CONSUMPTION DEMAND FOR SELECTED FOOD COMMODITIES IN SAUDI ARABIA WITH PROJECTIONS FOR 1993

by

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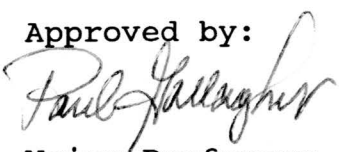

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CHAPTER 1

INTRODUCTION

The main objective of economic planning in most less-developed countries is to achieve a higher standard of living through more employment, higher production, and increases in per capita real income. A rise in per capita real income usually triggers an increase in demand for different food and nonfood commodities. This was especially true for Saudi Arabia in the past decade. As its petroleum export earnings bounded upward to $100 billion in 1980, Saudi Arabia gained prominence as an agricultural importer.

The recent economic growth and a population growth of about 4 percent annually dramatically increased the country's demand for food and agricultural products. This, together with lagging rates of local production, caused the country to import $6.7 billion worth of agricultural products in 1982, about 2,400 folds the 1970 import. Between 1973 and 1982 when incomes were accelerating, imports of cereals, vegetables, and fruits more than tripled, while that of meat increased even more.

Clearly if the government wishes to attain any sort of self-sufficiency in food, it must identify the current consumption patterns as well as possible trends in individual

items. The present study will investigate the relevant consumption function(s) with special emphasis on the relation between consumption and income for food commodities in Saudi Arabia and will utilize this demand relation(s) to provide answers to the following questions. How was the demand for food influenced by the dramatic increased in the general income level during the last decade? Was the demand for food nearly satiated from the point of view of average per capita food consumption? Granted that the average per capita real income will continue to increase at about the same rate as before, will this trend be accompanied by a substitution of cheap cereals (and potatoes) by more expensive but generally more health-protective food (such as meat, fruits, and vegetables)? What trend can be foreseen in the demand for the protein-rich animal foods, and in the vitamin-rich fruits and vegetables (and of course cereals and potatoes)? Will the projection indicate changes large enough to produce repercussions in the country's agricultural policy?

The relation between a consumer's income and his expenditure on the range of commodities available in the market has occupied a major role in economic thinking, ever since Earnest Engel (1821-1896) published a study on the condition of production and consumption in the Kingdom of Saxony in 1857 [10]. Engel formulated an empirical law concerning the relation between income and expenditure on food. Engel's law, as it has since become known, states that

the proportion of income spent on food declines as income rises. Its original statement was mainly based on an examination of about two hundred budgets of Belgian laborers collected by Ducpetiaus. Since that date the law has been found to hold in many other budget surveys, and a similar law has been formulated for other items of expenditure.[1]

The empirical study of consumption not only has been formulated for other items of expenditure, but has also had an international flavor from an early date. As budget statistics in individual countries were improved, however, the interest in international comparisons diminished.

The international comparison of expenditure patterns has recently acquired a new practical interest, which is quite similar to that which prompted Engel to use Belgian data--he was concerned with the balance between production and consumption when population increases. Since Saudi Arabia is now engaged in the construction of development programs, to adequately accomplish these programs, it is clearly necessary to have some idea about the changes in consumption that are likely to occur with rising income levels.

The determination and direction of future consumption requires a knowledge of a number of factors, such as price of

---

[1] The consumption function as it exists today stems from the "fundamental psychological law" stated by Keynes [22] that "men are disposed, as a rule on the average, to increase their consumption as their income increases, but not as much as the increase in their income."

the product in question, prices of the substitutes, population, and income. The validity and usefulness of the projections will be conditioned by the extent to which these factors were taken into account while arriving at a range in accordance with the order of magnitude.

A. The Study: Scope and Objectives

The work on long-term demand projections of various agricultural commodities in Saudi Arabia was first done by an independent research worker at the American University of Beirut [2]. Following that work the United States Department of Agriculture (USDA) came out with their own study in 1982 [19]. The present work is not just limited to income demand relationship, but, it has also investigated the existence of saturation levels in the consumption of selected food commodities in Saudi Arabia.

