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Consumer Demand for Food Commodities in Thailand

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CONSUMER DEMAND FOR FOOD COMMODITIES IN THAILAND

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DAE-CARD Sector Analysis Series: No. 10
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CONSUMER DEMAND FOR FOOD

COMMODITIES IN THAILAND

by

Bahram Dagostar, Wayne D. Ellingson, Earl O. Heady and Randall A. Hoffmann

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Ministry of Agriculture and Cooperatives
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FOREWORD

This report summarizes initial work completed to date on analyzing the interdependent nature of demand among several agricultural products in Thailand. Previous demand studies have focused primarily on a single commodity with little attempt to measure the overall relationships among demand quantities for all commodities. Interdependent demand relationships among 18 agricultural products are analyzed in this study. Direct, cross-price, and income elasticities are estimated for the individual commodities. An analysis of the farm retail price spread also is analyzed.

Consistent and comprehensive data series are a desirable requisite for implementation of interdependent demand analysis. Although the data available for this study were not as consistent nor as comprehensive as desired, it was felt that sufficient data were available to support the empirical analysis of this initial study. As improved data series become available, future studies of interdependent demand relationships among agricultural products in Thailand may benefit from the empirical methodologies and statistical procedures developed for this study. Summary discussions of empirical models of consumer demand and consumer behavior theory are presented in appendices of the report to assist researchers in carrying out further interdependent demand studies for agricultural products in Thailand.
The empirical analysis summarized in this report is part of a cooperative research effort being carried out by the Division of Agricultural Economics (DAE) of the Ministry of Agriculture and Cooperatives, Royal Thai Government, and the Center for Agricultural and Rural Development of Iowa State University. The cooperative research effort is funded by the Agency for International Development and the Royal Thai Government, and this study represents one phase of a sector analysis project being undertaken to provide models and empirical analysis which can aid development and policies for agriculture in Thailand.

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INTRODUCTION

Thailand is an important agricultural country. Although other sectors of its economy are rapidly gaining in importance, economic activity still centers largely on producing, marketing, and processing of farm commodities.

Agriculture employs about 78 percent of the labor force and provides 73 percent of total export earnings. In 1974, agriculture contributed about 30 percent of the gross national product. However, the national account data probably do not reflect the overall importance of agriculture in the economy, at least partly because of government policies to maintain a low domestic price for rice. Rice is by far the most important agricultural product. Thailand is one of the few countries of Asia with an exportable surplus of both food and feed.

Food availability is generally good throughout Thailand except for some small areas of the Northeast. Average per capita food consumption measured in energy value is estimated at about 2,200 calories. The average Thai diet, however, is limited in variety and somewhat deficient in proteins. Rice accounts for almost 70 percent of caloric intake, while fish provide about half of the animal protein. Although rice remains the staple food at all income levels, increased earning power is bringing about some improvement in the quality of the food diet. According to data collected for this study, per capita consumption of fish and meat has increased significantly over the past 15 years.
Despite the general availability of food throughout Thailand, about 49.5 percent of total family expenditures is still allocated for food purchases.

Focus of the Study

Because of the great importance attached to agriculture, the Thai government places considerable 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 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.
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 rice, beef, corn, or wheat, while the overall relationships among the quantities demanded of all commodities in the budget remain in the background. The majority of demand studies completed to date fall in this first category. This study is representative of a second group which is concerned primarily with the interdependent nature of demand among several products. 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 noteworthy of the initial studies falling within the second group. The basic reason for the comparatively small number of demand studies in the second group has been a gap between economic theory and statistical estimating procedures on the one hand and the lack of a comprehensive data series necessary to support interdependent demand analysis on the other hand. Economic theory and statistical procedures have been developed which provide the basis for improved empirical estimation of the interdependent demand relationships. While the lack of consistent comprehensive data series continues to be a problem, sufficient information is now becoming available to support the empirical analysis necessary to carry out research falling within the second group.

Knowledge of direct and cross price elasticities are important for use by policymakers 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 employs theoretical and empirical methods which provide ways for estimating demand interrelationships. For example, the estimation of direct or cross price elasticities can be achieved by the separation of commodities in the utility function into several separate groups, given the assumption of "want independence" and "neutral want association."

