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CHAPTER I. INTRODUCTION

Attempts to estimate demand equations and explain the factors that influence consumer behavior can be classified into two separate groups. The first group focuses attention on a single commodity such as beef, corn, or wheat, while the overall relationships among the quantities demanded of all commodities in the budget remain in the background. Most of the demand studies fall into the first category. There are relatively few studies in the second group, which concern themselves with the interdependent nature of demand. Brandow's study of demand interrelationships among all food commodities, and George and King's study of consumer demand for food in the United States are notable in the second group. The reason for the comparatively small number of demand studies in the second group is the existing gap between theory and empirical and statistical procedure. In addition to the vast amount of costly data and information on consumer behavior, new methods of collection of information are necessary. Recently economic theory and statistical procedures have been developed to such a degree that we are now able to deal with some of the existing problems.

This study addresses itself mainly to the measurement of income-consumption relationships and demand interrelationships at the retail and farm level in Thailand.

Knowledge of direct and cross price elasticity is necessary for policymakers to use in analyzing the effect of changes in the price of one commodity on its own consumption as well as on prices of other commodities.

Such knowledge can be obtained through the application of appropriate theory and statistical methods to the estimation of demand interrelationships. This study will employ theoretical and empirical methods which will provide ways for estimating demand interrelationships. For example, the estimation of direct or cross price elasticities can be best achieved by the separation of commodities in the utility function into several separate groups, given the assumption of "want independence" and "neutral want association."

It is necessary to analyze the demand for goods at the farm level in order to determine the shares of the retail price which go to the producer of raw materials and the supplier of the marketing services. By assuming a certain relationship between farm and market prices, all information needed regarding the cross price and direct price elasticities can be obtained. The information regarding farm level prices is quite useful to policymakers in determining how to increase the income level of farmers as well as the quantity of goods supplied. This is particularly important for food commodities.

In this study the above considerations will be dealt with in detail. The three main objectives of this study are:

1) to estimate the effect of prices and income on the consumption of food in Thailand by using time series and cross-section data,
2) to bridge the gap between theory and empirical analysis by separating commodities into different groups and using different necessary assumptions, and
3) to estimate the coefficients of demand at farm and market levels.

The agricultural sector contributes the largest share to the GNP of Thailand. Because of the great importance attached to agriculture, the Thai government places emphasis on agricultural planning and development. The adequacy of available information plays a major role in the improvement of plans and policies. The basic reason for doing demand analysis for Thailand is to provide a better basis for making judgments as to the impacts of some alternative courses of action. Better public policies and programs for agriculture will be obtainable if more accurate and more adequate information becomes available for estimating the results of alternative courses of action. Knowledge of the sensitivity of demand in conjunction with all other demand-related information is useful in formulating both economic plans and governmental policies. Carefully planned and competently executed research can provide sound basic information for policy decisions.

The overall objective of this study is to provide a better understanding of the behavior of demand for food in Thailand and also to furnish the policymakers with some insights which will be useful in the development of the agricultural sector. This study may be helpful in throwing light on agricultural development in Thailand, in particular, and may open new dimensions for further thinking on world food problems in general.

CHAPTER II. THE THEORY OF CONSUMER BEHAVIOR

According to Henri Theil (1975, p. 1), "The primary objective of consumption theory is to describe the factors that determine the amounts spent by the consumer on the goods and services which are available in the marketplace, and to assess the influence of these factors." In this chapter a brief review of utility theory is presented as a basis for describing consumer behavior.

The consumer is one of the two principal decision-making units in the economy; therefore, it is important to study his behavior. A tool used for this study in economics is utility maximization theory. Generally, the rational consumer desires to purchase a combination of commodities from which he derives the highest level of satisfaction. His problem is one of maximization. However, his income is limited and he is not able to purchase an infinite amount of commodities. In other words, he maximizes his satisfaction subject to a budget constraint.

An individual consumer faces a problem of choice. He must choose between different bundles of goods, so that the satisfaction he derives from consuming those bundles is as great as possible. This implies that he is aware of the alternatives facing him and is capable of rational evaluation. All the information concerning the benefits which the consumer derives from various quantities of commodities is contained in his utility function of preference relationship. Since utility has been a central point of controversy in the theory of consumer behavior, it must be discussed briefly.

Concept of Utility

According to Chipman (1960, p. 221):

> Utility in its most general form is a lexicographic ordering represented by a finite or infinite dimensional vector with real components unique only up to isotone (order preserving) homogenous transformation and these vectors are ordered lexicographically like decimal numbers or words in a dictionary.

Utility was not described as above by nineteenth century economists. For instance, Bentham, who brought the principle of utility into a prominent position, Stanley Jevons, Leon Walras and Alfred Marshall all considered utility measurable (see Stigler, 1965 and Dorfman, 1964). The consumer was assumed to possess a cardinal measure of utility; he was assumed to be capable of assigning to every commodity or combination of commodities the numbers representing the amount or degree of utility associated with it. According to Henderson and Quandt (1958, p. 7), "It was assumed by the nineteenth century economist that the addition to the consumer's total utility resulting from consuming additional units of a commodity decreases as he consumes more of it."

The assumptions of cardinal utility are very restrictive. Equivalent conclusions can be deduced from much weaker assumptions. The assumption of cardinality of utility was relaxed by Fisher (1892) and Pareto (1896). They realized that if a particular set of numbers associated with various combinations of commodities is a utility index, then any monotonic transformation of it is also a utility index.[1] In other words, if utility reaches a maximum

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[1] A function F(U) is a monotonic transformation of U if $F(U_1) > F(U_0)$ whenever $U_1 > U_0$.

with a certain group of commodities, then any order-preserving transformation of that function also reaches a maximum at that particular basket.

As noted above, there are two basic approaches to the study of consumer behavior. The first, generally called the cardinal utility theory, involves the use of measurable marginal utility. The alternative to the classical theory is the ordinal approach, which does away with restrictive assumptions of cardinality. In the latter approach, the preference of the individual requires satisfaction of certain rules and axioms.

The first axiom is comparability or ranking ability; according to this axiom the consumer is able to rank bundles of commodities in order of preferences. Given two bundles, q^0 and q^1, if the consumer derives more utility from q^0 than from q^1, he is said to prefer q^0 to q^1. The postulate of rationality is equivalent to the following statements: For all possible pairs q^0 and q^1, the consumer knows whether he prefers q^0 to q^1 or q^1 to q^0 or if he is indifferent between them. There is no stipulation as to the degree of one's preference for one bundle over the other. All that is certain is that one is preferred to the other or they are equally preferred by the individual. Nevertheless, both alternatives cannot be held simultaneously.

Axiom two is transitivity or consistency. Suppose there are three bundles (q^0, q^1 and q^2) and that the following conditions prevail:

(a) $q^0 > q^1$ and

(b) $q^1 > q^2$.

where $q^i > q^j$ means q^i is preferred to q^j

The axiom of consistency asserts that a set of preference relationships satisfying (a) and (b) will also satisfy the following relationship:

$q^0 > q^2$.

Axiom three is monotonicity. This axiom eliminates the possibility of consumer satiation. George and King (1971, p. 5) point out that, "In the preference ordering, if the commodity bundles are ranked in an increasing order of preference, the preference relationship remains monotonically increasing."

Axiom four is convexity. The consumption set C is called convex if, for any two bundles q^0 and q^1 in C and any λ, $0 \geq \lambda \geq 1$, the vector $\lambda q^0 + (1 - \lambda)q^1$ is in C. The convexity assumption is very important in the maximization procedure. From this assumption, it can be concluded that the indifference curves are convex. Quasi-concavity is a minimal property for a utility indicator. Arrow and Enthoven have shown that if the utility function is quasi-concave and monotonic the usual first order conditions are necessary and sufficient for obtaining a solution for a constrained maximization problem (Arrow and Enthoven, 1961).

Development of Demand Estimation

According to George and King (1971, p. 5):

> The concepts of demand, as stated in the middle of the nineteenth century by Cournot and Dupuit, were popularized by Marshall. The Marshall Theory, focusing on the quantity-price relation for a single commodity, holding income and all other prices constant, provided a demand function uncompensated for income effect. The work of Pareto and Walras focused on the more general case in which all the prices and income are variable. However, the basic theory was clarified by Hicks (1939), in his famous mathematical analysis. His work drew on the article written in 1915 by Slutsky (1952) who distinguished between income and substitution effects due to a price change and between a compensated and an uncompensated demand function.

Mathematical Demand Derivation

Given the consumer's preferences and his budget constraint, which restricts him to a subset of commodity space, the consumer will choose the bundle of goods which provides him with the greatest amount of satisfaction. The budget constraint states that the total money expenditure on all goods cannot exceed money income. Supposing that a consumer with a given income, Y, makes a choice of quantities, $q_1, q_2, \ldots, q_n$ from a commodity space with n elements, then the utility function can be specified as follows:

$$u = u(q_1, q_2, \ldots, q_n) \tag{2.1}$$

where $Q = (q_1, q_2, \ldots, q_n)$. It is assumed that all n money prices are summarized by a price vector: $P = (p_1, p_2, \ldots, p_n)$ where p_j is the price of commodity j. Therefore, the consumer's total expenditure is $p_1q_1 + p_2q_2, \ldots, p_nq_n$ which cannot exceed his money income. The above can be summarized in the following manner:

$$\sum_{j=1}^{n} p_j q_j \leq Y \tag{2.2}$$

where p_jq_j is the total expenditure on commodity j. Given the budget constraint, the problem facing the consumer is choosing the bundle $Q^* = \{q_1^*, q_2^*, \ldots, q_n^*\}$ which is most preferred over any other bundle Q, $Q^* \geq Q$. In terms of the utility function, the problem is:

$$\text{to maximize } U(q_1, \ldots, q_n)$$

$$\text{subject to } \sum_{j=1}^{n} p_j q_j = Y ,$$

$$q_j \geq 0 ,$$

which is a nonlinear problem. It is possible to use the Lagrangian method to obtain the solution.

From the utility function (2.1) and the budget constraint (2.2), we form the function:

$$V = U(q_1, q_2,\ldots,q_n) + \lambda(Y - p_1q_1 - p_2q_2,\ldots,p_nq_n)$$

where λ is an as yet undetermined Lagrange multiplier. V is a function of $q_1,\ldots,q_n$ and λ. Moreover, V is identically equal to U for those values of q_1 to q_n which satisfy the budget constraint, since $Y - p_1q_1 - p_2q_n$ $,\ldots,-p_nq_n = 0$. To maximize V, we calculate the partial derivatives of V with respect to the n ÷ 1 variables and set them equal to zero:

$$\begin{aligned} &U_1(q_1,\ldots,q_n) - \lambda p_1 = 0,\\ &\vdots\\ &U_j(q_1,\ldots,q_n) - \lambda p_j = 0,\\ &Y - p_1q_1 - p_2q_2,\ldots,-p_nq_n = 0,\\ &j = 1, 2, \ldots, n. \end{aligned} \qquad (2.3)$$

The system of equations in (2.3) provides (n + 1) equations in (n + 1) variables $(q_1, q_2,\ldots,q_n)$ and λ. When all prices and income are given, we can solve for q_1 to q_n in terms of prices and income so that

$$\begin{aligned} &q_j = q_j(p_1, p_2,\ldots,p_n, Y),\\ &j = 1, 2,\ldots,n . \end{aligned} \qquad (2.4)$$

The quantity of a commodity that the consumer purchases generally depends upon the prices of all commodities and his income. Thus the relationship in (2.4) represents a set of demand functions.

Here the quasi-concavity assumption about the utility indicator plays its role. The condition expressed in (2.3) only assures that the consumer is at a maximum or a minimum of his preference function. The sufficient condition for a maximum is the satisfaction of a second order condition. In other words, the utility function $U(q_1,\ldots,q_n)$ should be a twice differentiable quasi-concave function in the neighborhood of the optimum. Here we shall use a property of concave and quasi-concave functions. The Hessian matrix, H of U, can be written as:

$$H = \begin{bmatrix} U_{11} & U_{12} & U_{13} \cdots\cdots & U_{1n} \\ U_{21} & U_{22} \cdots\cdots\cdots & & U_{2n} \\ \vdots & & & \vdots \\ U_{n1} & U_{2n} & & U_{nn} \end{bmatrix} ,$$

where

$$U_{ij} = \frac{\partial^2 U}{\partial q_i q_j} \quad .$$

For a quasi-concave function, the bordered-Hessian matrix (bordered with the $\partial U/\partial q_i$) has principal minors of alternating signs starting with a negative. Therefore:

$$(-1)^r Dr \geq 0 \qquad (r = 1, 2, \ldots, n)$$

where

$$Dr = \begin{bmatrix} 0 & U_1 & U_r \\ U_1 & U_{11} & U_{1r} \\ \vdots & & \\ U_r & U_{r1} & U_{rr} \end{bmatrix}$$

and where

$$U_J = \frac{\partial U}{\partial q_j} \quad (J = 1 \ldots\ldots n) \quad ;$$

if n is equal to two,

$$\begin{bmatrix} 0 & U_1 & U_2 \\ U_1 & U_{11} & U_{12} \\ U_2 & U_{21} & U_{22} \end{bmatrix} > 0 \quad .$$

Properties of Demand Functions

The demand function which is derived from the first order condition satisfies a number of important relationships. Wold and Jureen (1964) and Pearce (1961) have summarized these demand properties. Demand functions are homogeneous of degree zero; this means if all prices and income change in the same proportion, the quantity demanded remains unchanged. In the case of two commodities, the first order conditions are:

$$U_1 - \lambda p_1 = 0 \quad ,$$

$$U_2 - \lambda p_2 = 0 \quad ,$$

$$Y^0 - p_1q_1 - p_2q_2 = 0 \quad .$$

From the above equations we obtain the following condition:

$$\frac{U_1}{U_2} = \frac{p_1}{p_2} \quad .$$

If we multiply the prices and income by a constant K, the first order conditions become:

$$U_1 - \lambda Kp_1 = 0 \; ,$$

$$U_2 - \lambda Kp_2 = 0 \; ,$$

$$KY^0 - Kp_1q_1 - Kp_2q_2 = 0 \; .$$

Since $K \neq 0$

$$Y^0 - p_1q_1 - p_2q_2 = 0.$$

By eliminating K from the first two equations, the same result obtained by equation (2.5) will appear:

$$\frac{U_1}{U_2} = \frac{p_1}{p_2} \text{ and } Y = p_1q_1 - p_2q_2 = 0$$

Therefore, the demand function for the price-income set (Kp_1, Kp_2, KY^0) is derived from the same equations as for the price-income set

(p_1, p_2, Y^0). It is also easy to demonstrate that the second order conditions are unaffected, providing that the demand functions are homogeneous of degree zero in prices and income.

Given a demand function for commodity i,

$q_i = q_i(p_1, p_2, \ldots, p_n, Y)$,

by applying Euler's theorem for homogeneous functions of degree zero, we have

$$p_1 \frac{\partial q_i}{\partial p_1} + p_2 \frac{\partial q_i}{\partial p_2} + \ldots\ldots p_n \frac{\partial q_i}{\partial p_n} + Y \frac{\partial q_i}{\partial Y} = 0 \cdot q_i \ . \tag{2.6}$$

If we divide (2.6) by q_i it will convert to elasticity terms, showing that the sum of own and cross-price elasticities (e_{ii} and e_{ij}) and income elasticities (e_{ip}) add to zero:

$e_{i1} + e_{i2} + \ldots\ldots e_{in} + e_{iY} = 0$.