Food is a necessity good for sustaining life, its importance cannot be overlooked and, therefore, accurate projections of demand (and supply) for food products are vital pre-requisites for any effective policy. This necessity is reflected in the continuing endeavors by researchers to improve analytical tools used in the projection process. It is recognized that the estimates of demand elasticities, i.e., income and price elasticities are crucial, and a projection is only as good as these estimates. The present study is an

attempt in this direction and seeks to fulfill the following objectives in respect of major food commodities in Saudi Arabia, viz., wheat, rice, potatoes, chicken, mutton and lamb, beef and veal, oranges, apples, grapes, bananas, tomatoes, eggplants and dry onions:

1. To develop a sensible income consumption relation for selected food commodities, taking into consideration the price effect.
2. To use this demand or consumption function to estimate the income and price elasticities for selected food commodities. And
3. To use the estimated model(s) for demand projections of selected food commodities up to 1993.

Layout of the Study

Six more chapters will follow the introductory chapter. The second chapter is divided into three parts. The first part furnishes a brief review of consumer demand theory and model specification for food commodities. The second part reviews related studies on the subject and the final portion of this chapter discusses the combined model specification for the Saudi food products. Chapter 3 contains discussions on the data sources and variable definitions.

Chapter 4 is about estimation procedures. The first part of the chapter discusses the efficient estimation of seemingly

unrelated regression equations. The second part furnishes the discussion on imposing linear equality restrictions. The final portion of Chapter 4 describes the estimation procedure with "SAS". Chapter 5 discusses the results. Chapter 6 addresses objective three and the final chapter, i.e., Chapter 7 furnishes summary and conclusions.

CHAPTER 2

DEMAND MODEL DEVELOPMENT FOR SAUDI FOOD PRODUCTS AND REVIEW OF LITERATURE

Introduction

The chapter is divided into three parts. The first part reviews consumer demand theory and also discusses the consumption demand model specification for 13 food commodities in Saudi Arabia. Review of literature is furnished in part two. The final section presents the combined model specification.

Consumer Demand Theory

The maximization of a utility function $U(Q_1,...,Q_n)$ subject to budget constraint $P'Q = Y$ gives rise to demand function of the form[1]

$$(2.0) \qquad Q_i^* = Q_i(P,Y) \qquad (i=1,2,...n)$$

where Q is the n x 1 vector whose ith component represents the

[1] For detail treatment of consumer behavior theory and the derivation of the demand function, see for example, George and King [14], Henderson and Quandt [16], and Phlips [32].

quantity of the ith commodity consumed, P is the corresponding vector of commodity prices, Y is the value of total expenditure, i.e., income, and the superscript * denotes the optimal quantities arising from the maximization problem.

On the basis of consumer demand theory there are n demand equations and they may be written as

$$
\begin{aligned}
Q_1 &= Q_1(P_1,\ldots,P_n,Y) \\
Q_2 &= Q_2(P_1,\ldots,P_n,Y) \\
&\vdots \\
Q_n &= Q_n(P_1,\ldots,P_n,Y)
\end{aligned}
\tag{2.1}
$$

where Q_i's, P_i's, and Y's are as defined in equation (2.0), i.e., commodity i consumed, prices of closely substitute goods, and income, respectively. Equation (2.1) can be reexpressed in elasticity form by, first taking the differential of the (first demand) equation

$$
\Delta Q_1 = \frac{\partial Q_1}{\partial P_1}\Delta P_1 + \ldots + \frac{\partial Q_1}{\partial P_n}\Delta P_n + \frac{\partial Q_1}{\partial Y}\Delta Y \tag{2.2}
$$

where Δ stands for "a change in." We can divide equation (2.2) by Q_1 to get

$$
\frac{\Delta Q_1}{Q_1} = \frac{1}{Q_1}\frac{\partial Q_1}{\partial P_1}\Delta P_1 + \ldots + \frac{1}{Q_1}\frac{\partial Q_1}{\partial P_n}\Delta P_n + \frac{1}{Q_1}\frac{\partial Q_1}{\partial Y}\Delta Y \tag{2.3}
$$

and then divide and multiply the right hand side of equation (2.3) by the respective prices and income variables we get

$$(2.4a)\qquad \frac{\Delta Q_1}{Q_1} = \frac{P_1}{Q_1}\frac{\partial Q_1}{\partial P_1}\frac{\Delta P_1}{P_1} + \ldots + \frac{P_n}{Q_1}\frac{\partial Q_1}{\partial P_n}\frac{\Delta P_n}{P_n} + \frac{Y}{Q_1}\frac{\partial Q_1}{\partial Y}\frac{\Delta Y}{Y}$$