Analysis of demand for goods at the farm level also is important 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, information needed regarding the cross price and direct price elasticities can be obtained. Information regarding farm level prices is quite useful to policymakers in determining how to increase both the income of farmers and the quantity of goods supplied. This study addresses itself primarily to the measurement of income-consumption relationships and demand interrelationships at the retail and farm level in Thailand. The three specific objectives of this study are:

(a) to estimate the effect of prices and income on the consumption of food in Thailand by using time series and cross-section data,
(b) to bridge the gap between theory and empirical analysis by separating commodities into different groups and using different necessary assumptions, and
(c) to estimate the coefficients of demand at farm and market levels.
EMPIRICAL ESTIMATION OF DEMAND FOR
FOOD IN THAILAND AT BANGKOK PRICES

The first part of this section reviews some studies important to demand interrelationships, presents the assumptions upon which the structure of the model is developed, and specifies the functional form of the model and the procedures for selecting the commodities considered. The second part considers the estimation of direct and cross-price elasticities and income elasticities for the 18 commodities included in the study.

Related Studies

A few studies 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 obtained the coefficients needed to construct the matrix of demand elasticities for 24 food items. 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 other studies.

The importance of his model lies in the application of Frisch's procedure (1959) 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. Further, Brandow used long time series including postwar and prewar periods in order to estimate the demand coefficients. He did not consider the possibility of structural change in the relationships over time. However, Brandow's was the most highly regarded demand study made by U.S. agricultural economists during the 1950s and included the advice of a committee of economists in synthesizing the estimated demand coefficients.

George and King's 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. George and King's 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 and uniform data, is the detailed breakdown of commodity groups.
Specification of the Model

In the present study an attempt is made to estimate the matrix of demand elasticities for 18 major food items in Thailand at retail prices. Also, the demand coefficients for some commodities at the farm level are estimated.

Assumptions of the Model

It is assumed that the commodities in the utility function can be divided into separate groups: for this model, the assumptions of Frisch (1959) and Barten (1964) 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, the determination of the proper commodity groups and the estimation procedure. In this study, the procedure is employed in such a way that both of the above assumptions is utilized as follows:

(a) 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 which are relatively close substitutes.
(b) A two-stage maximization procedure is used in estimating the demand coefficients. When used, this procedure gives the functional relationship in a form so 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.

(c) 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 (1959), crossprice elasticities for commodities can be obtained within a given group and 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 were obtained from the Bank of Thailand report (1974). The expenditure weight of each individual commodity in total food expenditure was calculated, given the assumption that all food commodities were 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:

\[
M = \frac{1}{3} \sum_{j=1}^{3} \sum_{i=1}^{n} p_i q_{ij},
\]

\[
H = \frac{1}{3} \sum_{j=1}^{3} p_i q_{ij},
\]

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

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

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:

\[
W_i = \frac{H}{M}.
\]

The functional form

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: \(^1\)

\(^1\)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.
\[ \Delta \log q_i = \epsilon_{i1} \Delta \log p_1 + \ldots + \epsilon_{in} \Delta \log p_n + \epsilon_{iY} \Delta \log Y \]

while using time series data,

\[ \Delta \log q_i = (\log q_{it} - 1 - \log q_{it}) , \]
\[ \log q_i = \epsilon_{i1} \log p_1 + \epsilon_{i2} \log p_2 + \ldots + \epsilon_{in} \log p_n + \epsilon_{iY} \log Y . \]

When the cross-section data is used and constant prices are assumed, the log difference of prices will vanish and therefore,

\[ \Delta \log q_i = \epsilon_{iY} \Delta \log Y . \]

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 may give a better result in some instances.

**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, the 18 commodities were classified 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 arbitrary and can be changed according to the judgment of the researcher concerned.

The commodities in the model are divided into five 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

The Retail Elasticities

The set of own price, cross price and income elasticities of demand at the retail level is given in Table 1. 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 price 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 also was among the criteria for selection.

Almost all the direct and cross price elasticities for commodities

¹Because of lack of data on sesame oil and cotton oil, the data on raw seeds have been used.
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. A discussion of how the income elasticities were obtained for the various commodities is presented later on in this section.