The sum of the income elasticities weighted by the total expenditure proportions equals unity. This is called the Engel aggregation. To show that, we can take the total differential of the budget constraint (2.2),

$$p_1 dq_1 + p_2 dq_2 \ldots\ldots + p_n \ dq_n = dY \ ; \tag{2.7}$$

multiplying through by Y/Y, dividing both sides by dY, and then multiplying the first term on the left by q_1/q_1, the second by q_2/q_2 and the n^{th} by q_n/q_n, equation (2.7) converts to weighted income elasticities:

$W_1 e_{1Y} + W_2 e_{2Y} \ldots\ldots W_n e_{nY} = 1$,

where $W_i = (p_i q_i / Y)$.

The weighted sum of the own and cross-price elasticities of the j^{th} commodity is equal to the negative of the expenditure proportion on the j^{th} commodity. This property is called the "Cournot aggregation." It is rather easy to prove the above statement. In the case of two commodities, if we take the total differential of the budget constraint:

$$dp_1q_1 + p_1dq_1 + dp_2q_2 + p_2dq_2 = dY^0$$

and set $dY^0 = 0 = dp_2 = 0$, we obtain

$$p_1dq_1 + q_1dp_1 + p_2dq_2 = 0 .$$

Multiplying through by $p_1q_1q_2/Y^0q_1q_2dp_1$, we obtain the desired result

$$W_1e_{11} + W_2e_{12} = -W_1 .$$

Substitution and Income Effects

A rational consumer will purchase quantities of goods in order to maximize his satisfaction. Therefore, equations (2.3) will be satisfied. The Slutsky (1952) relationship incorporates fundamental relationships between the change in quantities and the marginal utility of income. Change in price and income will normally alter the consumer's expenditure pattern; but the new quantities (and price and income) will still satisfy (2.3). The effects of simultaneous changes in price and income can be obtained by taking the total derivative of the first order conditions (2.3). The mathematical derivation of the Slutsky equation is developed in the Appendix. After necessary mathematical manipulations the equation below, known as the Slutsky equation, is obtained:

$$\frac{\partial q_i}{\partial p_i} = \left(\frac{\partial q_i}{\partial p_i}\right) u = \text{constant} - q_j \left(\frac{\partial q_i}{\partial Y}\right) . \qquad (2.8)$$

Equation 2.8 provides a breakdown of the effect of an own price change on the quantity demanded of a good into a pure substitution and a pure income effect. The Slutsky equation may be expressed in terms of the price and income elasticities. Multiplying (2.8) through by p_j/q_i and multiplying the last term on the right by Y/Y, we get:

$$e_{ii} = E_{ii} - W_j e_{Yi} .$$

The price elasticity of ordinary demand is equal to the price elasticity of compensated demand plus the corresponding income elasticity multiplied by the proportion of the total expenditure spent on q_i. It is possible to show that compensated cross-price derivatives are symmetrical

$$\frac{\partial q_i}{\partial p_j} + q_j \left(\frac{\partial q_i}{\partial Y}\right) = \frac{\partial q_j}{\partial p_i} + q_i \left(\frac{\partial q_j}{\partial Y}\right) ; \qquad (2.9)$$

by converting (2.7) into elasticity terms we get

$$e_{ij} = \frac{W_j}{W_i} e_{ji} + W_j \left(e_{jY} - e_{iY}\right) .$$

The substitution effect will be negative if i = j.

The demand restrictions expressed in terms of elasticity are summarized in Table 1 (see George and King, 1971, p. 10).

Table 1. Matrix of demand elasticities

q_i	P_i			
	P_i	$P_2 \ldots\ldots\ldots$	P_n	Y
q_1	e_{11}	e_{12}	e_{1n}	e_{1y}
q_2	e_{21}	$e_{22} \ldots\ldots\ldots$	e_{2n}	e_{2y}
$\vdots$				
q_n	e_{n1}	e_{n2}	e_{nn}	e_{ny}

A row restriction is shown as:

$$\sum_j e_{ij} + e_{iy} = 0 \; ;$$

for $i = 1,\; e_{11} + e_{12} + e_{13} + \ldots\ldots + e_{1n} + e_{1y} = 0$.

Engel aggregation can be written as:

$$\sum_i W_i \; e_{1y} = 1 \; ;$$

$$W_1 e_{1y} + W_2 e_{2y} + W_3 e_{3y} \ldots\ldots + W_n e_{ny} = 1 \; .$$

Cournot aggregation can be written as:

$$\sum_i W_i e_{ij} = -W_j \; ;$$

for $j = 3,\quad W_1 e_{13} + W_2 e_{23} + W_3 e_{33} \ldots\ldots W_n e_{n3} = -W_3$.

The Slutsky effect is shown as:

$$e_{ji} = e_{ij}(W_i/W_j) + W_i(e_{iy} - e_{jy})$$

for $j = 3,\; i = 2,\; e_{32} = e_{23}(W_2/W_3) + W_2(e_{2y} - e_{3y})$.

CHAPTER III. EMPIRICAL MODELS OF CONSUMER DEMAND

The theoretical basis of consumer behavior was discussed in the previous chapter. It was shown that consumer demand can be developed through the utility approach. Furthermore, the demand function is derived from utility maximization.

Explanation and prediction are the goals of economic theory. Both theoretical analysis and empirical investigation are necessary for the achievement of these goals. To test the conclusions based on the utility approach, empirical analysis is necessary. In the next few pages a summary of some important cases of empirical analysis of demand will be presented.

The effect of price and income on consumption has been the subject of many studies, such as Engel's study of family budgets based on data concerning the incomes and expenditures of a large number of families. Engel discovered that the income elasticity of demand for food was quite low. He concluded from his study that the proportion of the family's income spent on food was a good index of its welfare. The poorer the family, the greater the proportion of its total expenditure was allocated for food (Stigler, 1965, p. 203).

A new chapter in the development of empirical demand estimation was opened by the pioneer attempts of Benini (1907), Moore (1917) and Lehfeldt (1914), although as Fox (1958) pointed out, "applied work in this field did not really get underway until World War I." According to Stigler (1962, p. 1):

> Mathematical analysis became increasingly common after Walras's first edition . . . but statistical economics, the name given by Henry Moore, is one of the important modern developments. Henry Moore was its founder . . . Moore's basic contribution was not to invent this field, but he made statistical estimation of economic functions an integral part of modern economics.

Individual commodity studies proliferated after Holbrook Working's study of potatoes (1922). Elmer J. Working (1927) gave a clear account of what is now called the identification problem. Henry Schultz (1928) calculated weighted regressions, allowing for the effects of measurement errors in both price and quantity variables; in Schultz (1938), he reviewed economic theory and reported a large number of empirical studies of demand. All of his attempts to estimate demand functions were made in order to facilitate price-quantity forecasting and to approximate the demand curve of economic theory. The factors which contributed most to the improvement of empirical studies include the advancement of "econometric theory," the development of the calculating machine, data processing and data availability. Correlation techniques and other statistical procedures have helped in estimating the demand function and its parameters. The development of testing techniques has provided the framework for testing the hypotheses regarding the behavior of variables.

Studies in demand analysis use both time series and cross-section data. In this study, the same pattern will prevail. It has been assumed throughout that the behavior of a representative consumer at a certain time and locality will represent the consumption pattern of that particular area at the same period of time.

Cross Section Analysis

Cross-section data consists of observations of the values of economic variables at a given point in time or, typically, during a given interval of time. Each observation on a defined variable such as price may be the observed value of price in a specified geographic locality or in a given institution, such as a household. The number of observations in the sample would then be the total of such observed values of prices for all localities or all institutions included in the sample.

In most cases, published data on consumption patterns give the quantity of food items purchased by certain income classes. Based on these grouped data, it is possible to obtain a weighted regression to estimate an income elasticity. A systematic application of this procedure is available in Wold and Jureen (1964, p. 216) and also in the estimation of income elasticity by Prasit Supradit for Thailand (1975). Wold and Jureen divided the families in the sample into four groups according to size, further dividing each group into four subgroups according to income level. The regression equation was fitted in the form $d = cY^E$, using logarithmic regression. The income elasticity of the i^{th} family size group is calculated as follows:

$$E^i = \frac{\Sigma U_v \ (X_v - M_x) \ Y_v}{\Sigma U_v \ (X_v - M_x)^2}$$

where

$U_v = N_v C_v$ = total number of consumer units,

N_v = number of households or families,

C_v = consumer units per household,

X_v = income per consumer unit,

Y_v = food expenditure per consumer unit,

x_v = log X_v,

Y_v = log y_v, and

$$M_x = \frac{\Sigma U_v X_v}{\Sigma U_v} .$$

Prais and Houthakker (1955) considered the difficulties of using cross-section data to quantify the concepts of theoretical demand analysis. Most of the studies in this area are based on the assumption of constant elasticity over a range of time, where income and quantity are the only relevant variables. Some studies have been done to overcome the problem of variable selection. Herrman (1964), who analyzed U.S. consumption data, shows that the important variables in the food consumption pattern are income, urbanization, region, life cycle stage, education of household and social class.

Time Series Analysis

According to K. Fox (1968, p. 143):

> Most sciences are concerned in part with phenomena which show quantitative variation over time. Some scientists have had considerable success with time series problems, and economists have experimented with their methods. Some of these adaptations have been of little value, while others have at least provided valuable insights to experimenters.

The static theory of demand for an individual specifies that the quantity demanded is a function of own price as well as of prices of other goods and income (which includes saving). Prices and income are the given variables in the model. In other words, an individual cannot affect the price because of the assumption of "free competition." In order to estimate the market demand function within the above theoretical framework, some of the assumptions of the model should be reconsidered.

Predetermined variables for individual demand may not be valid for market demand. One group of commodity analysts argues that the classical model can be utilized for market demand estimation in a given country since prices are determined in the world market. Another group of commodity specialists from the United States has argued that prices of agricultural commodities are the function of (1) available quantities at the end of harvest season and (2) income shift variables. Separation of total demand into domestic, export, and inventory demands is often necessary even if we are only dealing with a study of a single commodity. It is necessary to adopt a multi-equation model in order to cover the various parts of the total demand. According to George and King (1971, p. 15), "The approach adopted by the analyst of time series data depends on a great variety of questions relating to the scope of the model and problems of estimation." A few important related problems of demand estimation are presented below.

Single Equation Models

There are two basic possible approaches to demand function estimation. (1) The demand function may be regarded as one member of a set of interdependent relationships, in which case the appropriate approach will be the simultaneous equation technique. (2) The demand function may be regarded as a single independent relationship and not affected by other commodity prices. If this condition prevails, the single equation approach is recommended for estimation. In such a procedure, one commodity can be singled out for analysis; the model below might be specified as a first approximation:

$$q_{it} = f_i(p_{it}, z_{it}, Y_t, U_{it}) ,$$

where

q_{it} = per capita consumption of i^{th} commodity,

p_{it} = price of the i^{th} commodity (assumed exogenous),

z_{it} = other factors affecting demand (assumed exogenous),

Y_t = per capita disposable income (assumed exogenous), and

U_{it} = a random disturbance.

Specification error

Strictly speaking the term "specification error" covers any type of error in the specification of the model being estimated. To justify estimation by ordinary least squares, specific assumptions must be considered. If any of the assumptions are violated, the estimation of parameters will be biased. For example, the error term should not be correlated with the independent variables. The absence of autocorrelation and constant variance over time is required. In addition, a sufficient number of observations should be made in relation to the number of parameters to be estimated. If any of these requirements is not met, more complex methods must be used. These methods can be found in econometrics texts such as Goldberger (1964), or Malinvaud (1966).

Multicollinearity

One of the basic assumptions of the general linear model is the absence of linear dependency between explanatory variables. In other words, the data matrix of explanatory variables of order n by k has the rank of k. In the case of the existence of multicollinearity, the following complications arise (see Johnston, 1963):

1) The degree of precision of estimation falls so that it becomes very difficult--if not impossible--to disentangle the relative influence of the various variables.
2) Investigators are sometimes led to drop variables incorrectly from the analysis because the coefficients are not significantly different from zero.
3) The estimation of coefficients will become very sensitive to particular sets of data. In demand estimation, price and income often move together over time, resulting in problems of multicollinearity. In such cases, other methods of estimation should be introduced.

<u>Relevant variables</u>

The quantity of any commodity is a function of all prices and income. The estimation of all the above parameters is very difficult or impossible when time series data are used. To simplify the estimation procedure, the concept of a separable utility function will be utilized.

<u>Mathematical form of equations</u>

It is very difficult to outline a functional form for demand which will be applicable in all cases. Nevertheless, one of the following functional forms is used by commodity analysts for demand estimation:

linear:

$q = a + by + cp + u$;

semilogarithmic:

$q = a + b \log y + c \log p + u$;

double logarithmic:

$\log q = a + b \log y + c \log p + u$;

inverse logarithmic:

$\log q = a + by + cp + u$.

Simultaneous Equation Models

Up to this point we have discussed the estimation of a single equation isolated from a larger economic model of which it may be a part. The demand equation for a particular commodity is a part of the system of equations that determines the equilibrium price and quantity in the market for that commodity. Concentration on the demand matrix alone would limit to some extent the realistic analysis of an individual commodity in the market. This is unfortunate but necessary within the scope of this study. However, estimation of simultaneous relationships is difficult within a demand matrix. According to demand theory, the consumption of commodities is interrelated. Therefore, if the single equation method is applied for the estimation of demand functions, it is certainly possible to arrive at some biased coefficients.

There are different procedures used to handle simultaneous equations such as two-stage least squares, full information maximum likelihood, and three-stage least squares. There are many problems involved in using the simultaneous estimation procedures. Even though some of these problems have been solved, there still remains some doubt regarding the advantage of simultaneous over single equation approaches (see Christ, 1960).

Due to the existence of endogenous variables among the explanatory variables in simultaneous equations, the ordinary least square estimators of the structural coefficients are not consistent. However, application of the same procedure to the reduced form gives a consistent estimation of parameters. Finally, the major task facing a researcher is not the estimation procedure, but rather the definition of an identifiable model.

Supposing that there are n endogenous variables $Y_1, Y_2, \ldots, Y_n$ and m exogenous variables $z_1, z_2, \ldots, z_m$, the structural equations can be represented as

$$BY + CZ = U \; .$$

The reduced form is given by

$$Y = -B^{-1}CZ + B^{-1}U \; .$$

Whether the estimates of structural coefficients can be derived from the consistent estimation of reduced form coefficients is a question which still remains to be answered. The answer is positive if the identification problem is resolved. There is one condition, known as the order condition, that must be satisfied for the model to be identified. According to J. Kmenta (1971, p. 534), this condition in fact states that, "A necessary condition for identification of a given structural equation is that the number of predetermined variables excluded from the given equation is at least as large as the number of endogenous variables included in the equation less one." So in the present example, the maximum number of variables that can appear in any equation is

$\{n + m - (n-1)\} = m + 1$

As far as the system of demand equations for all commodities is concerned, it is difficult to meet this identification criterion.