which is

$$(2.4b)\qquad \frac{\Delta Q_1}{Q_1} = E_{11}\frac{\Delta P_1}{P_1} + \ldots + E_{1n}\frac{\Delta P_n}{P_n} + E_{1Y}\frac{\Delta Y}{Y}$$

where E_{11} and E_{1j} are direct- and cross-price elasticities, and E_{1Y} is income elasticity, respectively. Thus, equation (2.1) can be written in elasticity form as

$$(2.5)\qquad \begin{aligned}
\frac{\Delta Q_1}{Q_1} &= E_{11}\frac{\Delta P_1}{P_1} + \ldots + E_{1n}\frac{\Delta P_n}{P_n} + E_{1Y}\frac{\Delta Y}{Y}\\
\frac{\Delta Q_2}{Q_2} &= E_{21}\frac{\Delta P_1}{P_1} + \ldots + E_{2n}\frac{\Delta P_n}{P_n} + E_{2Y}\frac{\Delta Y}{Y}\\
&\vdots\\
\frac{\Delta Q_n}{Q_n} &= E_{n1}\frac{\Delta P_1}{P_1} + \ldots + E_{nn}\frac{\Delta P_n}{P_n} + E_{nY}\frac{\Delta Y}{Y}\,.
\end{aligned}$$

In matrix form equation (2.5) can be written as

$$(2.6)\qquad \begin{bmatrix} \frac{\Delta Q_1}{Q_1} \\ \vdots \\ \frac{\Delta Q_n}{Q_n} \end{bmatrix} = \begin{bmatrix} E_{11} & \ldots & E_{1n} & E_{1Y} \\ \vdots & & \vdots & \\ E_{n1} & \ldots & E_{nn} & E_{nY} \end{bmatrix} \begin{bmatrix} \frac{\Delta P_1}{P_1} \\ \vdots \\ \frac{\Delta P_n}{P_n} \end{bmatrix}$$

or

$$Q = EP \tag{2.7}$$

where Q is an (n x 1) vector of commodity consumed, E is an (n x K) vector of price and income elasticities, and P is an (n x 1) vector of prices and income.

The demand equations in (2.1) are homogenous of degree zero in prices and income, i.e.,

$$E_{i1} + E_{i2} + \ldots + E_{in} + E_{iY} = 0 \qquad \text{(for i=1)} \tag{2.8}$$

and the matrix of Slutsky substitution term is symmetric and negative semidefinite, i.e.,

$$E_{ji} = E_{ij}(w_i/w_j) + w_i(E_{iY} - E_{jY}) \tag{2.9}$$

where w_i or w_j represents the share of expenditures (budget proportions) on ith or jth commodity. The restrictions are desirable since they simplify the estimation problem and improve efficiency of the estimates. The restrictions are empirically useful, however, only if they still allow adequate representation of the data.

The nature of demand for individual commodities can be developed from time series data by estimating demand equations which have relative prices and relative income as explanatory variables. Note that relative prices (and income) are normal prices (and income) deflated by price index -- The nonfood price index, PNF, is the deflator in the present inquiry. This ensures that demand function to be homogeneous of degree zero as explained in equation (2.8), without including parameter restrictions across equations. In addition, a set of restrictions for the Slutsky conditions [equation (2.9)] are imposed. Thus, the homogeneity and symmetry conditions are both incorporated in demand estimation.

1. The Income Demand Relationship

Particular care must be taken in specifying the consumption and income relationship because of the rapid growth in Saudi income[2]. This study follows an approach suggested by Prais and Houthakker [34] for food commodities. Indeed a focal point of this study is that a rapid income growth in Saudi Arabia should permit the investigation of characteristics of income-food relationship which cannot

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[2] Private consumption expenditure is used as an income measure in the present investigation, thus, throughout the course of this dissertation the term income and private consumption expenditure will be used interchangeably.

normally be obtained from time series data.[3]

(A) A Plausible Engel Curve for Food when Wide Ranges of Income are Observed : The Declining Income Elasticity Function

Future demand is viewed as a function of the average current consumption of each commodity plus (or minus) any change which will result from the expected growth of income. A crucial step in estimating the future demand for any commodity is, therefore, the specification of mathematical relationship between changes in the quantity demanded of that commodity and the changes in income. The price of the commodity in question and the prices of its substitutes also are taken into account. But, for the present discussion, it was assumed that relative commodity prices are constant. To see how income/expenditure was used in estimating various forms of demand relations, the following section reviews some of the related literatures.