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

\[ e_{11} = e_{1Y} - \frac{1 - w_{i1} e_{11}}{\phi} \]

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

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

\[ \phi = \frac{e_{1Y} - w_{i1} e_{11}}{e_{11} + w_{i1} e_{1Y}} \]

For meat, \(\phi\) was calculated taking into account the income and price elasticities of the meat group and the value of \(\phi\) was equal to 1.18. According to the assumption of "want independence" prevailing in this model, the money flexibilities (\(\phi\)) 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:

\[
e_{FY} = \frac{w_1e_{1Y} + w_2e_{2Y} + \ldots + w_{17}e_{17Y}}{w_1 + w_2 + \ldots + w_{17}},
\]

\[(4.6)\]

\(e_{FY} = .352.\)

(c) By utilizing Engel's aggregation the income elasticity of the non-food item (\(e_{18Y}\)) can be obtained. Since 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

\[
e_{18Y} = 1 - .495 \times .352 = .505
\]

\(e_{18Y} = 1.65.\)

(d) To obtain the own price elasticity for all food (\(e_{ff}\)) the Frisch (1959) equation (4.4) was used:

\[
e_{ff} = -w_{f}e_{FY} - \frac{1 - w_{f}e_{FY}}{\theta}.
\]

\[(4.7)\]
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,

$$e_{ff} = 0.505.$$  

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

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

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

$$e_{f18} + e_{ff} + e_{fY} = 0, 
\quad (4.8) 
\begin{align*}
  e_{f18} &= -e_{ff} - e_{fY}, \\
  e_{f18} &= 0.505 - 0.352, \\
\end{align*}$$

thus

$$e_{f18} = 0.153.$$  

(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),

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

---

1To facilitate the presentation of results, negative signs for own price elasticities of demand were not included in the text. However, negative signs of these elasticities have been included in Table 1 for reference purposes.
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) To show the effects of nonfood price on the consumption of individual foods ($e_{i18}$) for ($i = 1, 2, \ldots, 17$), the Frisch equation is used as follows:

$$e_{ij} = \frac{1}{\theta} e_{iY} e_{jY} - e_{iY} e_{jY} \, \text{ or}$$

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

If we assume $j$ to be nonfood, we have

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

therefore,

$$\frac{e_{i18}}{e_{iY}} = w_{18} (1 + \frac{e_{18Y}}{\theta}) . \quad (4.9)$$

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 $i$ ($i = 1, 2, \ldots, 17$). 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.
(h) Cross price elasticities showing the effect of each individual commodity price on the commodities outside the group \((e_{iy})_{i \neq j, i \in I}\) 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 \(e_{i1}, e_{i2}, \ldots, e_{ik}, e_{i18}\) and \(e_{iY}\). Since we have

\[
(e_{i1} + e_{i2} + e_{i3} \ldots + e_{ik}) + e_{ik} + e_{i17} + e_{i18} + e_{iY} = 0,
\]
the sum of the unknown coefficients will be

\[-(e_{i1} + e_{i2} \ldots + e_{ik} + e_{i17} + e_{i18} + e_{iY}).\]

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

\[
e_{ij} = -e_{iY}w_j (1 + \frac{e_{iY}}{\theta}). \tag{4.10}
\]

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 \(-e_{iY}w_j (1 + \frac{e_{iY}}{\theta})\).
Estimation of Income Elasticities

The income elasticities used 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 multiplied 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.

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

\[ \sum_{i=1}^{n} w_i e_{1i} + w_2 e_{2y} + \ldots + w_n e_{nY} = 1. \]

The last column of Table 1 shows the estimated income elasticities after adjustments made for this study.
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<th>Poultry</th>
<th>Fish</th>
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ANALYSIS OF THE FARM

RETAIL PRICE SPREAD

Various economic and legislative groups 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 less developed societies, there often 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. The retail and farm price then are the same. As the society becomes more modernized and complicated, farmers have less direct contact with consumers and their share of the retail price decline.

In highly advanced countries, farmers receive 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 and the generation of services between farmers and consumers. These charges include payments for services such as assembling raw material from farms, processing, storage, packaging, transportation, wholesaling, and retailing. 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
is useful. An analysis of farm-retail price spreads is presented in
the following section. A method also is illustrated for obtaining de­
mand elasticities at one level in the marketing system from 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 pro­
duct 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 were able to obtain
necessary data on 11 items for estimating their demand elasticities at
the farm level. These commodities are 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

\[
p' = (1 - k)p.
\] \hfill (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

\[
p = p' + m^0.
\] \hfill (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:

\(^1\)Price flexibility was Moore's term, as outlined in Stigler (1961), for the elasticity of price with respect to quantity.
\[ m = a + bq . \]  \hspace{1cm} (5.3)

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

\[ p = a + bq + p' . \]  \hspace{1cm} (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:

\[ m_j = \alpha_j + b_j p_j , \]  \hspace{1cm} (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

\[ p_j = p'_j + m_j . \]  \hspace{1cm} (5.6)
By substituting equation (5.5) in equation (5.6) we obtain:

\[ p'_j = p_j + \alpha_j + b_j p_j. \]