Time Dimension in the Demand Model

The time dimension generally poses quite a serious problem in economic analysis. The econometric analysis of demand is no exception. A number of attempts have been made to incorporate time in the static formulation of the demand function. For this purpose, distributed lag models and recursive systems have been used. The history of the distributed lag model dates back to the 1930s, with the work of Irving Fisher and Tinbergen. Tinbergen (1951) suggested a model with no assumptions regarding the relations among parameters of successive prices. Furthermore, he suggested that no restriction be imposed on the distribution of the lagged effect of past prices on the quantity demanded. The past prices should be added up to the point where the coefficient associated with the last price turned out to be statistically nonsignificant.

Cagan (1956) suggested the adaptive expectation model in which expectations of (p^*) are revised in proportion to the error associated with the previous level of expectation:

$$p^*_{t+1} - p^*_t = B(p_t - p^*_t) \;, \quad 0 < B < 1 \;.$$

This model implies a geometrically decaying distributed lag from expected price as a function of all past prices.

$$p^*_{t+i} = \sum_{i=0}^{\infty} B(1 - B)^i p_{t-i}$$

Cagan used a variable in a more general equation of the form

$$q_t = ap_t^* + U_t ,$$

trying out different B's, constructing the associated $\hat{p}$ series and choosing that B which led to the highest R^2 in the above equation.

Koyck (1954) showed that an equation of the form

$$q_t = a\Sigma(1 - \lambda) \lambda^i p_{t - i} + U_t$$

could be reduced or slowed by applying one set of lagged prices and multiplying through by λ. The next step is to substract the resultant equation from the original equation to yield

$$q_t = a(1 - \lambda) p_t + \lambda q_{t - 1} + U_t - \lambda u_{t - 1}$$

Nerlove (1958a) combined the Cagan adaptive expectation model with Koyck's reduction procedure to provide both an acceptable rational and feasible estimation procedure applicable to a wide range of problems. In addition, he suggested an alternative justification for the assumed form of lag. In this model, current values of the independent variables determine the "desired" value of the dependent variable:

$$q_t^* = ap_t + U_t ,$$

but only some (fixed) fraction of the desired adjustment can be accomplished within any one particular time period

$$q_t - q_{t - 1} = V(q_t^* - q_{t - 1}) .$$

Nerlove's (1958b, p. 308) comparison of the three approaches indicates that

Because of the limited length of, and degree of autocorrelation in, most economic time series the first approach where nothing is assumed is not always feasible. On the other hand, the second approach must necessarily contain a somewhat arbitrary assumption concerning the form of distribution of the lag. The third approach leads to a direct interpretation of the distribution of the lag in terms of producer or consumer behavior and therefore in terms of difference between short- and long-run elasticities of supply or demand.

Mixed Data Studies

Two types of data are used for estimating the demand function. When the collinearity of the explanatory variables is strong, there is difficulty in estimating the individual influence of each variable. This has been true in many time series studies, and therefore cross-section data have been used to estimate the income coefficient before estimating the price coefficient from time series data.

The easiest way of using the two types of data can be illustrated by a simple example. Consider the model:

$$Y = \alpha + B_1X_1 + B_2X_2 + U ,$$

$$Y - BX_1 = \alpha + B_2X_2 + U ;$$

if, in cross-section data, X_2 is held constant while regressing Y on X_1, then the least squares estimate of B_1 can be obtained. Then, using the time series, if we regress $(Y - bX_1)$ on X_2, we will get an estimate of B_2. This estimation approach disregards the fact that B_1 is a stochastic variable.

Goreux (1960) analyzed consumption behavior, based on data derived from household surveys and time series of national averages. The latter consisted of three kinds of comparisons: (1) household surveys: consumption of households in a given period; (2) international comparisons: average consumption in different countries in a given period; and

(3) time-series: change in the average consumption over the last decade. More recently, however, techniques of mixed estimation have been developed which allow for use of stochastic information. Barten (1964) used the latest development, introducing extraneous estimates of means and variances of coefficients into his estimation procedure. Unfortunately, there are still many problems unsolved in the combined use of time series and cross-section data. For a more extensive study, see Bridge (1971).

Shifts in Demand Curves

One of the characteristics of the demand curve is its temporary nature. This implies that the shape and position of the curve is likely to change with the passage of time. The shift in the demand curve is normally accounted for by a change in the value of some of the variables which affect demand.

The effect of such shifts on coefficients has been recognized by Daly (1956). If such a change in the structure of demand is recognized and the shift variables are identified, it is possible to introduce this factor into the equation by using dummy variables, in the form of one and zero. The former is used when a shift variable appears; otherwise, zero is used. Another method of handling this problem is to break the total period into subperiods, in each of which no shift has occurred. However, the disadvantage of using the latter method is the problem that will arise regarding the number of observations per subgroup.

The Gap Between Demand Theory and Empirical Analysis

Economic researchers have always been faced with the existing gap between theory and empirical analysis. P. S. George and G. A. King (1971, p. 20) state this problem clearly.

> In theoretical development, we specify certain postulates and deduce the behavior of the variables through logic. In contrast, empirical studies deal with quantifiable phenomena. Often theoretical development and empirical analysis complement each other--empirical analysis can be used to verify the validity of certain theories. Sometimes certain theories are reached by starting from an empirical analysis. In the field of demand analysis, econometrians have often built empirical models based on the significance of economic variables, like price and quantities, and justified their findings through economic theory. On the other hand, some models in consumption theory are not subject to empirical verification because of deficiencies in data or in statistical procedure. As a result of this, we are faced with a situation of insufficient predictive power, inappropriate basis for empirical analysis, and difficulties in establishing empirical confrontation which is often referred to as the gap between theory and empirical analysis.

Economic theory has long recognized the mutual interdependence of a large number of consumer goods in the budget decisions of the individual consumer. Therefore, demands for all commodities are interrelated and any empirical study should consider the demand for all commodities simultaneously.

However, the formulation of an empirical model which explicitly recognizes the simultaneity of many price and income effects is difficult because of the number of parameters involved. In the budget of n goods there are $(n^2 + n)$ price and income elasticities. The symmetry of compensated price effects reduces the number to $1/2n(n + 1) + n$. The Engel and Cournot elasticity aggregation relationships further reduce the number by $n + 1$, leaving $1/2(n^2 + n - 2)$ parameters to be estimated. This number still remains too large to permit direct estimation of a system of equations involving large numbers of commodities.

Given the above problem, two different approaches have been adopted: a single commodity or subsector analysis, and the "integrationist's approach" of Boutwell (1965, p. 8).

Single and Integrated Approaches

Estimation of the demand functions for commodities is possible by either the single of the integrated approach. In view of the rather short span of available time series data for some important categories of consumer goods, the estimation of so many parameters may be difficult. One could take a single equation partial equilibrium approach and eliminate many parameters by the assumption of zero effect of omitted variables. The difficulty which arises here, aside from other complications, is the possibility that each individual omitted variable has a negligible effect but the combined effect of all omitted variables may be significant. Furthermore, the number of variables included in the model is totally dependent upon the subjective judgment of the researcher.

The second approach, which considers the interrelationships among all commodities, is faced with degree of freedom and identification problems. An attempt has been made to overcome these problems by assuming certain relations among commodities in the utility function. Strotz (1957) and Houthakker (1960) were among the first to develop and use such an approach. Their major contributions were the ideas of the utility tree, additivity of preferences, and separability. A further contribution to the second approach was made by Frisch (1959), who developed the assumption of "want independence" and tried to estimate direct price and cross-price elasticities by utilizing this assumption.

The Frisch model

This model incorporates the principle of integration. The model postulates a utility function $U(X_1, X_2,\ldots,X_n)$ for which one can specify particular effects on the marginal utility $U_i = \{\partial U(X_1, X_2,\ldots,X_n)\}/\partial X_i$ of certain goods in response to consumption change in certain other goods. Several intuitively tenable postulated relationships have been defined, which reduce the number of parameters to the desired level while still preserving most of the simultaneity of the system. Frisch assumes that the marginal utility of some or all commodities is independent of the consumption level of other commodities. "The marginal utility of using more electricity in the home can safely be regarded as independent of the quantity of Swiss cheese consumed" (Frisch, 1959, p. 178). In other words, the marginal utility of good i is not affected by the consumption level of good j for all $j \neq i$.

Thus far, many properties of the demand function have been discussed. From this point the discussion of the same properties under the "want independence" assumption will be continued.

Frisch started with the utility function and the budget constraint of the representative consumer as:

$U(q_1, q_2,\ldots,q_k,\ldots,q_n)$ and

$p_1q_1 + p_2q_2\cdots\cdots + p_kq_k,\ldots,p_nq_n = Y$

where q_1 to q_n are the quantities of goods possessed by the consumer, $p_1, p_2,\ldots,p_n$ are prices, and Y is income. This consumer is in equilibrium when

$$\frac{U_1}{p_1} = \frac{U_2}{p_2} \cdots\cdots = \frac{U_n}{p_n} = \lambda \ ,$$

where

λ is the marginal utility of money and

$$U_k = \frac{\partial U(q_1,\ q_2,\ldots,q_n)}{\partial q_k} \ . \qquad (3.1)$$

The demand for good i can be derived from the first order condition as a function of income and prices:

$$q_i = q_i(p_1,\ p_2,\ldots,p_n,\ Y) \ .$$

The demand elasticities with respect to price (e_{ij}) and the income elasticity (e_{iY}) are defined as

$$e_{ij} = \frac{\partial q_i}{\partial p_j} \cdot \frac{p_j}{q_i} \ ,$$

$$e_{iY} = \frac{\partial q_i}{\partial Y} \cdot \frac{Y}{q_i} \ , \qquad (i = j = 1,\ 2,\ldots,n) \ .$$

The budget proportions are

$$W_i = \frac{p_i q_i}{Y} \ .$$

Considering the equations that defined the marginal utility (3.1) as a function of quantities consumed,

$$U_i = U_i(q_1,\ q_2,\ldots,q_n) \ . \qquad (3.2)$$

The inverse function of (3.2) can be written as

$$q_i = q_i(U_1,\ U_2,\ldots,U_n) \ .$$

Frisch respectively defines acceleration, want elasticity, and money flexibility as

$$C_{ik} = \frac{\partial U_i(q_1, q_2,\ldots,q_n)}{\partial q_k} \cdot \frac{q_k}{U_i(U_1,\ldots,U_n)} ,$$

$$J_{ik} = \frac{\partial q_i(U_1,\ldots,U_n)}{\partial U_k} ,$$

$(i = 1, 2,\ldots, n)$

$(k = 1, 2,\ldots, n)$,

$$\emptyset = \frac{d\lambda}{\partial Y} \cdot \frac{Y}{\lambda} .$$

If we take the derivative from the first order conditions with respect to p_j and manipulate the result,[1] for the Slutsky equation we will get

$$e_{ij} = \sigma_{ij} - W_j e_{iY} - \frac{1}{\emptyset} W_j e_{jY} e_{iY} , \tag{3.3}$$

and for the homogeneity condition the result will be

$$e_{iY} = \emptyset \Sigma \sigma_{ij} . \tag{3.4}$$

If we assume that all goods are "want independent," then $\sigma_{ij} = 0$ except when $i = j$. Under such assumptions, equations (3.2) and (3.3) will change according to the following equation:

$$e_{ij} = -W_j e_{iY} - 1/\emptyset\, W_j e_{jY} e_{ij} \text{ , or}$$

$$e_{ij} = -e_{iY} W_j (1 + \frac{e_{jY}}{\emptyset}) \text{ , and}$$

$$e_{iY} = \emptyset \sigma_{ii} .$$

By using equations (3.1) and (3.2) and the assumption of "want independence," we get the following own price elasticity of demand and money flexibility equation:

$$e_{ii} = -e_{iY} W_i - \frac{1 - W_i e_{iY}}{\emptyset} , \tag{3.5}$$

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[1]The mathematical manipulation is in the Appendix.

and

$$\emptyset = \frac{e_{iY}(1 - W_i e_{iY})}{e_{ii} + W_i e_{iY}} \quad . \tag{3.6}$$

Given direct price elasticities, income elasticity and expenditure weights, $\emptyset$ can be estimated. If the assumption of "want independence" is valid, the estimate of $\emptyset$ must be the same for all commodities or commodity groups. In the Frisch model, the complete additivity of utility is assumed, but is a very restrictive assumption. Barten (1964, 1967) in his model tried to relax somewhat the complete additivity assumption.

The Barten model

In the Frisch model σ_{ij} is equal to zero if $i \neq j$. Barten, however, relaxes this assumption and permits some σ_{ij} to not equal zero. He limits the number of parameters to the sum of n income elasticities, n direct price elasticities, Frisch money flexibility terms, and finally the number of cross-price effects. The terms of cross-price elasticity under the Barten model follow:

$$e_{ij} = \frac{p_j}{q_i} U_{ij}^{-1} - W_j e_{iY}(1 + e_{jY}/\emptyset) \quad . \tag{3.7}$$

The equation (3.7) is identical to that of Frisch except for the first term in the right-hand side.

A different approach to the formulations of Frisch and Barten has been introduced by Strotz (1957, 1959) who obtained his approach by using the complete additivity assumptions of Frisch and the "almost additive" assumption of Barten and introducing different concepts of separability, developed from the "utility tree."

Maximization Under Different Assumptions About Separability

The concept of a utility tree

Assuming n commodities in the consumer's bundle, the basic idea underlying this approach is that we can partition these n commodities into S groups $Q(q^1, q^2, \ldots, q^S)$ similar to the branches of a tree. In addition, it is assumed that the consumer allocates his budget in two separate steps, first assigning each group a part of his budget and second taking the budget assigned to each group and allocating it among different commodities within that group. Given that certain parameters of the demand equation are obtained, this enables us to obtain the remaining parameters in the system of demand equations.

The utility function must have certain characteristics if the two-stage maximization procedure is to be used. The addition of the Strotz concept of the "utility tree" to the classical model will make it possible to apply the two-stage maximization procedure. If this concept is introduced into the classical utility function, we have

$$U = f\{U^1(q^1) + U^2(q^2), \ldots, U^S(q^S)\} ,$$

where

$$U^i(q^i) = U^i(q^i_1, q^i_2, \ldots, q^i_n) \quad \text{and}$$

n_i = number of commodities in the i^{th} group such that

$$n_1 + n_2 + \ldots\ldots n_S = n .$$

For the derivation of the demand function, the usual maximization procedure will be used

$$\max V = F\{U^1(q^1) + U^2(q^2) \ldots\ldots U^S(q^S)\} + \lambda(Y - \sum_{i=1}^{n} p_i q_i)$$

where $\sum_{i=1}^{n} p_i q_i = Y$ is the consumer budget constraint. By solving the first order conditions we arrive at the following demand function:

$$q_j^{(i)} = a_j^{(i)} + \sum_{i \varepsilon I} B_{ji}^{(i)} p_i + \sum_{K \notin I} B_{jk}^{(i)} p_k + \gamma_j^{(i)} Y ,$$

$q_j^{(i)} = j^{th}$ commodity belonging to the i^{th} group,

$j = 1, 2, \ldots, n_i$;

$i = 1, 2, \ldots, S$.