Prais and Houthakker [34] in their investigation on British family budgets, adopted different non-linear forms of demand relationships, i.e., double-logarithmic, semi-logarithmic, hyperbolic, and log-reciprocal. Based on the

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[3] The present study is not just limited to the investigation of the consumption/income relationship, but, it has also investigated the existence of saturation levels in the consumption of selected food commodities in Saudi Arabia (see Chapter 7).

goodness of fit, they concluded that the semi-logarithmic function gave the best results, as far as food items were concerned. For all other goods and services, the double logarithmic form gave the best statistical results.

Pureell and Ranikar [35] analyzed annual household food purchased data in Atlanta, Georgia during 1958 and 1962. Consumption and income relationship was worked out by employing linear, semi-logarithmic, exponential and modified hyperbolic type of functions. It was found that the income elasticities of demand for food differed by types of food and for many food grains by the level of income.

Slater [37] worked out the quantity and expenditure elasticities of demand for apples for various regions of Great Britain for the year 1965. Six forms of functions, viz., linear, semi-logarithmic, double-logarithmic, logarithmic-inverse and logarithmic-normal were tried. The double-logarithmic functions gave better results. The income elasticity of apples was found to be 0.6550.

Tryphos and Tryphonopoulos [41] estimated consumer demand for meat in Canada. The demand function for beef, pork, lamb, and chicken were simultaneously estimated on the basis of annual data for the period 1954 and 1970. The per capita consumption of beef, pork, domestic lamb, and chicken were dependent variables, deflated retail price (or price indices) and per capita deflated personal disposable income were the principle explanatory variables used in the function.

(i) The Performance of Saudi Economy Before and After Oil Boom Years

In the following section a brief review of the performance of the Saudi economy is furnished. The model specification is then developed based on the economic framework previewed and the past studies.

The relation of food consumption to disposable income or total private consumption expenditure has been subjected in many countries to thorough statistical and analytical study since Engel pointed out in the nineteenth century that the proportion of expenditure on food tends to fall as total expenditure rises. A variety of mathematical functions had been tried by several authors. A theoretically preferred function is the sigmoid function or Engel's curve represented by an integral of a log normal distribution.[4] In practice, the log-inverse function has been used more often to represent it. The function implies a decline in the absolute value of the elasticity coefficient proportional to the increase in per capita income. When income tends towards infinity, the elasticity tends towards zero and the consumption towards a saturation level. To see whether the log-inverse function fits the Saudi Arabian data, we need first to review the performance of the Saudi economy in the period under

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[4] See Aitchison and Brown [1, Chapter 12].

investigation.

The growth of the Saudi economy (measured by private consumption expenditure, referred to here as income, Table 2.0 and Figure 2.0) has been uneven over the years. Nominal income, on the average has grown at the dramatical annual rate of 20 percent per year. For the purpose of comparison, the 24 year period, i.e., from 1963 to 1986, may be divided into period 1, the pre-oil boom years of 1963-73; period 2, the oil boom years of 1974-81; and period 3, the post-oil boom period of 1982-86. In terms of nominal income, the Saudi economy grew at an annual rate of 44 percent in the oil boom period, compared with only 13 percent before that, and only 2 percent in the post-oil boom years. The explanation for the uneven performance of the economy in the latter two periods was simply the increased and decreased in oil revenues in the former, and the latter periods, respectively.

During the 1970-83 span, inflation accelerated, and consequently the real rate of growth of income at constant (1981 prices) was lower than the nominal rates. Thus, if the rate of inflation in the entire period is taken into account, the real income is found to have grown at 11 percent, 37 percent, 3 percent, and 17 percent for period 1, period 2, period 3, and the entire span, respectively.