Therefore,

\[ p'_j = -\alpha_j + (1 - b_j) p_j, \]

or

\[ p'_j = a_j + b_j p_j, \]

where

\[ a_j = -\alpha_j \quad \text{and} \quad (1 - B_j) = b_j. \]

The equations of type (5.7) have been fitted for 11 commodities. The results are presented in Table 2. The table shows that eight commodities have both slopes and intercepts significantly different from zero: beef, pork, poultry, garlic, chili, onions, coconuts, pineapples. Bananas, cotton seed, watermelons had significant intercepts but the slopes were not significant. 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 for deriving demand elasticities at all of these levels. It is possible to determine simultaneously the quantity demanded by processors, the quantity consumed, the retail price and the farm price level. To show this, a simplified model is used which contains the following elements:

(a) **consumer demand.**

\[ f_1(q_c, p, Y) = 0 , \]  

(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:

\[ f_2(q_c, p, p', v_2) = 0 , \]  

(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.**

\[ f_3(p, p', v_3) = 0 , \]  

(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 condition 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

\[ f_4(q, p', Y) = 0. \] (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:

\[ e_{ij} = \frac{\partial q_i}{\partial p_j} \cdot \frac{p_j}{q_i}, \quad (i, j = 1, 2, \ldots, n) \] (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

\(^1\) 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 rather than equilibrium prices might be used.
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

\[(1 - B_j)p_j = \alpha_j + p_j'.\] (5.13)

Thus,

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

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

\[E_{ij} = \frac{\partial q_i}{\partial p_j} \cdot \frac{p_j'}{q_i}.\] (5.15)

The term \(\frac{\partial q_i}{\partial p_j}\) can be expressed as

\[\frac{\partial q_i}{\partial p_j} = \frac{\partial q_i}{\partial p_j} \cdot \frac{\partial p_j}{\partial p_j} \cdot \frac{\partial p_j}{\partial p_j}.\] (5.16)

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

\[\frac{\partial p_j}{\partial p_j'} = \frac{1}{(1 - B_j)}.\] (5.17)

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

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

\[= \frac{1}{(1 - B_j)} \cdot \frac{\partial q_i}{\partial p_j} \cdot \frac{p_j}{q_i} \cdot \frac{p_j'}{p_j},\]
We can write the equation (5.18) in terms of $e_j$ by subtracting the value of $(1 - B_j)p_j$ from equation (5.13) as

$$E_{ij} = e_{ij} \frac{p_j'}{p_j} \quad \text{and}$$

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

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:

$$p_j' = k_j p_j \quad \text{(5.19)}$$

Comparing (5.19) with (5.13),

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

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 are obtained:

$$m_j = \alpha_j \quad \text{and} \quad B_j = 0 . \quad \text{(5.20)}$$
From (5.18) and (5.20) we can write

\[ E_{ij} = e_{ij} \cdot \frac{p'_{j}}{p_{j}}. \]  

(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. The retail price is usually 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

\[ \eta_{j} = \frac{\partial p'_{j}}{\partial p_{j}} \cdot \frac{p'_{j}}{p_{j}}. \]  

(5.13)

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

\[ \frac{\partial p'_{j}}{\partial p} = \frac{1}{(1 - B_{j})}. \]  

(5.14)

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

\[ \eta_{j} = \frac{1}{(1 - B_{j})} \cdot \frac{p'_{j}}{p_{j}}. \]  

(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

\[ E_{ij} = e_{ij} \frac{p_j'}{(1 - B_j)p_j} ; \quad (5.16) \]

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 2 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 has been shown, elasticities at the two levels are the same.
Table 2. Own price, cross price, and income elasticities of demand at the farm level

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<tr>
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<th>Hogs</th>
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<th>Coconuts</th>
<th>Pineapple</th>
<th>Bananas</th>
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SUMMARY AND CONCLUSIONS

This study was conducted to achieve a better understanding of the behavior of demand for food in Thailand. It also was conducted to furnish policymakers with some insights on demand structure which might be useful in the development of the agricultural sector. The questions that might reasonably be asked in this connection take 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 as a result of removal of the rice export tax? 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 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 his approach is used in this study.

According to Brandow (1961, p.1) with reference to his own estimates, "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 1. 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 1 when different equations exist for the same commodity. In the estimation of cross price elasticities, the relationships provided by the economic theory that govern demand functions are utilized. Considerable judgment was also applied in arriving at the set of cross price elasticities presented in the preceding chapter.