By combining two demand functions from the same group (i.e., first and second), Strotz (1957, 1959) arrives at the following relationship:

$$\frac{B_{j1k_1}^{(i)}}{B_{j2k_1}^{(i)}} = \frac{B_{j1k_2}^{(i)}}{B_{j2k_2}^{(i)}} = \frac{B_{j1k}^{(i)}}{B_{j2k}^{(i)}} = \frac{\gamma_{j1}^{(i)}}{\gamma_{j1}^{(i)}} \quad (k_1, k_n, \ldots, \notin I) \; ; \tag{3.8}$$

for any such two commodities in a given group, the coefficient $B_{j1k}^{(i)}$ and $B_{j2k}^{(i)}$ will be in fixed proportion for k in branch i and equal to the ratio of income slopes $\gamma_{j1}^{(i)}/\gamma_{j2}^{(i)}$. If we know the income elasticity, and at least one other interbranch coefficient, we use the relationship (3.8) to calculate the i numbers of parameters in the system of demand equation.

Concepts of separability

The concept of complete additivity used by Frisch assumed that the goods entering the utility function can be separated into i, j, k groups so that

$$\frac{\partial \left(\frac{U_i}{U_j}\right)}{\partial q_k} = 0$$

for $i \varepsilon I$,
$j \varepsilon J$,
$k \varepsilon K$, (with $k \neq J$) ;

in other words, the ratio of the marginal utilities of commodities i and j is not affected by the consumption level of commodity k. The concept of separability assumes that the marginal utilities of i and j will change in the same proportion when the consumption of commodity k changes. According to the assumption made, it is possible to define four different types of separability.

Weak separability

This concept implies the possibility of the division of the utility function into subgroups so that

$e_{ik} = e_{jk}$

for all $i, j \varepsilon G$,

$k \neq G$,

$G = 1, 2, \ldots, N$,

where N is the number of groups and n_i is the number of commodities in each group. The essence of this approach is that the marginal rate of substitution between two commodities i and j belonging to the same group is not affected by the quantity of commodity k in another group. Later, other economists added some properties to the concept of weak separability. Green (1964) added the homogeneity property to the utility function such that

$U(q_1^{(i)}, q_2^{(i)}, \ldots, q_3^{(i)})$ is homogeneous of degree one for all i.

Strong separability

This concept implies that

$e_{ik} = e_{jk}$

for all $i, j \notin G$,
$k \varepsilon G$,
$G(1, 2, \ldots, N)$,

or

$$\frac{\partial(\frac{U_i}{U_j})}{\partial q_k} = 0 ,$$

if i and j are from groups n and m and k is from group G. Strong separability can be used in cases where additivity exists between groups in the utility function.

Pearce's separability

Pearce (1964) introduced the concept of "neutral association," showing that goods can be divided into groups so that

$$\frac{\partial(\frac{U_i}{U_j})}{\partial q_k} = 0$$

for all $i, j \varepsilon G$,
$k \neq i, j$.

This condition requires the existence of at least two commodities in each group. Furthermore, any two commodities within the group must be in "neutral want association" with all other commodities. This approach combines the strong and weak separability concepts.

Two-stage maximization

As has been noted so far, given the assumptions of separability the commodities in the utility function can be separated into different groups. This assumption is made to reduce the number of parameters to be estimated, and to make the estimation of demand interrelationships possible. To maximize a consumer's satisfaction under the separability assumption, the two-stage maximization procedure will be applied.

Suppose that there are n commodities which are divided into S groups and the total available income of the consumer is Y. The consumer in the first stage tries to allocate his total income to S groups in order to get maximum satisfaction. Let $y_1, y_2, \ldots, y_S$ represent the amounts spent on the different groups $(Y = y_1 + y_2, \ldots, + y_S)$.[1] To calculate the optimum amount of y_i which maximizes the consumer's utility function, the first order conditions are required.

$$U(y_1, y_2, \ldots, y_S) + \lambda(Y - \sum_{i=1}^{S} y_S) .$$

The first order conditions are as follows:

$$\frac{\partial U}{\partial y_i} - \lambda = 0 \quad \text{and}$$

$$\sum_{i=1}^{S} y_S - Y = 0 , \qquad (3.9)$$

$$i = (1, 2, \ldots, S) .$$

By solving equations (3.9), the group expenditures $(y_1, y_2, \ldots, y_S)$ will be obtained. The expenditure for each group y_i is a function of price indices $\overline{P}_1, \overline{P}_2, \ldots, \overline{P}_S$ and total available income. Therefore

$$y_i = y_i(\overline{P}_1, \overline{P}_2, \ldots, \overline{P}_S, Y) ,$$
$$i = (1, 2, \ldots, S) .$$

In the second stage of maximization, the consumer will allocate the amount of expenditures for each group among the commodities within the

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[1] y_i is the amount spent on group i. If we denote the quantity of the commodity in group i by the Q_i then $y_i = \overline{P}_i \overline{Q}_i$.

group, so that he achieves maximum utility. He cannot exceed the amount of expenditure already allocated in the first stage to each group; this constitutes the budget constraint in the second stage. In the second stage, the following should be maximized:

$$U^i(q^{(i)}, q_2^{(i)}, \ldots\ldots q_n^{(i)}) + \lambda_i \left(\sum_{j=1}^{n} p_j^{(i)} q_j^{(i)} - Y^{(i)} \right). \tag{3.10}$$

From the first order condition we can get the demand function for q_j as follows:

$$q_j^{(i)} = q_j^{(i)} \{(p_1^{(i)}, p_2^{(i)}, \ldots, p_n^{(i)}), Y_i(\overline{P}_1, \overline{P}_2, \overline{P}_3, \ldots, \overline{P}_S Y)\}$$

where $p_j^{(i)}$ is equal to the price of commodity j in group i,

for all $j = 1, 2, \ldots, n$,

$i = 1, 2, \ldots, S$;

in this manner we can get the demand equations for all commodities in each and every group.

The condition for the consistency of two-stage maximization is provided by Gorman (1959) and Green (1964, p. 22). Accordingly, two-stage maximization of the utility function will be consistent if the weak separability conditions are satisfied together with any one of the following conditions: (1) if only two groups exist, (2) if strong separability exists, (3) if weak homogeneity conditions are satisfied, (4) if all functions U^i except one (say the first) are homogenous and U can be written as

$U = U\{U^1, \emptyset(U^2, U^3, \ldots, U^S)\}$; and

(5) if the functions U^i beyond m are homogeneous and U can be written as

$U = U\{U^1 + U^2 + U^m + H(U^{m+1} \ldots, U_S)\}$.

When the two-stage maximization is consistent, then the result obtained by the direct and by the two-stage maximization will be the same.

The purpose of all these assumptions and empirical procedures is to close the gap between theory and empirical work. Nevertheless, there are several practical difficulties which should be considered: (1) the demand concept, (2) the grouping of commodities, (3) the problem of aggregation, and (4) the nature of the data. In the next few pages a short discussion of each problem will be presented.

The demand concept

The concept of demand stated by Walras, Hicks and Pareto serves as the basis for defining demand in pure economic theory. It was not meant to provide a basis for empirical analysis. The fundamental task of the demand analyst is to provide an answer to the question of how the consumer behaves toward changes in price.

According to Baumol (1972, p. 235)

> The peculiarity of the concept is well illustrated by the fact that only one point on a demand curve can ever be observed directly with any degree of confidence, because by the time we can obtain the data with which to plot a second point, the entire curve may well have shifted without our knowing it.

It is difficult to single out shifting variables from the other economic variables such as price and income. Sometimes the economic variables do not offer significant explanatory elements in the demand function.

The grouping problem

So far we have been concerned about the possibility of dividing the commodities in the utility function into separable groups. Since in reality it is not very simple to identify separable groups in the utility function, here we shall address ourselves to the commodity assignment problem for various groups. There are some general procedures, such as factor analysis (DeJanvry, 1966), for group assignment. However, a uniform grouping technique is not possible, due to the fact that it is rather dependent on the subjective judgment of the researcher.

The aggregation problem

According to Green (1964, p. 1), "Aggregation is a process whereby a part of the information available for the solution of a problem is sacrificed for the purpose of making the problem more easily manageable." To reduce the number of variables to a manageable level, aggregation is necessary.

Most economic theories of demand are meant to be applied to an individual consumer. On the other hand, empirical work, econometric estimation techniques and hypothesis testing are usually based on aggregate data. Therefore, a consistent procedure for aggregation and the nature of the bias introduced by such an aggregation should be specified. Theil (1971, p. 556) defines the theory of aggregation as ". . . concerned with the transformation of individual relationships to a relation for the group as a whole." He is one of the first researchers to work on linear aggregation. According to Theil (1959, p. 14), "if linear microrelations are aggregated in terms of linear aggregates to a linear macrorelation, the resulting macroparameters are the weighted sum of all microparameters."

The nature of data

There is an argument about data which has been related to price; in other words, whether this price corresponds to the intersection of supply and demand, or whether it refers to the quantity purchased by the consumer.

In the long run, the quantity demanded and supplied have a tendency to be equal. In the short run, generally, these two quantities are different. For demand analysis the quantity we use should be the amount that the consumer purchases in a given period of time. In case data on consumption is lacking, a consumption balance sheet should be built for each commodity. To construct a balance sheet, data on production will be used; after the deduction of exports and ending stocks from production and the addition of imports and the initial stocks to it, the remaining quantity is the amount purchased by the consumer.

CHAPTER IV. EMPIRICAL ESTIMATION OF DEMAND FOR FOOD IN THAILAND AT BANGKOK PRICES

This chapter consists of two parts. The first part deals with some studies germane to demand interrelationships, and presents the assumptions upon which the structure of the model is developed, specifying the functional form of the model and the procedures for selecting the commodities considered in this study. The second part considers the estimation of direct and cross-price elasticities and income elasticities for the 20 commodities selected for this model.

Related Studies

There are a few studies which have considered the complete interdependent nature of demand. Among these, the studies of Brandow (1961) and of George and King (1971) on demand interrelationships among all food commodities in the United States are notable and of special value.

Brandow's study

Brandow took 24 food items and obtained the coefficients needed to construct the matrix of demand elasticities. In order to calculate the coefficients required for the matrix, he assumed certain demand properties and used estimated values of the direct elasticities obtained from a number of studies by other economists.

The importance of his model lies in the application of Frisch's procedure to obtain all the coefficients required for the demand matrix.

There are some methodological problems involved in Brandow's estimation procedure for demand coefficients: first, he used statistical estimates from a number of other studies which might not follow a consistent pattern of estimation. Different studies may have employed somewhat different data sets gathered from different sources and in different time periods. Furthermore, Brandow used long time series of data including postwar and prewar periods in order to estimate the demand coefficients, without considering the possibility of structural change in the relationships. However, Brandow used the most highly-regarded demand studies made by U.S. agricultural economists during the 1950s and sought the advice of a committee of such economists in synthesizing his demand coefficients.

George and King's study

In this study George and King used annual data for the postwar period and a uniform estimation procedure to estimate the demand coefficients for 49 food commodities in the United States. In some cases, if data were not available, estimates from other studies (especially from Brandow's) were used. This study is based on the assumptions of "want independence" and neutral "want association." The two-stage maximization method was applied for estimation of the demand coefficients. The main advantage of this study over Brandow's (aside from the adoption of more advanced methodology, uniform data and analytical procedure) is the detailed breakdown of commodity groups according to the individual commodity belonging to a particular group.

Specification of the Model

In this study an attempt is made to estimate the matrix of demand elasticities for 20 major food items in Thailand at retail prices. Also, the demand coefficients for some commodities at the farm level will be estimated.

Assumptions of the Model

It is assumed that the commodities in the utility function can be divided into separate groups: in this model, the assumptions of Frisch and Barten implying cardinality and those of Strotz and Pearce implying ordinality of utility will be used.

Pearce (1961) points out the possibility of deriving the same result under his proposition and those of Frisch and Barten. According to Hallberg (1968, pp. 378-79), " . . . if the proper combinations of commodities are involved, either of these propositions (neutral-want association of Pearce and want independence of Frisch) will probably be acceptable as reasonable approximations to actual consumer behavior." Therefore, the important problem is not the selection between these two propositions. However, much consideration should be devoted to the selection of the proper commodity groups and the estimation procedure. In this study, the procedure is employed in such a way that both the above assumptions will be utilized as follows:

(1) Because of the inclusion of a large number of commodities in the model, all commodities are allocated among different separable groups, compiled from food items having relatively close substitution.

(2) The two-stage maximization procedure will be used in order to estimate the demand coefficients. The above procedure, when used, gives the functional relationship in the form that the quantity of a commodity demanded is the function of the prices of items within the group, the index prices of other groups, and income.

(3) The assumption of "want independence" is used to explain the relationship between each commodity in a single group and commodities outside the group. By using Frisch's procedure, cross-price elasticities for all commodities can be obtained in a given group with the commodities outside the group.

Choice of commodities

The first major consideration for including a commodity in the model is based on the availability of time series data on its quantity and prices. However, an attempt has been made to include all commodities which account for at least 0.1 percent of the food budget.

Determination of expenditure weights

The expenditure proportions for all food items are obtained from the Bank of Thailand report (1974). The expenditure weight of each individual commodity in total food expenditure is calculated, given the assumption that all food commodities are included in the model. Actually, this assumption is not unrealistic because most, if not all, of the food commodities in the Thai diet are included in the model. To estimate the expenditure weight for each individual commodity, the three year averages of expenditure on all food items and on each individual food commodity have been calculated, and then the latter has been divided by the former. In other words, if we have n food commodities in the model, the three year average of the total expenditure on all food items and individual commodity will, respectively, be as follows:

$$M = 1/3 \sum_{j=1}^{3} \sum_{i=1}^{n} p_i q_i \ , \tag{4.1}$$

$$H = 1/3 \sum_{j=1}^{3} p_i q_i \ , \tag{4.2}$$

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

$$j = (1, 2, 3) \ ,$$

where p_i is the price of the i^{th} commodity and M and H are the expenditures on all food and on the individual food respectively. The expenditure weight for the i^{th} commodity (W_i) has been calculated as follows:

$$W_i = \frac{H}{M} \ . \tag{4.3}$$

<u>The functional form</u>

The regression equations which will be extensively used in this study are in terms of first differences of logarithms of the original variables, and as follows:[1]

$$\Delta \log q_i = e_{i1} \Delta \log p_1 + \ldots . . e_{in} \Delta \log p_n + e_{iy} \Delta \log Y$$

while using time series data,

$$\Delta \log q_i = (\log q_{it-1} - \log q_{it}) \ ,$$

$$\log q_i = e_{i1} \log p_1 + e_{i2} \log p_2 + \ldots . . + e_{in} \log p_n + e_{iY} \log Y \ .$$

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[1]However, in some cases, a double logarithmic function gave statistically better estimates than the first difference equation; in such cases, the coefficients with better statistical properties have been selected.

