R^2 = 0.9923$$
$$F(2,9) = 578.249$$
$$SEE = 0.02889$$

(b) Per capita:

$$\ln (E_F/P_T) = -3.793 + 0.68758 \ln (Y/P_T) + 0.95768 \ln (P_F/P_T)$$
$$(0.783) \quad (0.03164) \qquad (0.1772)$$

$$R^2 = 0.9866$$
$$F(2,9) = 331.032$$
$$SEE = 0.02622$$

$$\ln (E_F/P_N) = -5.807 + 1.1386 \ln (Y/P_N) + 0.95463 \ln (P_F/P_N)$$
$$(1.05) \quad (0.04874) \qquad (0.2152)$$

$$R^2 = 0.9838$$
$$F(2,9) = 273.075$$
$$SEE = 0.04204$$

For Nonfood:

(a) Total Population:

$$\ln (E_N/P_T) = -5.998 + 1.1097 \ln (Y/P_T) + 0.94008 \ln (P_N/P_T)$$
$$(1.07) \quad (0.03842) \qquad (0.2137)$$

$$R^2 = 0.9893$$
$$F(2,9) = 417.792$$
$$SEE = 0.04196$$

$$\ln (E_N/P_F) = -\underset{(0.670)}{3.946} + \underset{(0.04074)}{1.1208} \ln (Y/P_F) + \underset{(0.1229)}{0.47698} \ln (P_N/P_F)$$

$R^2 = 0.9883$
F(2,9) = 378.720
SEE = 0.04338

(b) Per capita:

$$\ln (E_N/P_T) = -\underset{(1.05)}{5.807} + \underset{(0.04874)}{1.1386} \ln (Y/P_T) + \underset{(0.2152)}{0.95463} \ln (P_N/P_T)$$

$R^2 = 0.9838$
F(2,9) = 273.075
SEE = 0.04204

$$\ln (E_N/P_F) = -\underset{(0.656)}{7.376} + \underset{(0.07494)}{0.84953} \ln (Y/P_F) + \underset{(0.1436)}{1.4040} \ln (P_N/P_F)$$

$R^2 = 0.9575$
F(2,9) = 101.282
SEE = 0.05069

C. National Income Accounts Consumption Data[1]: *P_F and P_N Represented by Whole sale Price Indexes*

For Food:

(a) Total Population:

$$\ln (E_F/P_N) = -\underset{(0.472)}{1.030} + \underset{(0.04674)}{0.74633} \ln (Y/P_N) + \underset{(0.1584)}{0.49389} \ln (P_F/P_N)$$

$R^2 = 0.9929$
F(2,9) = 626.649
SEE = 0.04052

(b) Per capita:

$$\ln (E_F/P_N) = \underset{(0.778)}{0.8097} + \underset{(0.2066)}{1.2703} \ln (Y/P_N) - \underset{(0.1631)}{0.28715} \ln (P_F/P_N)$$

$R^2 = 0.8989$
F(2,9) = 18.944
SEE = 0.07679

For Nonfood:

(a) Total Population:

$$\ln (E_N P_F) = -\underset{(1.25)}{3.883} + \underset{(0.06923)}{1.1817} \ln (Y/P_F) + \underset{(0.1796)}{0.36390} \ln (P_N/P_F)$$

$R^2 = 0.9828$
F(2,9) = 257.874
SEE = 0.06003

(b) Per capita:

$$\ln (E_N/P_F) = -\underset{(1.14)}{1.605} + \underset{(0.2085)}{0.84762} \ln (Y/P_F) + \underset{(0.2328)}{0.14641} \ln (P_F/P_N)$$

$R^2 = 0.8294$
F(2,9) = 21.882

$$SEE = 0.07748$$

Note that all coefficients of the price variable are, as usual, estimates of the elasticity of expenditure with respect to price; the elasticity of quantity with respect to price can be obtained by subtracting.[1]

Reference

1. The Bank of Korea, *Economic Statistics Yearbook,*
2. The Bank of Korea, *National Income Statistics Yearbook,*
3. Ministry of Agriculture and Fisheries, *Report on the Results of Farm Household Economy Sureey and Production Cost Survey of Agricultural Products,*
4. National Agricultural Cooperation Federation, *Prices of Household Goods Paid by Farmers Obtained from Agricultural Year Book,*
5. Economic Planning Board, Bureau of Statistics, *Annual Report on the Family Income and Expenditure Survey,*
6. Tolley, G.S., Y. Wang and R.G. Fletcher, *Re-examination of the Time Series Evidence on Food Demand,*

[1]Time series for "1963–1974."