The sharp growth of income in this short time period gives an idea of the likely model that fits the Saudi food consumption pattern. The author hypothesizes the logarithmic

reciprocal function as the appropriate model.[5] Thus if income is an explanatory variable, the consumption function can be written as

$$(2.10) \qquad \text{Ln } Q = a - b(1/Y) + U,$$

where it is assumed that the effect of commodity prices are included in the constant term, a. Ignoring the disturbance term, equation (2.10) can be written as

$$(2.11a) \qquad Q = e^{a-b/Y}$$

or

$$(2.11b) \qquad Q = e^{a}\, e^{-b/Y}$$

Q is not defined for Y=0, but $Q \to 0$ as $Y \to 0$, so we can define Q(0) as zero, we then have an Engel curve which is the right-hand continuous at the origin. From equation (2.11)

$$(2.12) \qquad dQ/dY = (b/Y^2)e^{a-b/Y}.$$

Thus the slope is positive for positive b. The second

---

[5] In this study relative prices and income are used as explanatory variables, however, since the study is about validating the Engel's law, only the effect on demand of changes in income is considered.

derivative is

$$(2.13) \qquad d^2Q/dY^2 = (b^2/Y^4 - 2b/Y^3)\ e^{a-b/Y}.$$

Hence there is a point of inflection where $Y = b/2$. To the left of this point the slope increases with Y; to the right of it the slope diminishes. As $Y \to \infty$, $Q \to e^a$. Substituting $Y = b/2$ in equation (2.11) gives the value of Q at the point of inflection as $0.135\ e^a$ or, in other words, about 13 percent of the asymptotic value of Q. The general shape of this function is shown in Figure 2.1.

Since Y represents income, equation (2.11) then pictures an Engel curve. The consumption of food i, Q_i, starts at zero and approaches an asymptotic level. Rewriting equation (2.12) in an equivalent form gives

$$(2.14) \qquad 1/Q\ dQ/dY = b/Y^2$$

that is, the rate of growth (or consumption of Q_i) per unit change in Y is inversely proportional to the square of Y. Thus the rate of growth falls off sharply after low values of Y, as shown in Figure 2.1.

Equation (2.14) can be rewritten in elasticity form as follows

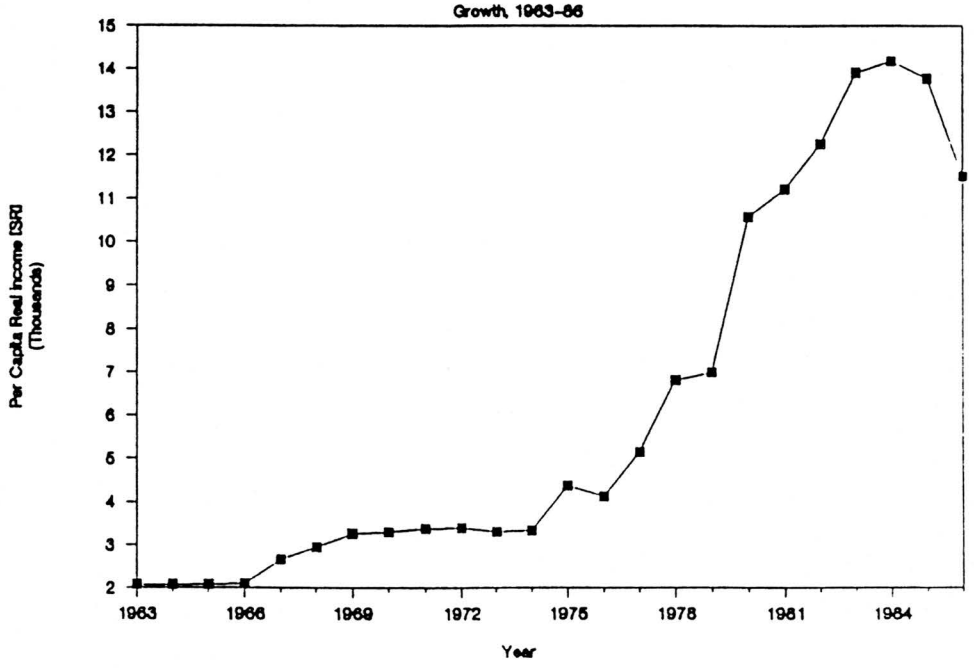
$$(2.15) \qquad 1/Q\ \partial Q/\partial Y = Y\ b/Y^2 = b/Y$$

TABLE 2.0. Per Capita Private Consumption Expenditure for Saudi Arabia and the United States (U.S.), and Per Capita Private Consumption Expenditure Ratio, 1963-86