When we use the cross-section data, given the prices constant, the log difference of prices will vanish and therefore,

$$\Delta \log q_i = e_{iY} \Delta \log Y .$$

If serial correlation exists in the original data, the first difference equation will reduce this auto-correlation to some degree. However, application of the double logarithmic function gives a better result.

Grouping procedure

To reduce the number of commodities in any given equation, allocation of commodities into separate groups is necessary. In addition, such grouping is a necessary condition for applying the two-stage maximization procedure. Therefore, classified the 17 commodities into five separable groups. The grouping has been done on the basis of the nature of the commodities included in the diets of the Thai people; but such grouping is made totally arbitrarily and can be changed according to the judgment of the researcher concerned.

The commodities in the model are grouped into five different groups as follows:

(1) rice;

(2) beef, buffalo, pork, poultry, fish;

(3) onions, garlic, chili, potatoes;

(4) watermelon, pineapple, bananas, coconuts; and

(5) coconut oil, groundnut oil, sesame, and cottonseed.[1]

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[1] Due to lack of data on sesame oil and cotton oil, the data on raw seeds have been used.

The Retail Elasticities

The set of own price, cross price and income elasticities of demand at the retail level is given in Table 2. Each row sum is zero (or very close to zero), and the elements in the last row are expenditure weights. To obtain these elasticities, the quantity demanded of each commodity was specified as the dependent variable while the prices of all commodities belonging to the same group, the price indices of other groups, and income were used as independent variables. As a result of such specification, the direct and cross price elasticities of commodities belonging to the same group were obtained from direct estimation. The selection of elasticity coefficients from different equations was based on statistical considerations, including (among others) the fit of the equation as indicated by the coefficient of determination (R^2). The significance of each individual coefficient was appraised by means of a "t" test, and a Durbin-Watson test was applied to detect the existence of serial correlation. The sign of each coefficient was also among the criteria for selection.

Almost all the direct and cross price elasticities for commodities in the same group were obtained in this manner. However, an adjustment of the cross price elasticities has been made to meet the symmetry condition across each row.

Synthesis of Demand Interrelationships

So far, the method of obtaining direct and cross price elasticities belonging to the same group has been discussed. At the end of this chapter we will show how the income elasticities for the various commodities were obtained.

Given the above information and utilizing the demand properties and Frisch's equation:

$$e_{ii} = e_{iY} - \frac{1-w_i e_{iY}}{\emptyset} \quad , \qquad (4.4)$$

the following procedure was used to obtain the remaining coefficients in Table 2.

a) The money flexibility element ($\emptyset$) was calculated by using the following equation:

$$\emptyset = \frac{e_{iY} - w_i e_{iY} e_{iY}}{e_{ii} + w_i e_{iY}} \quad . \qquad (4.5)$$

For meat, $\emptyset$ was calculated taking into account the income and price elasticities of the meat group and the value of $\emptyset$ was equal to 1.18. According to the assumption of "want independence" prevailing in this model, the money flexibilities ($\emptyset$) estimated for other individual commodities or commodity groups should have similar values.

b) To estimate the income elasticity for all food as an aggregate (e_{fY}), the product of the income elasticity and the expenditure weight for each individual commodity was computed and the sum of these products was then divided by the all food expenditure weight:

$$e_{fY} = \frac{w_i e_{iY} + w_2 e_{2Y} + , \ldots, + w_{17} e_{17Y}}{w_1 + w_2 + , \ldots, w_{17}} \quad , \qquad (4.6)$$

$$e_{fY} = .352 \ .$$

c) By utilizing Engel's aggregation we can also get the income elasticity of the nonfood item (e_{18Y}). We know that the weighted sum of all the income elasticities is unity. The income elasticity of demand for food is available from the previous calculation. Therefore, the nonfood income elasticity can be estimated as follows:

$$w_{18}e_{18Y} + w_f e_{fY} = 1$$

thus

$$e_{18Y} = \frac{1 - w_f e_{fY}}{w_{18}}$$

so

$$e_{18Y} = \frac{1 - .495 \times .352}{.505} \;,$$

$$e_{18Y} = 1.65 \;.$$

d) To obtain the own price elasticity for all food (e_{ff}) the Frisch equation (4.4) has been used:

$$e_{ff} = -w_f e_{fY} - \frac{1 - w_f e_{fY}}{\phi} \;. \qquad (4.7)$$

All the information required for estimating e_{ff} is available from (a) and (b). Inserting the required values into equation (4.7) gives the result,

$$e_{ff} = .505 \;.$$

e) The procedure used to estimate the direct price elasticity for food can also be applied in estimating the direct price elasticity for nonfood; we obtain

$$e_{18,18} = 1.14 \;.$$

f) The crosselasticity of all food with respect to nonfood price (e_{f18}) is obtained using the homogeneity property of demand as follows:

$$e_{f18} + e_{ff} + e_{fY} = 0 \;, \qquad (4.8)$$

$$e_{f18} = -e_{ff} + e_{fY} \;,$$

$$e_{f18} = .505 - .352 \;,$$

thus

$$e_{f18} = .153 \;.$$

g) To obtain the cross price elasticity for nonfood with respect to the all food price (e_{18f}), we use the symmetry condition (2.10),

$$e_{18f} = \frac{w_f}{w_{18}} e_{f18} - w_f(e_{18Y} - e_{fY}) \ . \qquad (2.10)$$

From the previous estimates, we have all the information necessary to estimate e_{18f}. Inserting the appropriate values into equation (2.10), we obtain

$$e_{18f} = .51 \ .$$

h) In order to show the effects of nonfood price on the consumption of individual foods (e_{i18}) for (1 = 1, 2, ..., 17), the Frisch equation is used as follows:

$$e_{ij} = \frac{1}{\emptyset} e_{iY} e_{jY} w_j - e_{iY} w_{jY}, \quad \text{or}$$

$$e_{ij} = -e_{iY} w_j (1 + \frac{e_{jY}}{\emptyset}) \ .$$

If we assume j to be nonfood, we have

$$e_{i18} = -e_{iY} w_{18} (1 + \frac{e_{18Y}}{\emptyset}) \ ;$$

therefore,

$$\frac{e_{i18}}{e_{iY}} = -w_{18} (1 + \frac{e_{18Y}}{\emptyset}) \ . \qquad (4.9)$$

From equation (4.8) the assumption of "want independence" can be seen. The right-hand side of this equation is independent of i. This implies that the ratio of the cross price elasticity of individual food i with respect to changes in the price of nonfood to the income elasticity of the same food i is the same for all i (i = 1, 2, ..., 17). Given the above result and the results obtained in (a) and (g), we can compute the ratio e_{f18}/e_{fY} which is equal to 0.43. If we multiply 0.43 by the income elasticity of each food we will get the effect of changes in nonfood price on the consumption of each food.

j) Cross price elasticities showing the effect of each individual commodity price on the commodities outside the group (e_{iy}) $i \neq j$, $i \varepsilon I$ and $J \notin I$ can also be calculated. Suppose that we are considering the i^{th} commodity. We have obtained the direct and cross price elasticities for all commodities in the same group, and the income elasticity of each food is also available. The nonfood cross elasticities have been calculated. By applying the homogeneity condition, we can get the sum of the unknown coefficients in any row. Assume there are k commodities in the group which contains commodity i; we know e_{i1}, e_{i2}, ..., e_{ik}, e_{i18} and e_{iY}. Since we have

$$(e_{i1} + e_{i2} + e_{i3} \ldots\ldots + e_{ik}) + e_{ik+1} \ldots\ldots + e_{i17} + e_{i18} + e_{iY} = 0 ,$$

the sum of the unknown coefficients will be

$$- (e_{i1} + e_{i2} \ldots\ldots + e_{ik} + e_{i18} + e_{iY}) .$$

Let us denote S_i as the sum of all the unknown values in row i. We have to distribute S_i among the coefficients which are unknown. For this purpose we use Frisch's equation

$$e_{ij} = -e_{iY} w_j (1 + \frac{e_{iY}}{\emptyset}) . \tag{4.10}$$

As all the values in the right-hand side are known, we can calculate the (18 - k - 2) remaining cross elasticities. There is the possibility that the sum of the coefficients calculated by equation (4.15) will not equal S_i. In such a case the cross elasticities will be adjusted in proportion to $-e_{iY} w_j (1 + \frac{e_{iY}}{\emptyset})$.

Estimation of Income Elasticities

The income elasticities in this study have been taken from two sources, the FAO (1971) estimates of income elasticities in urban areas and Supradit's (1975) estimates of income elasticities in rural areas of Thailand. To obtain income elasticities for the whole country, the elasticities in rural and urban areas have been multipled by the proportions of the total population living in the respective areas and then added together. In a few cases the estimated value from the present study has been used.

Some adjustments have been made in the values of income elasticities to satisfy the Engel's aggregation condition

$$w_i e_{iY} + w_2 e_{2Y} \ldots\ldots + w_n e_{nY} = 1 .$$

The last column of Table 3 shows the estimated income elasticities after adjustment for this study.

Table 2. Own price, cross price, and income elasticities of demand at the retail level

	Rice	Beef	Pork	Poultry	Fish	Potatoes	Chili	Garlic	Onions	Water-melon
1-Rice	0	.01814	.02416	.0105	.02984	.03807	.00722	.00411	.00213	.00677
2-Beef	.01221	-.95787	.00700	.16963	.18647	.01544	.0092	.00881	.00367	.00990
3-Pork	.01223	.0000	-.32096	.0000	.0000	.00296	.00559	.00321	.00165	.00526
4-Poultry	.0054	.0000	.15241	-.27390	.0000	.00444	.00665	.00492	.00049	.00453
5-Fish	.0181	.33164	.28286	.24212	-.22262	.00439	.00658	.00469	.00194	.00218
6-Potatoes	.000212	.00249	.00033	.00119	.00010	-.52973	.0000	.06667	-.14507	.00491
7-Chili	.00261	.00194	.0000	.00367	.00550	.0000	-.34885	.0000	.05093	.00466
8-Garlic	.00186	.00130	.00078	.00159	.00053	.0000	.0000	-.48474	.0000	.00581
9-Onion	.00057	.00420	.0000	.00082	.00014	.0000	.37410	.07892	-.35365	.00402
10-Watermelon	.000367	.00310	.00239	.000217	.0000	.01100	.005418	.009746	.0131	-.67803
11-Coconuts	.0153	.0398	.02052	.0442	.0494	.00974	.05177	.10830	.04537	.0000
12-Pineapple	.00352	.00218	.00901	.00791	.0001	.00925	.00553	.00913	.0132	.0000
13-Bananas	.02097	.01629	.03333	.0037	.032182	.00571	.0247	.00231	.00081	.0000
14-Sesame	.00028	.0000	.0000	.0000	.00001	.0002	.0000	.0001	.00748	.00012
15-Cotton	.00029	.0000	.0000	.00451	.00002	.0000	.0000	.0000	.00001	.00061
16-Coconut Oil	.00164	-.00004	.00012	.00018	.28178	.00082	.0005	.00068	.00045	.0080
17-Groundnut Oil	.00178	.0000	.00014	.00017	.0000	.00092	.008157	-.4231	.00086	.00051
18-All Food	-.1509	-.03607	-.04909	-.02603	-.05339	-.01799	-.0100	-.01695	-.0030	-.01224
Nonfood	-.3643	-.00937	-.01925	-.0028	-.02786	-.00244	-.01107	-.00454	-.00338	-.00563
Expenditure Proportions	.2587	.0226	.0340	.0143	.0405	.0055	.0105	.0057	.0032	.0089

Table 2. (continued)

	Coco-nuts	Pine-apple	Bananas	Sesame	Cotton	Coconut Oil	Ground-nut Oil	All Food	Non-food	Income Elastic-ities
1-Rice	.02333	.00680	.03403	.002	.0010	.0011	.0019	-.210	.06063	.141
2-Beef	.03110	.0079	.0095	.0022	.0004	.0033	-.03010	-.9108	.26273	.611
3-Pork	.01805	.00181	.02394	.00098	.00026	.00153	-.20164	-.58344	.17544	.408
4-Poultry	.02115	.00619	.02805	.00091	.00031	.00190	-.44500	-.6835	.2055	.478
5-Fish	.0000	.000128	.02996	.0009	.0003	-.48161	-.3945	-.6764	.2034	.473
6-Potatoes	.01686	.00493	.02266	.00073	.00044	.00152	.00153	-.54483	.16383	.381
7-Chili	.01602	.00469	.00469	.00069	.00023	.00144	-.2855	-.5177	.1557	.362
8-Garlic	.01996	.00584	.02646	.00086	.000293	.00179	-.2277	-.6449	.1939	.451
9-Onion	.01380	.00404	.01831	.00059	.00020	-.47144	-.10125	-.44616	.13416	.312
10-Watermelon	.0000	-.212123	.0000	.00061	.00188	.00061	.01172	-.7537	.2267	.527
11-Coconuts	-.54271	.0000	.0000	.00107	.00067	-.2894	.00226	-.8022	.24123	.561
12-Pineapple	.0000	-.76816	.0000	.0163	.00512	.03184	.03216	-.7164	.2154	.501
13-Bananas	-.2357	.0000	-.5909	.00100	.00034	.06209	.00217	-.75218	.22618	.526
14-Sesame	.0036	.0000	.0000	-1.03181	.0000	.0000	.48131	-.5076	.1526	.355
15-Cotton	.0001	.0034	.0086	.22914	-.67953	.0000	.0000	-.5076	.1526	.355
16-Coconut Oil	.0020	.0100	.0090	.0000	.0000	-.30682	.0000	-.5849	.1759	.409
17-Groundnut Oil	.00062	.0012	.00013	.55346	.0000	.0000	-.63922	-.5849	.1759	.409
18-All Food	-.02144	-.0159	-.05796	-.00541	.0095	.00158	-.00963	-.505	.153	.352
Nonfood	-.01694	-.00634	-.02590	-.00146	-.00049	-.00243	-.00278	-.51	-1.14	1.65
Expenditure Proportions	.0300	.0091	.0406	.00148	.0005	.0028	.003	.495	.505	1.000

CHAPTER V: ANALYSIS OF THE FARM RETAIL PRICE SPREAD

Various economic and legislative groups which are concerned with agricultural policy have shown keen interest in price spreads between the farm and the consumer. This concern leads to the measurement of the price spreads and the relation of changes in spreads to changes in the production and marketing of farm products.

In primitive societies, usually there is a direct contact between the producer of a commodity and its consumers. In other words, the original producer sells directly to the consumer and no other organizations or persons are involved inbetween. Therefore the retail and farm price are the same and farmers and fishermen in such society get the retail price. As the society becomes more modernized and complicated, farmers have less direct contact with consumers and their share of the retail price goes down.

In highly advanced countries, farmers get less than one half the retail price of food commodities. This small proportion results because of the costs incurred and profits enjoyed by all agencies involved in the transfer of products from farmers to consumers. These charges include payments for services such as assembling raw material from the farms, processing, storage, transportation, wholesaling, and retailing. Often, public policy decisions may be influenced by the behavior of marketing margins. To analyze the factors affecting farm prices, a proper consideration of this aspect seems necessary.