Interpretation of the Demand Coefficients

The procedures used in estimating the price and income elasticities were discussed previously. A discussion and interpretation of the results obtained is presented in the following paragraphs.

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 when 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. Thus, rice can be considered as an inferior economic good in Thailand. If the price of rice goes up, low income families will consume less of other more expensive foods and more rice, but 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 activity in the 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 1.

Total food

The second from the last column of Table 1 titled "All Food" 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

¹This conclusion has also been proposed by other studies of rice in Thailand.
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.

**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 is shown in Table 1.

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. In general, commodities in the vegetable 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 .37. Changes of 1 percent in disposable personal income 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 changes 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 are .54, .77 and .59, respectively. 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 supplied to the market in the same seasons, and no 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 1) 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

Approximately fixed relations exist between the flows of commodities from farms and the quantities going into consumption. Changes in inventories may be important for some products. 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.

This 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.

Because of lack of data and information, it was not possible to calculate the elasticities at the farm level for all 18 of the commodities included in this study. Therefore, seven commodities were dropped from the demand matrix at the farm level.
Conclusions

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

(a) 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.

(b) 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.

(c) 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 within the same group are on firmer ground than those of cross price elasticities involving commodities between different groups.
UTILIZATION 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 were obtained can be used for estimating price and income consequences of different policies for increasing or controlling the supplies of agricultural commodities. They can also be used for estimating the effects of agricultural and other policies upon consumers in the economy.

Some uses and implications of the findings in this study will be discussed in the following sections: utilization of the study, implications of the demand parameters, and implications of the methodology.

Utilization of the Study

Agricultural policies implemented by governments frequently consist of policies which are directed at benefiting producers and/or consumers. These policies may be categorized as either developmental or compensational policies. Each of the two categories may be used for different purposes.

Developmental policies frequently focus on increasing commodity supplies for the purpose of reducing food prices at the consumer level. Compensational policies promote the expansion of food supplies, but
They also provide compensation to farmers for income which might be lost as a result of lower farm level prices. Knowledge of demand relationships is important for evaluating the possible effects of alternative developmental and compensational policies. To demonstrate the importance of demand analysis for agricultural policy development several possible situations are considered in subsequent paragraphs. Knowledge of demand elasticities also is important for evaluating policies, such as the export rice premium employed in Thailand.

If a government should desire to increase farm level income by promoting the expansion of a certain commodity such as beef, the income effects from an expanded beef supply would be directly related to the price elasticity of demand for beef and the way in which the farmers costs vary with the quantity of product. If demand for beef were price elastic and unit costs remained constant, an increase in the supply of beef would result in an increase in farm level income. However, if the demand for beef were price-inelastic and unit-costs remained constant, an increase in the supply of beef would result in a decline in farm level income. With the exception of sesame oil, all commodities included in this study were found to be price-inelastic.

Results of demand analysis could also be used in the evaluation of alternative policies directed at changing the protein or caloric intake of consumers. Should a government desire to increase the average per capita intake of protein by increasing the consumption of specific commodities such as beef and rice, demand analysis such as is provided by this study would be helpful by indicating the effects of such a
program on the price of individual commodities, on the price of close substitute goods, and on total food prices.

Supply control is another area in which the results of this or similar studies could be useful for policymakers. If the local market supply of a commodity such as rice were to be curtailed for the purpose of increasing the price received by farmers, information concerning the demand elasticities of rice and other close substitutes would be highly desirable. The extent to which a change in the supply of a commodity will effect a change in price will depend on the demand elasticities of the specific good and its close substitutes. When the demand for a product is highly price-inelastic, a small decrease in the supply of the product will cause a large increase in the price.

Quadratic programming is an additional area where the results of this study could be used. The elasticities determined by this study, in combination with mean prices and quantities, could be used to determine linear demand equations. A quadratic programming routine could then be used to solve a spatial equilibrium problem in which both product prices and consumption levels would be determined.

The price elasticity for total food in Thailand was estimated in this study to be about 0.505. One aspect of developmental policy could be a program to increase the output of agricultural products. Unless the increase in output were accompanied by lower per unit costs of production, this type of policy could result in lower farm incomes, given the previously cited inelastic price for food. In the absence
of lower unit costs of production, a rapid increase in the supply of food products would tend to favor consumers because of the expected lower prices at the retail level.