Year	Saudi Per Capita Private Consumption Expenditure	Saudi Per Capita Private Consumption Expenditure	U.S. Per Capita Private Consumption Expenditure	Per Capita Private Consumption Expenditure Ratio
	(SR/person)	($/person)	($/person)	(U.S.$/Saudi $)
1963	533.1	118.5	1,979.7	16.7
1964	538.9	119.8	2,088.3	17.4
1965	537.9	119.5	2,225.7	18.6
1966	545.9	121.3	2,364.0	19.5
1967	701.8	155.9	2,471.5	15.9
1968	783.3	174.1	2,663.7	15.3
1969	888.9	197.5	2,841.7	14.4
1970	945.2	210.0	3,014.4	14.4
1971	1,004.7	223.3	3,221.9	14.4
1972	1,051.8	253.8	3,490.7	13.8
1973	1,168.6	316.8	3,859.2	12.2
1974	1,410.3	397.3	4,208.3	10.6
1975	2,488.3	707.3	4,584.9	6.5
1976	3,136.5	888.5	5,065.8	5.7
1977	4,264.3	1,209.7	5,579.1	4.6
1978	6,432.3	1,891.9	6,176.4	3.3
1979	7,112.0	2,116.0	6,844.7	3.2
1980	10,927.4	3,284.5	7,607.8	2.3
1981	11,725.5	3,466.0	8,325.1	2.4
1982	12,366.6	3,608.5	8,825.9	2.4
1983	14,192.3	4,107.8	9,257.2	2.3
1984	14,190.3	4,026.8	10,228.7	2.5
1985	12,650.8	3,492.7	10,988.8	3.1
1986	10,164.0	2,744.8	11,588.6	4.2

Source: International Monetary Fund (IMF), International Financial Statistics Yearbooks, various issues, Washington, D.C.

Figure 2.0. Per Capita Real Income



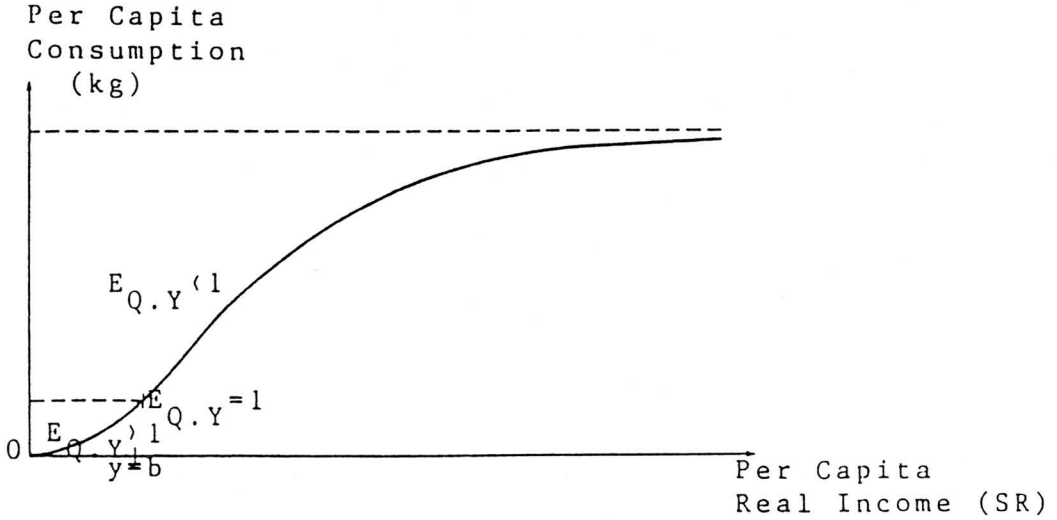


Figure 2.1. Hypothesized Engel Curve for Saudi Food Consumption.

or

(2.16) $E_{Q.Y} = b/Y.$

As $Y \to b$, $b/Y = 1$, i.e., $E_{Q.Y} = 1$ as $Y \to b$. Note that $E_{Q.Y}$ is the income elasticity. Hence there is a point of inflection where Y=b, i.e., when $E_{Q.Y} = 1$. To the left of this point the income elasticity is elastic, i.e., $E_{Q.Y} > 1$, and the food commodities are classified as luxuries; and to the right of it the income elasticity is not elastic, i.e., $E_{Q.Y} < 1$, and the foods in general are classified as necessities. In other words, as income increases according to the curve (Figure 2.1.), goods are luxuries at low income level, and necessity goods at much higher income level; when income goes towards infinity, the elasticity tends towards zero and the consumption towards a saturation level.