In the following section, an analysis of farm-retail price spreads will be presented. Also, it will be shown how to obtain demand elasticities at one level in the marketing system from a knowledge of these measures at another level.

Farm Retail Spread

According to the U.S. Department of Agriculture (1957, p. 1), "A farm retail spread is the difference between the retail price of a product and its farm value--the payment (adjusted for by-product values) to farmers for an equivalent quantity of farm products."

The expenditures of consumers on food items can be considered in two parts: payments to the farmers in exchange for their production of raw food items and payments to the agencies that assemble, process and distribute the products. The latter payments constitute the share going to intermediaries; the former payments make up the share going to farmers. The sum of these two shares equals the retail price. Knowledge of two of these three factors (farm price, marketing margin, and retail price) is required for measurement purposes. If any two factors are known we can deduce the third. In the present study, we could obtain necessary data on 11 items in order to estimate their demand elasticities at the farm level. These commodities are as follows: rice, beef, pork, poultry, watermelon, coconuts, pineapples, bananas, garlic, onions, chili, and cotton.

Types of price spread

The effect of price spreads between the farm and the consumer depends partly on the size and the nature of spreads. In many studies on price spreads (Dalrymple, 1961), it is assumed that price spreads are determined in one of the following ways.

Constant percentage If the spread were a constant percentage of retail price, the "flexibilities"[1] of retail price and farm price would be equal. Although it is not necessary to assume that the percentage remains the same at all levels of volume, in many cases it is assumed to be constant. Let p denote the retail and p' the farm level price and m the marketing margin. If the margin is a constant percentage, k, of the retail price we can write:

$$m = kp \ ,$$

therefore,

$$p = p' + kp \ ,$$

or

$$p' = (1 - k)p \ . \qquad (5.1)$$

Absolute amount In this case the difference between retail and farm price is an absolute amount in dollars and cents. It is possible to get the retail price by adding a specific amount to the farm price. In some cases, the amount to be added may be a function of price and quantity. In case the margin is a fixed amount (m^0), we can write

$$p = p^1 + m^0 \ . \qquad (5.2)$$

The price spread may have a relationship with the quantity handled. In such cases their relation is usually assumed to be linear. If we denote the quantity handled as q we can write:

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[1]Price flexibility was Moore's term for the elasticity of price with respect to quantity.

$$m = a + bq \,. \tag{5.3}$$

Therefore, if we substitute (5.3) in (5.2) the relation between farm and retail price can be written as:

$$p = a + bq + p' \,. \tag{5.4}$$

So far, we have discussed the nature of price spreads and assumptions regarding the behavior of marketing margins. These assumptions (constant percentage spread, absolute spread, linear relation between price spread and quantity handled) may be applicable in certain cases. For a more general case, it seems appropriate to assume that the marketing margin contains both percentage and absolute elements. According to Dalrymple (1961, pp. 5-6), wholesalers appear to use a constant percentage markup and retailers appear to make use of an absolute margin. Since the marketing system includes a combination of retailers and wholesalers, the marketing margin is a combination of the absolute and the constant percentage spread.

Waugh (1964, p. 20) points out that " . . . many studies of this matter (percentage and absolute spreads) in the U.S. Department of Agriculture suggest that the price spreads are neither constant percentage nor constant absolute amounts, but somewhere inbetween the two." By assuming a linear relation between margins and retail price we can incorporate Waugh's approaches as follows:

$$m_j = \alpha_j + b_j p_j \,, \tag{5.5}$$

where j refers to the j^{th} commodity. The retail price is equal to the farm price plus the marketing margin, so the relation between retail and farm price can be written as

$$p_j = p'_j + m_j \,. \tag{5.6}$$

By substituting equation (5.5) in equation (5.6) we obtain:

$$p'_j = p_j + \alpha_j + b_j p_j \ .$$

Therefore,

$$p'_j = -\alpha_j + (1 - b_j)p_j \ , \qquad (5.7)$$

or

$$p'_j = a_j + b_j p_j \ ,$$

where

$$a_j = -\alpha_j \quad \text{and}$$

$$(1 - B_j) = b_j \ .$$

The equations of type (5.7) have been fitted for 11 commodities. The results are presented in Table 3. The table shows that eight commodities have both slope and intercept significantly different from zero: beef, pork, poultry, garlic, chili, onions, coconuts, pineapples. Three commodities--bananas, cotton seed, watermelons--had significant intercepts but not significant slopes. Nonsignificant slope ($b_j = 1 - B_j$) implies that B_j is not significantly different from one, implying that the marketing margin may not change with a change in retail prices. For the commodities with slope and intercept both significantly different from zero, the hypothesis that the margin is a linear function of retail price is valid.

Derivation of Demand Functions at the Farm Level

In the previous chapter, the demand parameters at retail prices were derived. In many studies it may be necessary to derive the parameters of demand at the farm level from the knowledge of corresponding parameters at the retail level or vice versa. In the more general case where we have processors, wholesalers, and retailers as intermediaries, the possibility exists to derive demand elasticities for all of these levels. It is possible to determine simultaneously the quantity demanded by processors, the quantity consumed, retail price and farm price level. To show this, a simplified model is used which contains the following elements:

a) consumer demand.

$$f_1(q_c,p,Y) = 0 , \tag{5.8}$$

where

q_c is quantity consumed,

p is retail price, and

Y is consumer income;

b) marketing group behavior. This term refers to all the intermediaries. The supply and demand of this group can be shown in a single equation as follows:

$$f_2(q_c,p,p',v_2) = 0 , \tag{5.9}$$

where

q_c and p are the same as in the preceding equation,

p' is price at the farm level, and

v_2 represents all other variables influencing marketing group behavior;

c) producer supply.

$$f_3(q_p,p',v_3) = 0 , \tag{5.10}$$

where

q_p is quantity supplied by producers, and

v_3 represents all other variables influencing supply.

If we assume farm price and retail price are determined in the same time period,[1] as an equilibrium conditon we can write:

$$q_p = q_c = q \ .$$

We can derive the demand function at the farm level by eliminating p using equations (5.8), (5.9), and (5.10),[2] and it can be written as

$$f_4(q, p', Y) = 0 \ . \qquad (5.11)$$

Therefore, if we know the demand equation at one marketing level we can derive the demand equation at another level.

Specifically, we can estimate the demand elasticities at the farm level given the corresponding elasticities at retail and the above conclusion. Assume we have n commodities $(q_1, q_2, \ldots, q_n)$ with retail prices $(p_1, p_2, \ldots, p_n)$. The elasticities at retail prices can be defined as follows:

$$e_{ij} = \frac{\partial q_i}{\partial p_j} \cdot \frac{p_j}{q_i} \ , \qquad (i,j = 1, 2, \ldots, n) \qquad (5.12)$$

where e_{ij} is the elasticity of commodity i with respect to the price of commodity j. Let the corresponding farm prices and marketing margins respectively be $(p'_1, p_2, \ldots, p'_n)$ and $(m_1, m_2, \ldots, m_n)$. Given the assumption of linear relations between the marketing margins and the retail prices, we can obtain relations between farm-level prices and retail prices. Using equation (5.7) we can write

$$(1 - B_j)p_j = \alpha_j + p'_j \ . \qquad (5.13)$$

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[1]A similar derivation can be found in Hildreth and Jarrett (1955, p. 108) and also in Foote (1958, pp. 100-102).

[2]In a more complete and realistic formulation, expected prices might be used rather than equilibrium prices.

Thus,

$$p_j = \frac{1}{(1 - B_j)} (\alpha_j + p_j') \ . \tag{5.14}$$

The elasticities of demand at the farm level (E_{ij}) can be defined as

$$E_{ij} = \frac{\partial q_i}{\partial p_j'} \cdot \frac{p_j'}{q_i} \ . \tag{5.15}$$

The term $\frac{\partial q_i}{\partial p_j'}$ can be expressed as

$$\frac{\partial q_i}{\partial p_j'} = \frac{\partial q_i}{\partial p_j} \cdot \frac{\partial p_j}{\partial p_j'} \ . \tag{5.16}$$

Taking the partial derivative of equation (5.14) with respect to p_j', we get

$$\frac{\partial p_j}{\partial p_j'} = \frac{1}{(1 - B_j)} \ . \tag{5.17}$$

By substituting equations (5.16) and (5.17) in (5.15), the demand elasticity at the farm level can be obtained as:

$$E_{ij} = \frac{1}{(1 - B_j)} \cdot \frac{\partial q_i}{\partial p_j} \cdot \frac{p_j'}{q_i} ,$$

$$= \frac{1}{(1 - B_j)} \cdot \frac{\partial q_i}{\partial p_j} \cdot \frac{p_j}{q_i} \cdot \frac{p_j'}{p_j} ,$$

$$= \frac{1}{(1 - B_j)} \cdot e_{ij} \cdot \frac{p_j'}{p_j} , \text{ and}$$

$$E_{ij} = e_{ij} \frac{p_j'}{(1 - B_j)p_j} \tag{5.18}$$

We can write the equation (5.18) in terms of α_j by substracting the value of $(1 - B_j)p_j'$ from equation (5.13) as

$$E_{ij} = e_{ij} \cdot \frac{p_j'}{\alpha_j + p_j} \ .$$

The constant percentage spread and constant absolute spread situations could be derived from equation (5.18). In other words, they are special cases of the general form expressed in equation (5.18). If the farm price of a commodity is a constant percentage of its retail price, the following relation is sustained:

$$p_j' = k_j p_j \quad . \tag{5.19}$$

Comparing (5.19) with (5.13),

$$\alpha_j = 0 \text{ and } (1 - B_j) = k_j \ ;$$

if we substitute $\alpha_j = 0$ in equation (5.19) we will get

$$E_{ij} = e_{ij} \ .$$

Thus, when the farm price is a constant percentage of the retail price, the elasticity at the farm level is the same as the elasticity at the retail level.

In the case of a constant absolute spread, the following relations obtain:

$$m_j = \alpha_j \text{ and } B_j = 0 \ . \tag{5.20}$$

From (5.18) and (5.20) we can write

$$E_{ij} = e_{ij} \cdot \frac{p_j'}{p_j} \ . \tag{5.21}$$

Therefore, to obtain the farm price elasticity from the retail price elasticity in the case of constant absolute spread, we can multiply the elasticity at retail price by the ratio of the farm price to the retail price. Usually the retail price is higher than the farm price, so the elasticity at the farm level is lower than that at the retail level.

Elasticity of price transmission

The elasticity of price transmission is the ratio of the relative change in retail price to the relative change in the farm level price.

The elasticity of price transmission for the j^{th} good can be written as

$$\eta_j = \frac{\partial p_j}{\partial p_j'} \cdot \frac{p_j'}{p_j} \quad . \tag{5.13}$$

If we assume the relation between retail and farm price is linear, then from (5.17) we can write

$$\frac{\partial p'}{\partial p} = \frac{1}{(1 - B_j)} \quad . \tag{5.14}$$

If we substitute (5.14) in (5.13) the elasticity of transmission for the j^{th} commodity will be as follows:

$$\eta_j = \frac{1}{(1 - B_j)} \cdot \frac{p_j'}{p_j} \quad . \tag{5.15}$$

Derivation of Demand Elasticities at the Farm Level

The possibility of deriving elasticities at one level of the marketing system from the knowledge of elasticities at another level has been discussed. In this section we show the procedure for obtaining demand elasticities at the farm level from knowledge of elasticities at the retail level. From equation (5.18) we can write

$$E_{ij} = e_{ij} \frac{p_j'}{(1 - B_j)p_j} \; ; \tag{5.16}$$

substituting (5.15) in (5.16) we will get,

$$E_{ij} = e_{ij}\eta_j \; ,$$

where $\eta_j = \frac{p_j'}{(1 - B_j)p_j}$ is defined as the "elasticity of price transmission."

Therefore, elasticities at farm level can be obtained as the product of elasticities at the retail level and the elasticity of price transmission. Table 3 shows elasticities at the farm level derived from those at the retail level, in this manner. In the cases of beef, onions, and garlic, the elasticities at the farm level are equal to those at the retail level, because these commodities fell in the special category in which the slope was significant and the intercept was not significant. In such cases, as we have shown, elasticities at the two levels are the same.

Table 3. Own price, cross price, and income elasticities of demand at the farm level

	Beef	Hogs	Poultry	Chili	Garlic	Onions	Water-melon	Coco-nuts	Pine-apple	Bana-nas	Cotton-seed
Beef	-.95787	.00700	.16963	.0092	.00881	.00367	.00990	.0311	.0079	.0095	.0004
Hogs	.0000	-.2665	.0000	.00461	.00260	.00136	.00435	.0149	.00149	.0197	.00021
Poultry	.0000	.1280	-.23007	.00558	.00413	.00041	.00380	.0178	.00520	.02356	.00026
Chili	.00163	.0000	.00308	-.29303	.0000	.04277	.00391	.01346	.003939	.003855	.00121
Garlic	.00130	.00078	.00159	.0000	-.48474	.0000	.00581	.01996	.00584	.02646	.0029
Onions	.00420	.0000	.00082	.3741	.07892	-.35365	.00402	.01380	.00404	.01831	.0002
Watermelon	.00208	.00160	.00014	.00363	.006529	.00878	-.4543	.0000	-.14212	.0000	.0004
Coconuts	.03423	.01765	.0380	.04452	.09314	.03901	.0000	-.46673	.0000	.0000	.00161
Pineapple	.00109	.00450	.00395	.00275	.00457	.0066	.0000	.0000	-.38485	.0000	.00256
Bananas	.01548	.03166	.0035	.02346	.002194	.0077	.0000	-.2257	.0000	-.56136	.00032
Cottonseed	.0000	.0000	.00029	.0000	.0000	.0000	.0000	.00037	.00006	.00218	-.4349

CHAPTER VI: SUMMARY AND CONCLUSIONS

This study was conducted to achieve a better understanding of the behavior of demand for food in Thailand and also to furnish the policy-makers with some insights on demand structure which would be useful in the development of the agricultural sector. The questions that might reasonably be asked in this connection are of many forms. For instance, if the legal age of buffaloes to be slaughtered were reduced, what would be the probable changes in the prices of other meats and close substitutes for meat? How much would the rice demand quantity be reduced if the price of rice jumped by 10 percent? To answer such questions, a systematic description of the economic relationships between the quantities of farm products available and the prices at which farm products can be sold is required.

Some policy questions can be clarified by estimating the demand function for a single food, or a set of demand functions for two or more foods which are fairly close substitutes. However, there are some conceptual advantages in describing these relationships for all foods and farm products simultaneously by means of a comprehensive demand model. Such a model was pioneered by Brandow (1961), and we have used his approach in our present study.

According to Brandow (1961, p. 1), "The complete structure of demand relationships is a synthesized one." The retail part of such a synthesized structure for Thailand has been estimated in this study and presented in Table 2. From this retail part, the demand relationships at the farm level have been derived. The income elasticities coefficients are primarily supplied from other sources. Economic theory and statistical properties are used. To select the coefficients included in Table 2 when different equations exist for the same commodity. In the estimation of cross price elasticities, the relationships provided by the economic theory that governs demand functions is utilized. Considerable judgment was also applied in arriving at the set of cross price elasticities presented in Chapter IV.