Up to this point, only the relationship between price and quantity demanded has been considered. Other factors such as changes in family incomes and population changes also affect the total demand of food products. Results of this study indicate the income elasticity for all food is about 0.35 in Thailand. Thus, for every one percent increase in family incomes, the consumption of food should increase by about 0.35 percent. Knowledge of income elasticities along with estimated changes in per capita income and population growth rates can be used to project future demand requirements at present price relationships. Future prices may also be predicted, if estimates of future commodity supplies, income elasticities and the population growth rate are available.

Implications of Demand Parameters

To supply the policymaker with more information about demand, four submatrices on 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. (These coefficients have been estimated by regression analysis.) 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 also is much easier to study a group of a few commodities which are close substitutes for each other than to analyze a commodity in its relations to all other commodities in the demand matrix.

The figures presented in Table 1 represent the following matrix equation:

\[ q = Bp + CY \]  

(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:

\[
\begin{align*}
B^{-1}_q &= (B^{-1}B)p + (B^{-1}C)Y \\
B^{-1}_q &= Ip + (B^{-1}C)Y \\
B^{-1}_q &= p + (B^{-1}C)Y \\
\end{align*}
\]

therefore

\[
p = B^{-1}_q - (B^{-1}C)Y .
\]

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 1. The four commodity groups are as follows: meats, vegetables, fruits, and oil seeds.
Meat group

The B matrix 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 Table 3 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 and the only other commodity which will be affected by such a reduction is pork whose 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 very little competition within this group because the individual fruit products are supplied to the market in different time periods.

**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 increase by 14 percent but the prices of sesame and groundnut oil will increase 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

The $B^{-1}$ coefficients for the different commodity groups are presented in tables three through six for additional information.

Table 3. $B^{-1}$ matrix for meat group

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<tr>
<th>Commodity</th>
<th>Beef</th>
<th>Pork</th>
<th>Poultry</th>
<th>Fish</th>
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<tr>
<td>Beef</td>
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<td>Poultry</td>
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<td>Fish</td>
<td>-2.19049</td>
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<td>-6.94927</td>
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</table>

¹All coefficients in the $B^{-1}$ matrices are derived from the coefficients in the corresponding submatrices of the complete demand matrix (presented in Table 1); the latter coefficients were based on regression analyses and are subject to sampling 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.
Table 4. $B^{-1}$ matrix for vegetable group

<table>
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<tr>
<th>Commodities</th>
<th>Potatoes</th>
<th>Chili</th>
<th>Garlic</th>
<th>Onions</th>
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Table 5. $B^{-1}$ matrix for fruit group

<table>
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<th>Commodities</th>
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<th>Pineapple</th>
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Table 6. $B^{-1}$ matrix for vegetable oil group

<table>
<thead>
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<th>Sesame</th>
<th>Cotton</th>
<th>Coconut Oil</th>
<th>Groundnut Oil</th>
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<td>Groundnut oil</td>
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Recommendations for Further Study

Just as other studies have been used partly as the basis for this one, the present study can serve as a basis for further research. The limitations of data on 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. Each commodity has special characteristics of its own which could not be explored in this study.

The lack 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 consistent 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 is a relevant further topic for empirical study.

Another needed field for applied statistical and theoretical research is the further study of price spreads. The behavior of marketing margins in the present analysis has been represented by specifying them as linear functions of retail prices. It would be useful to impose other behavioral assumptions for price spreads, do the necessary empirical work, and compare the results with those of this study.
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APPENDIX: DATA SOURCES AND "T" VALUES

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 presently no time-series data available on agricultural consumption. Thus, commodity consumption data in this study have been calculated as shown below:

\[
\text{consumption} = \text{production} + \text{imports} - \text{exports}
\]

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.
<table>
<thead>
<tr>
<th>Commodity</th>
<th>&quot;t&quot; Value</th>
<th>Commodity</th>
<th>&quot;t&quot; Value</th>
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<tbody>
<tr>
<td>Rice</td>
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<td>Watermelon</td>
<td>2.50</td>
</tr>
<tr>
<td>Beef and Buffalo</td>
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<td>Coconuts</td>
<td>2.80</td>
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<td>Pork</td>
<td>2.80</td>
<td>Pineapple</td>
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<td>Poultry</td>
<td>2.70</td>
<td>Banana</td>
<td>2.30</td>
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<td>Sesame seed</td>
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<td>Cottonseed</td>
<td>1.90</td>
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<td>Chili</td>
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<td>Coconut oil</td>
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<td>Garlic</td>
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<td>Ground nut oil</td>
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<tr>
<td>Onions</td>
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</table>

¹Values of "t" are from regressions calculated as a part of this study.