The use of the above function, i.e., the log-inverse function, for Saudi food consumption is not only justified by the nature of the Saudi's income growth in the period under investigation, but also is justified on the following grounds

(a) in many cases, there is a saturation level which acts as an upper limit, whatever the level of income; and

(b) previous studies[6] have concluded that the logarithmic

---

[6] Prais and Houthakker [34], for instance, have concluded that the semi-log formulation with its assumption of declining elasticity with growth in income, was more appropriate on the expenditure on food, in view of the presence of a satiation level for food consumption. The

reciprocal model gave good results, as far as food items were concerned. This is understandable: the log-inverse forms makes it possible for a commodity to appear as luxury at low income levels, and as a necessity (income elasticity below one) at higher income levels.

(ii) Measuring Effects of Substitute and Complement Commodity Prices

In order to show in general outline the effect of rising income and varying price levels on food demand, it is convenient to break down all food items into a few large groups based on the texture characteristics, marketing periods, and taste of the products. Thus, it is quite natural from the agricultural standpoint to deal with food from animal sources, i.e., meats, as one group, then the other food commodities could be grouped in similar fashion. To illustrate, wheat, rice, and potatoes could be classified under staple foods; oranges, apples, grapes, and bananas

---

log-inverse and semi-log formulations were both investigated by Prais and Houthakker since these two functions showed the same property of declining elasticity as income grew except that the former function passed through the origin and thus does not give the initial income. This does not mean the two functions would yield the same results, however, in light of their discussions [pp. 87-103] one could say that the log-inverse function could be as good the semi-log formulation since they almost exhibit the same properties.

belong to fresh fruits category; and tomatoes, eggplants, and dry onions are fresh vegetables. In the present study the author intends to estimate the demand for a large number of these substitute commodities.

Theoretically, a demand function should have relative prices of all commodities under investigation and income as independent variables. This creates several problems for time series data because prices as well as income, generally move in the same direction and it becomes difficult to separate their individual impacts on consumption. In other words, it is impossible to include all the relevant substitutes for a given food commodity because of multicollinearity and few degrees of freedom.

One way to solve the multicollinearity problem is to include no substitutes. Pasour [31], for instance, included no substitutes in his study of demand for apples. Yet many agricultural economists believe that grapes, oranges, and bananas are important substitutes for apples.

The problem caused by the interdependence of prices also can be solved by using cross-section data since prices remain unchanged across individuals. Quantity consumed then becomes a function of income only (with price effects remaining constant).[7]

It was impossible to include all relevant substitutes

---

[7] See Leser [29], Prais [34].

for given commodities under investigation, even with the mixed-estimation procedure adopted by Theil and Goldberger [40]. As has been alluded to earlier, if a large number of substitutes was included, multicollinearity and few degrees of freedom led to problems of imprecise estimates. Even though efficiency is improved with mixed estimation, imprecision can persist if too many substitutes are included. Therefore, only food substitutes with similar taste, marketing periods, and texture characteristics were included in the respective group.

The present study is unique in the sense that the author used time series data to estimate Engel curves. The emphasis was on cases involving a changing income response. 13 commodities were studied. To get around the multicollinearity problem, the author separated the 13 food commodities into four groups. Wheat, rice, and potatoes,[8] for example, were included in the staple foods group; chicken, mutton and lamb, and beef and veal were in the meats group; oranges, apples, grapes and bananas were in the fresh fruits category; and tomatoes, eggplants, and dry onions were included in the fresh vegetables group. Annual observations were used for the 24 year period, 1963-86. The author developed separate equations

---

[8] Potatoes are classified as vegetables by the Ministry of Agriculture and Water (MOAW) [23], however, the author feels that it is appropriate to include potatoes under staple foods since a growing proportion of population becoming familiar with Western foods, making potatoes as part of their staple diet. This is especially true if one looks at the growing numbers of fast food chains in the Kingdom.

for each food commodities. Thus, the staple foods group has three separate equations; one of each for wheat, rice, and potatoes. More discussion on the grouping of these commodities is found in Chapter 5.

Literature Review

The distinguishing feature of this review is the way it examined the methodological details rather than just compiling findings of such studies. This review of literature was mainly based on time-series data.