Interpretation of the Demand Coefficients

The procedures used in estimating the price and income elasticities were discussed in Chapter IV. In the following pages, we will discuss and interpret the results obtained.

Retail demand for food commodities

The matrix of demand coefficients obtained in the present study contains both price and income elasticities. A price elasticity shows the percentage change in the quantity purchased from the market when the price changes by 1 percent. An income elasticity shows the percentage change in the quantity purchased when disposable personal income changes by 1 percent. In both cases, the assumption of "other things equal" is implied.

Rice

Rice is the most important food item in the Thai people's diet. In the Thai language, "khaaw" is the word for rice, and "kabkhaaw" is the term for a meal, which means "eat with rice." According to this study, rice accounted for 53 percent of food expenditures and 26 percent of total expenditures in 1971. The own price elasticity of rice is not significantly different from zero. Rice can be considered as an inferior good in Thailand. If the price of rice goes up, the low income families will consume more of it and when the price falls, the increase in consumption will be very small.[1] This is one of the reasons for our estimate of a zero price elasticity for rice. Another reason for this result is the government's intervention in rice market. There is no very close substitute commodity for rice in Thailand. Cross price elasticities of other foods for rice are presented in Table 2.

Total food

The second from the last column of Table 2 shows the cross price elasticity of each food with respect to the price of total food. In other words, it shows the percentage change in consumption of each product when the prices of all foods change together by 1 percent. The second from the last figure in this column is the direct price elasticity of demand for all food which is equal to .505. The income elasticity for all food is .352, indicating that if disposable personal income changes by 1 percent the percentage change in total food consumption will be .352. The cross price elasticity of total food consumption on nonfood prices is .153. The sum of the own price, cross price and income elasticities of total food is equal to zero.

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[1]This conclusion has been borrowed from other studies on rice.

Nonfood

The "total nonfood" commodity is elastic with respect to its price. The estimated own price elasticity for total nonfood is 1.14 and its income elasticity is 1.65, which shows the high responsiveness of quantity demanded of all nonfood items with respect to a change in income. The cross price elasticity of total nonfood consumption on all food prices is .51.

Meat group

Total meat accounted for 21 percent of food expenditure and 10.7 percent of total expenditure, and was second only to rice in its proportion of total expenditure. The estimated percentage increase in own consumption when the retail price of an individual meat falls by 1 percent but other retail prices do not change is .958 for beef and buffaloes, .32 for pork, .27 for poultry and .22 for fish. This information can be found in Table 2.

The cross price elasticities estimated for the meat group indicate that the changes in quantity of pork consumed with respect to changes in other meat prices are not significantly different from zero. But if the price of poultry or fish changes by 1 percent the quantity of beef consumed will change by .17 and .19 percent respectively. Beef, pork, and poultry meat are comparably high substitutes for fish and their cross price elasticities are .33, .28, and .24 respectively.

Vegetable group

Vegetables are very important in the Thai diet although the expenditure weight of this group is not as high as for rice and meat. Potatoes have the highest price elasticity in this group (.52). There do not appear to be close substitutes for potatoes, although onions and potatoes seem to be complementary goods. Own price elasticities for chili, garlic, and onions are .35, .48, and .35 respectively. The commodities in this group are not very competitive, so changes in the price of one do not seem to change the consumption of other food in this group. The only competitive commodities in this group appear to be chili and onions. The value of the cross price elasticity of chili for onions is equal to .37. Changes of 1 percent in disposable personal income will evidently change the quantity demanded of potatoes by .38, chili by .36, garlic by .45, and onions by .31.

Fruit group

This group accounted for 18 percent of consumers' expenditure on food and 8.8 percent of consumers' total expenditure. A 1 percent change in the price of watermelons will change the quantity demanded by .68 percent assuming other things constant. The changes in quantity demanded of coconuts, pineapples, and bananas associated with 1 percent changes in their own prices will be .54, .77 and .59 respectively. The income elasticities for the commodities in this group are very similar (.53 for watermelons, .56 for coconuts, .50 for pineapples, and .53 for bananas); a change in disposable personal income has fairly equal percentage effects on the consumption of each fruit in this group. There seems to be little substitution of one fruit for another in this group. One reason for this situation is that they are not being supplied to the market at the same seasons, and no proper storage facilities for such perishable products are available to supply them to the market gradually over a period of months.

Vegetable oil group

The commodities included in this group are sesame, cotton seed, coconut oil, and groundnut oil. The reason for using sesame and cotton as raw seed in this group is the lack of information and data on the oils produced from these two commodities. The oil group accounted for about 1.5 percent of consumers' expenditures on food. The income elasticities for sesame and cotton seed are equal (.355), and those for coconut oil and groundnut oil are equal at .409.

Sesame with 1.03 has the highest own price elasticity among the commodities in this group. The commodity which substitutes most closely for sesame is groundnut oil. The cross price elasticity of groundnut oil for sesame is .48. The own price elasticity for cotton seed is .68; the corresponding values for coconut oil and groundnut oil are .31 and .64 respectively. The cross price elasticities of other commodities in this group for coconut oil are zero. But sesame is a good substitute for cotton seed and groundnut oil; the value of the cross price elasticity for the former is .22 and for the latter is .56.

Considering the demand matrix (Table 2) as a whole, commodities within the same group show rather high substitutability for each other; in contrast, the cross price elasticities of a commodity belonging to a certain group with the commodities outside that group are usually small.

Farm level demand for food

There exist approximately fixed relations between the flows of commodities from farms and the quantities going into consumption. (Changes in inventories may be important in some cases.) The marketing margin is the difference between a farm price and a retail price. Usually the retail price is higher than the farm price. The farm level demand is usually less elastic than the demand at retail, and may be very much less elastic if the marketing margin absorbs a large percentage of the retail price and contains charges which are fixed in absolute amount. Under these circumstances, large percentage changes in prices of food products at the farm level may result from small changes in the level of food production.

In the present study, eight commodities show lower own price elasticities at the farm level than at retail. Beef, onions, and garlic show approximately equal elasticities at farm and retail levels.

Due to lack of data and information, it was not possible to calculate the elasticities at farm level for all 17 of the commodities included in this study. Therefore, six commodities have been dropped from the demand matrix at the farm level.

Conclusions

The more important conclusions of this study may be summarized as follows:

1) This study showed the feasibility of incorporating the assumptions of Frisch's "want independence" and Pearce's neutral want association to obtain a complete demand matrix for food in Thailand.

2) The behavior of marketing margins was studied, and for most of the commodities included in the model a linear relation between the marketing margin and the retail price was found. This specification has the advantage of incorporating both "absolute amount" and "constant percentage" spreads in (respectively) the intercepts and the slopes of the linear regressions of margins upon retail prices. For some commodities the slopes, and for others the intercepts, were not significant.

3) Overall, the results obtained in this study based on the data available seem satisfactory. The estimates of own price and cross price elasticities for commodities belonging to the same group are on firmer ground than those of cross price elasticities involving commodities in different groups.

CHAPTER VII: IMPLICATIONS AND SUGGESTIONS FOR FURTHER RESEARCH

In recent years, serious attention has been paid to agricultural policy and research, both in the developed and the developing countries. This study can be a potential source of useful information for policymakers in Thailand. The results which are obtained in the present study can be used for estimating price and income consequences of different policies for increasing or controlling the supplies of agricultural commodities. They also can be used for estimating the effects of agricultural and other policies upon consumers in the economy.

Some implications of the findings in this study will be discussed in two parts: implications of the demand parameters, and implications of the methodology.

Implications of the Demand Parameters

To illustrate some policy implications, four submatrices in the diagonal of the demand matrix at the retail level have been inverted. The reason for inverting each submatrix on the diagonal separately instead of inverting the whole demand matrix is that the submatrices show the own and cross price elasticities of commodities belonging to the same group and these coefficients have been estimated by regression analysis. But the remaining figures in the matrix have been calculated on the basis of the assumptions of theoretical demand properties (such as homogeneity conditions, symmetry conditions, and so on) which apply strictly to an individual rational consumer rather than to a national aggregate of rural and urban consumers with different incomes and life styles. The commodities in the same group are more closely related to each other in terms of price and consumption effects than they are to commodities outside the group. It is much easier to study a closed group of a few commodities which are close substitutes for each other than to look at a commodity in its relations to all other commodities in the demand matrix. The matrix as a whole will help us to recognize whether the cross price elasticities between commodities in different groups are large enough to upset the results of policy analyses for the closed groups; the complete matrix will also help us to appraise the effects of the income constraint and of price competition between foods and nonfoods in the aggregate. But in studying a smaller group, we can look in depth at the most important interactions between commodities and avoid the most serious errors in policy which might otherwise occur. The figures presented in Table 2 represent the following matrix equation:

$$q = Bp + CY \qquad (7.1)$$

where q is a vector of quantities consumed, p is the corresponding vector of prices and Y is per capita income. If we use logarithms or first differences of logarithms of the original data, B and C represent the price and income elasticities of demand. Taking the inverse of equation (7.1) we get:

$$B^{-1}_{q} = (B^{-1}B)p + (B^{-1}_{C})Y$$

$$B^{-1}_{q} = Ip + (B^{-1}_{C})Y$$

$$B^{-1}_{q} = p + (B^{-1}_{C})Y \; ;$$

therefore

$$p = B_q^{-1} - (B_C^{-1})Y \; .$$

Since we are interested in substitution relationships between competing commodities belonging to each group, we will consider separately each of four submatrices on the diagonal of the whole demand matrix presented in Table 2. The four commodity groups are as follows: meats, vegetables, fruits, and oil seeds.

Meat group

The matrix B for the meat group is (4 x 4) and all off-diagonal elements are positive (if they are not zero). This implies that all four commodities in the meat group are competitive (i.e., substitutes). For example, an increase in the price of fish will increase the quantity demanded of beef. The corresponding inverse matrix B^{-1} (4 x 4) presented in the Appendix shows all the elements, both diagonal and off-diagonal, to be negative. The coefficients imply that if the quantity of beef is reduced by 10 percent the price of beef will increase by 15 percent and the prices of pork, poultry, and fish will increase by 20 percent, 19 percent and 12 percent respectively. In the case of pork, a 10 percent reduction in the quantity offered to consumers does not have much effect on the other meat prices, but the price of pork will go up by 36 percent. A reduction of 10 percent in the quantity of poultry available for consumption will cause its own price to increase by 27 percent; the only other commodity which will be affected by such a reduction is pork, and its price will increase by 17 percent. In order to reduce the prices of meat in Thailand, the government could boost the production of fish. The B^{-1} matrix implies that if the quantity of fish offered to consumers goes up by 10 percent, the price of fish will decrease by 6.3 percent and the prices of pork, poultry, and beef will fall by 2.2 percent, 8.9 percent and 6.9 percent respectively.

Vegetable group

Commodities in this group are also competitive (except in the case of potatoes). For example, if an agricultural policy promoted a 10 percent increase in the production of chili, not only would the price of chili decline by 33 percent but the prices of garlic and onions would go down by 0.7 percent and 4.9 percent respectively. In the case of garlic, changes in the quantity supplied to consumers do not have much effect on the prices of other foods in this group. A 10 percent reduction in the quantity of onions offered for consumption will increase its own price by 33 percent, the price of garlic by 5 percent and the price of chili by 36 percent.

Fruit group

There is not much competition within this group because the fruits are supplied to the market in different periods. (We have discussed this matter in the interpretations section of Chapter V.)

Oil group

The B^{-1} matrix for oils shows that the commodities in this group are substitutes for each other. Increasing the quantity of sesame offered to consumers by 10 percent will reduce its own price by 16 percent and the price of groundnut oil by 12 percent. If for any reason the quantity of cotton seed offered to consumers is reduced by 10 percent, not only will its own price go up by 14 percent but the prices of sesame and groundnut oil will go up by 5.4 percent and 4.1 percent respectively. Changes in the quantity of coconut oil supplied does not have much effect on prices of the other commodities in this group. Groundnut oil and sesame are substitutable. For example, a 10 percent increase in the quantity of groundnut oil offered to consumers will reduce the price of groundnut oil by 26 percent and the price of sesame by 14 percent, but will not have significant effects on the prices of other commodities in this group.[1] All the B^{-1} tables are presented in the Appendix for more information.

Implications of the methodology

The objective of this study is to derive a useful and consistent set of demand functions for food commodities in Thailand. The methodology used for achieving the above objective is based on theoretical considerations and empirical analysis. The results of this study also lend empirical support to the conclusions of some earlier writers on demand analysis.

A summary of the implications of this study is as follows:

1) The demand functions were specified as (alternatively) linear in the logarithms of the variables or linear in first differences of the logarithms of the variables. The results based on first

[1]All coefficients in the B^{-1} matrices are derived from the coefficients in the corresponding submatrices of the complete demand matrix (presented in Table 2); the latter coefficients were based on regression analyses and are subject to sampling (and perhaps other) errors. Similar percentage errors would no doubt apply to the coefficients of the inverse matrices B^{-1}. We have described the implications of the coefficients as though they were exact to avoid cumbersome and monotonous repetitions of these cautions which must be recognized by policy analysts in practice.

differences of logarithms fulfilled theoretical expectations as to the signs of coefficients more consistently than did those based on the logarithms themselves. When the original logarithms of variables were used, the Durbin-Watson statistic in most cases showed the existence of autocorrelation. When the first differences of logarithms of the original variables were used, the autocorrelations, and in some cases the intercorrelations among the independent variables, were reduced. Such conclusions were also obtained in the study by Parks (1968), when he compared the different functional forms of demand.

2) The assumptions of "want independence" and "neutral want association" have been used in this study. Although the former assumption may hold for commodities in different groups, it may not be true for all the individual items of food within the same group (of competing or closely substitutable commodities). Therefore, the latter assumption is used in order to obtain the demand interrelationship matrix presented in this study. (The procedures involved in applying these two assumptions have been discussed in Chapter III, pages 34-40.)

Recommendations for Further Study

Just as other studies have been used in the preparation of this one, I believe the present study can serve as a basis for further research.

The limitations of data on the one hand and the large number of commodities included on the other have caused us to focus on the broad characteristics of demand applicable to all commodities. It is obvious that each commodity has special characteristics of its own, which we were unable to explore in the present study.

The unavailability of consistent estimates of income elasticities for Thailand as a whole reduces the accuracy of the off-diagonal elements of the demand matrix. To improve their accuracy, additional information on income elasticities will be needed.

If we only apply the ordinal assumption of separability in estimating the simultaneous system of demand equations for a large number of commodities, we obtain a nonlinear system which is difficult to solve. This can be a relevant topic for further theoretical and empirical study.

Another promising field for applied statistical and theoretical research is the study of price spreads. The behavior of marketing margins in the present analysis is represented by specifying them as linear functions of retail prices. It is possible to impose other behavioral assumptions for price spreads, do the necessary empirical work, and compare the results with those of the present study.

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APPENDIX

Sources of Data

Data on consumption of agricultural products in Thailand have been derived from the following sources:

The Ministry of Agriculture

Bank of Thailand

F.A.O., and

Various independent reports.

Time-series

Time-series data have been used in this study for the period 1957 to 1975. The price indexes and per capita income are published by the Bank of Thailand. But, there are actually no time-series data on agricultural consumption. Thus, the commodity consumption data in this study have been calculated as shown below:

consumption = production + imports - exports

where production and import-export data are reported by the Ministry of Agriculture publications, such as Agricultural Statistics of Thailand, and F.A.O. publications.

Frisch Model[1]

Frisch started with the utility function and the budget constraint of the representative consumer as:

[1]This part has been borrowed totally from Frisch (1959) and George and King (1971).

$$U(q_1, q_2, \ldots, q_k, \ldots, q_n) \text{ , and} \tag{A.1}$$

$$p_1q_1 + p_2q_2, \ldots + p_kq_k, \ldots, p_nq_n = Y$$

where q_1 to q_n are the quantities of goods possessed by the consumer, $p_1, p_2, \ldots, p_n$ are prices, and Y is income. The first order conditions of utility maximization for this consumer can be written as

$$U_j = (q_1, q_2, \ldots, q_n) - \lambda p_j = 0 \qquad (j = 1, 2, \ldots, n)$$

where

$$U_j = \frac{\partial U}{\partial q_i} \text{ , and} \tag{A.2}$$

$$Y - p_1q_1 + p_2q_2, \ldots - p_nq_n = 0 \text{ .}$$

The consumer is in equilibrium when

$$\frac{U_1}{p_1} = \frac{U_2}{p_2}, \ldots = \frac{U_n}{p_n} = \lambda, \tag{A.3}$$

where

λ is the marginal utility of money, and

$$U_k = \frac{\partial U(q_1, q_2, \ldots, q_n)}{\partial q_k} \text{ .} \tag{A.4}$$

The demand for good i can be derived from the first order condition as a function of income and prices:

$$q_i = q_i(p_1, p_2, \ldots, p_n, Y) \text{ .} \tag{A.5}$$

The demand elasticities with respect to price (e_{ij}) and the income elasticity (e_{iY}) are defined as

$$e_{ij} = \frac{\partial q_i}{\partial p_j} \cdot \frac{p_j}{q_i} \text{ ,} \tag{A.6}$$

$$e_{iY} = \frac{\partial q_i}{\partial Y} \cdot \frac{Y}{q_i} \text{ ,} \qquad (i = j = 1, 2, \ldots, n) \text{ .}$$

The budget proportions are

$$W_i = \frac{p_i q_i}{Y} \quad . \tag{A.7}$$

Considering the equations that defined the marginal utility (3.1) as a function of quantities consumed,

$$U_i = U_i(q_1, q_2, \ldots, q_n) \quad . \tag{A.8}$$

The inverse function of (3.2) can be written as

$$q_i = q_i(U_1, U_2, \ldots, U_n) \ .$$

Frisch respectively defines acceleration, want elasticity, and money flexibility as

$$f_{1k} = \frac{\partial U_i(q_1, q_2, \ldots, q_n)}{\partial q_k} \cdot \frac{q_k}{U_i(U_1, \ldots, U_n)} \quad , \tag{A.9}$$

$$\sigma_{ik} = \frac{\partial q_i(U_1, \ldots, U_n)}{\partial U_k} \quad , \tag{A.10}$$

$(i - 1, 2, \ldots, n)$

$(k = 1, 2, \ldots, n)$,

$$\emptyset = \frac{d\lambda}{\partial Y} \cdot \frac{Y}{\lambda} \quad . \tag{A.11}$$

If we take the total differential from first order conditions in (A.2) and rearrange them in matrix form, we will have:

$$\begin{bmatrix} U_{11} & \cdots & U_{1n} & -p_1 \\ \vdots & & & \vdots \\ U_{1n} & \cdots & U_{nn} & -p_n \end{bmatrix} \begin{bmatrix} \frac{\partial q_1}{\partial p_1} & \cdots & \frac{\partial q_1}{\partial p_n} & \frac{\partial q_1}{\partial Y} \\ \frac{\partial q_n}{\partial p_1} & \cdots & \frac{\partial q_n}{\partial p_n} & \frac{\partial q_n}{\partial Y} \\ \frac{\partial \lambda}{\partial p_1} & \cdots & \frac{\partial \lambda}{\partial p_n} & \frac{\partial \lambda}{\partial Y} \end{bmatrix} = \begin{bmatrix} \lambda & 0 & 0 & 0 & 0 & 0 \\ 0 & \lambda & 0 & \cdot & \cdot & 0 \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ 0 & \cdot & \cdot & \cdot & \lambda & 0 \end{bmatrix} \quad . \tag{A.12}$$

Writing the first equation in full,

$$U_{11} \frac{\partial q_1}{\partial p_1} + \ldots + U_{1n} \frac{\partial q_n}{\partial p_1} - p_1 \frac{\partial \lambda}{\partial p_1} = \lambda$$

or

$$\frac{\partial U_1}{\partial q_1} \cdot \frac{\partial q_1}{\partial p_1} + \dots + \frac{\partial U_1}{\partial q_n} \cdot \frac{\partial q_n}{\partial p_1} = p_1 \frac{\partial \lambda}{\partial p_1} + \lambda, \text{ or}$$

$$\frac{\partial U_1}{\partial q_1} \cdot \frac{q_1}{U_1} \cdot \frac{U_1}{q_1} \cdot \frac{\partial q_1}{\partial p_1} + \dots + \frac{\partial U_1}{\partial q_n} \cdot \frac{q_n}{U_1} \cdot \frac{U_1}{q_n} \cdot \frac{\partial q_n}{\partial p_1} = p_1 \frac{\partial \lambda}{\partial p_1} + \lambda \ . \tag{A.13}$$

Using (A.3), (A.6), and (A.9), (A.13) can be expressed in terms of price elasticities and utility accelerators as

$$F_{11}e_{11} + \dots + F_{in}e_{in} = 1 + \lambda \ . \tag{A.14}$$

Similarly, expressing all the other equations in (A.12) in terms of price elasticities, income elasticities, and utility accelerators, (A.12) can be rewritten as

$$\begin{bmatrix} F_{11} & \cdots & F_{in} \\ \vdots & & \\ F_{n1} & \cdots & F_{nn} \end{bmatrix} \begin{bmatrix} e_{11} & \cdots & e_{1n} & e_{1Y} \\ & & & \\ e_{n1} & \cdots & e_{nn} & e_{nY} \end{bmatrix} = \begin{bmatrix} 1+\lambda_1 & \lambda_2 & \cdots & \lambda_n & \phi \\ \lambda_1 & 1+\lambda_2 & \cdots & \lambda_n & \phi \\ \lambda_1 & \cdots & \cdots & 1+\lambda_n & \phi \end{bmatrix} \tag{A.15}$$

where

$$\lambda i = \frac{\partial \lambda}{\partial p_i} \frac{p_i}{\lambda}$$

From (A.15)

$$\begin{bmatrix} e_{11} & \cdots & e_{1n} & e_{1Y} \\ \vdots & & & \\ e_{ni} & \cdots & e_{nn} & e_{ny} \end{bmatrix} = \begin{bmatrix} F_{11} & \cdots & F_{1n} \\ \vdots & & \\ F_{n1} & \cdots & F_{nn} \end{bmatrix}^{-1} \begin{bmatrix} 1+\lambda_1 & \lambda_2 & \cdots & \lambda_n & \phi \\ \lambda_1 & 1+\lambda_2 & \cdots & \lambda_n & \phi \\ \lambda_1 & \cdots & \cdots & 1+\lambda_n & \phi \end{bmatrix} \tag{A.16}$$

Now Frisch shows that

$$[F_{ij}]_{nxn} \times [\sigma_{ij}]_{nxn} = I$$

therefore

$$[\sigma_{ij}]_{nxn} = [F_{ij}]^{-1}_{nxn} \tag{A.17}$$

From (A.16) and (A.17)

$$\begin{bmatrix} e_{11} & \cdots & e_{1n} e_{1Y} \\ \cdot & & \\ \cdot & & \\ \cdot & & \\ e_{n1} & \cdots & e_{nn} e_{nY} \end{bmatrix} = \begin{bmatrix} \sigma_{11} & \cdots & \sigma_{1n} \\ \cdot & & \\ \cdot & & \\ \sigma_{n1} & \cdots & \sigma_{nn} \end{bmatrix} \begin{bmatrix} 1+\lambda_1 & \lambda_2 & \cdots & \lambda_n & \phi \\ \lambda_1 & 1+\lambda_2 & \cdots & \lambda_n & \phi \\ \lambda_1 & \lambda_2 & \cdots & 1+\lambda_n & \phi \end{bmatrix}$$

Therefore,

$$e_{iY} = \phi \sum_j \sigma_{ij} \quad \text{and} \tag{A.18}$$

$$e_{ij} = \lambda_i \Sigma_j \sigma_{ij} + \sigma_{ij} \quad . \tag{A.19}$$

Further, Frisch shows that

$$w_i \sigma_{ij} = w_i \sigma_{ji} \quad .$$

Summing over j

$$w_i \sum_j \sigma_{ij} = \sum_j w_j \sigma_{ji} \quad \text{or} \tag{A.20}$$

$$\sum_j \sigma_{ij} = \frac{1}{w_i} \sum_j w_j \sigma_{ji} \quad .$$

From (A.18) and (A.19)

$$e_{iy} = \frac{\phi}{w_i} \sum_j w_j \sigma_{ji} \quad \text{and}$$

$$w_i e_{iY} = \phi \sum_j w_j \sigma_{ji} \quad . \tag{A.21}$$

Summing (A.21) over i,

$$\sum_i w_i e_{iY} = \phi \sum_i \sum_j w_i \sigma_{ji} \quad . \tag{A.22}$$

Using the Engel aggregation,

$$\sum_i w_i e_{iY} = 1 \quad .$$

Therefore, (A.22) can be written as

$$= \frac{1}{\sum_i \sum_j w_j \sigma_{ji}} = \frac{1}{\sum_i (w_i \sum_j \sigma_{ij})} \quad . \tag{A.23}$$

From (A.19) and (A.20), we have

$$e_{ij} = \frac{\lambda_i}{w_i} \sum_j w_j \sigma_{ji} + \frac{w_j}{w_i} \sigma_{ji} \quad .$$

From the Cournot aggregation, we have

$$\sum_i w_i e_{ij} = -w_j \quad . \qquad \text{(A.24)}$$

From (A.19) and (A.24),

$$\sum_i w_i (\lambda_j \sum_j \sigma_{ij} + \sigma_{ij}) = -w_j \quad \text{and}$$

$$\lambda_j \sum_i (w_i \sum_j \sigma_{ij}) + \sum_i \sigma_{ij} w_i = -w_j \quad . \qquad \text{(A.25)}$$

From (A.23) and (A.25),

$$\lambda_j \frac{1}{\phi} + \sum_i w_i \sigma_{ij} = -w_j \quad \text{and}$$

$$\lambda_j = -(w_j + \sum_i w_i \sigma_{ij}) \phi \quad . \qquad \text{(A.26)}$$

Frisch also shows that

$$e_{iY} = \phi \sum_j \sigma_{ij}$$

$$= \phi \frac{1}{w_i} \sum_j w_j \sigma_{ji} \quad \text{[using A.20]} \qquad \text{(A.27)}$$

$$w_i e_{iY} = \phi \sum_j w_j \sigma_{ji} \quad .$$

Interchanging i and j,

$$w_j e_{jY} = \phi \sum_i w_i \sigma_{ij} \quad . \qquad \text{(A.28)}$$

From (A.26) and (A.28),

$$\lambda_j = -w_j \phi - w_j e_{jY} \quad \text{and}$$

$$= -w_j (\phi + e_{jY}) \quad . \qquad \text{(A.29)}$$

Using (A.19) and (A.26)

$$e_{ij} = -(w_j + \sum_i w_i \sigma_{ij})\, \phi \sum_j \sigma_{ij} + \sigma_{ij} \quad ,$$

$$= \sigma_{ij} - w_j \phi \sum_j \sigma_{ij} - \phi \sum_i w_i \sigma_{ij} \sum_j \sigma_{ij} \quad \text{, and}$$

$$= \sigma_{ij} - w_j e_{iY} - w_j e_{jY} \frac{e_{iY}}{\phi} \quad \text{[from (A.27) and (A.29)].}$$

Therefore,

$$e_{ij} = \sigma_{ij} - w_j e_{iY} \left(1 + \frac{e_{iY}}{\phi}\right) \quad . \tag{A.30}$$

In particular, when i = j,

$$e_{ii} = \sigma_{ii} - w_i e_{iY} \left(1 + \frac{e_{iY}}{\phi}\right) \quad . \tag{A.31}$$

A good i is defined as want independent of good j if $U_{ij} = 0$. Since σ_{ij} is the $(ij)^{th}$ element of the inverse of matrix (U_{ij}), it follows that $\sigma_{ij} = 0$ for want independent commodities. Therefore, (A.30) can be written as

$$e_{ij} = -w_j e_{iY} \left(1 + \frac{e_{iY}}{\phi}\right) \quad . \tag{A.32}$$

Also, if a good i is want independent of all other goods,

$$\sigma_{ii} = \frac{e_{iY}}{\phi}$$

and, therefore, from (A.31),

$$e_{ii} = \frac{e_{iY}}{\phi} - w_i e_{iY} - w_i e_{iY} \frac{e_{iY}}{\phi} \quad ,$$

$$e_{ii} = -e_{iY} \left(w_i - \frac{1 - w_i e_{iY}}{\phi}\right) \quad . \tag{A.33}$$

Solving for ϕ, from (A.33),

$$\phi = \frac{e_{iY} (1 - w_i e_{iY})}{e_{ii} + w_i e_{iY}} \quad . \tag{A.34}$$

Table 4. B^{-1} for meat group

Commodities	Beef	Pork	Poultry	Fish
Beef	-1.47041	-2.06692	-1.99938	-1.23164
Pork	0.0000	-3.11565	0.0000	0.0000
Poultry	0.0000	-1.73368	-3.65097	0.0000
Fish	-2.19049	-8.92340	-6.94927	-6.32675

Table 5. B^{-1} for vegetable group

Commodities	Potatoes	Chili	Garlic	Onions
Potatoes	-1.88775	.98209	- .11054	.9158
Chili	0.0000	-3.39012	-0.07949	-0.48822
Garlic	0.0000	0.0000	-2.06296	0.0000
Onions	0.0000	-3.58615	- .54445	-3.34411

Table 6. B^{-1} for fruit group

Commodities	Watermelons	Coconuts	Pineapple	Bananas
Watermelons	-1.47486	0.0000	0.0000	0.0000
Coconuts	0.0000	-1.84260	0.0000	0.0000
Pineapple	0.0000	0.0000	-1.30181	0.0000
Bananas	0.0000	.073498	0.0000	-1.69233

Table 7. B^{-1} for vegetable oil group

Commodities	Sesame	Cotton	Coconut Oil	Groundnut Oil
Sesame	-1.62585	0.0000	0.0000	-1.22421
Cotton	-0.54824	-1.47161	0.0000	- .41281
Coconut oil	0.0000	0.0000	-3.25924	0.0000
Groundnut oil	-1.40772	0.0000	0.0000	-2.62437