Studies Based on Time-Series Data

In projecting demand for food commodities, it is necessary to tackle certain methodological issues such as (i) selection of appropriate form of the demand function and projection model, (ii) selection of appropriate concept and values of the demand coefficients, and (iii) choice of the base period and base level demand. In this section, the review based on time-series data is given and will follow as studies based on both income and price elasticities.

Schultz's [36] book, the Theory and Measurement of Demand, is generally considered the pioneering work in the field of time-series analysis. The volume contains, apart from a theoretical exposition, studies of demand in the U.S. for

particular agricultural products such as sugar, wheat, cotton, potatoes, etc. Schultz tried to satisfy the "ceteris paribus" condition by putting all variables that theory supposes constant in a time trend shifts the demand curves in a systematic way. It includes the effects of changing tastes, of prices other than the products price, of income and of changes in the population structure. Schultz also divided the observation period into subperiods, and recomputed his regressions for each of these whenever history suggested that structural breaks might have been present.

Stone [39] has introduced, beside the trend, a number of prices (of complementary and competing goods) and per capita income in his regression equations. More importantly, perhaps, he has given much greater attention to the theoretical plausibility of his computations. He imposed the homogeneity of degree zero to double-logarithmic demand functions. Double-logarithmic specification was adopted because of its goodness of fit. Stone was, however, unable to take other general restrictions into account. The only thing he could do was to decompose the cross-price elasticity into a substitution effect and income effect, using the Slutsky equation.

Stone's work, remained unsatisfactory from the point view of its theoretical plausibility: the homogeneity restriction was the only one to be satisfied. However, in 1954, he succeeded and was responsible for the "first"

empirical estimation of a system of demand equations satisfying all general restrictions. This system is known as, "The Linear Expenditure System"[9], and is still widely used in applied work, especially for short-term projections.

Brandow's [4] study incorporated various theoretical restraints and extraneous estimators. The study provided a matrix of direct, cross, and income elasticities for 24 food and 1 nonfood commodity. Brandow used Frisch's idea of want independent and the concept of money flexibility in specifying a uniform relation for each food between the price elasticity for nonfood and for income elasticity for that respective food; namely, the nonfood price elasticity was estimated at 33 percent of the income elasticity.

Brandow's approach was however, subject to criticism. The demand elasticity matrix generated by the synthetic approach may not closely reflect actual data since most of the demand elasticities are not estimated directly from the observations. Thus it may not be a reliable model for structural interpretation and forecasting food consumption. Also, no statistical inference can be derived to verify the accuracy of the generated estimates.

---

[9] For detail treatment of the subject, see Klein and Rubin [27], and Stone [38]. Other related topics which the present author will not cover in the current study are, "Duality and Flexible Functional Forms," see for instance, Caves and Christensen [5], Cooper and McLaren [7], Weymark [43], and Heien [18], and "Almost Ideal Demand System," see for instance, Deaton and Muellbauer [8], Blanciforti, Green, and King [3].

Another related study was made by George and King [14]. They constructed a demand matrix for 49 food commodities and 1 nonfood commodity. All food commodities were grouped into 16 major categories. The income elasticities for food were obtained from cross-section household survey data. Some of the direct, cross-price elasticities within each commodity group were generated by applying the symmetry condition. To generate the demand elasticities in association with nonfood, i.e., income elasticity, cross-price elasticities for individual food commodities with respect to nonfood price, and cross-price elasticities for nonfood with respect to individual food price, they used the Engel aggregation, the block additivity assumption, and the symmetry relationship, respectively, and used money flexibility estimate of -0.86.

The George and King procedures are quite parallel to those used by Brandow. Thus, the general drawbacks of the synthetic approach also apply to George and King's study. Some of the demand elasticities in each food commodity category are estimated, and others are generated by satisfying the symmetry condition. The problem with this procedure is that it introduces a subjective choice for determining the cross-price elasticities, and moreover, the estimated standard errors are not reported for verifying the directly estimated elasticities.

The latest development was from Huang [20]. He used a constrained maximum likelihood method incorporating into

estimation the parameter restrictions derived from classical demand theory. The constrained estimation used ensures consistency within the framework of classical demand theory and greater statistical efficiency for the estimated demand parameters. The procedures also provide a methodology for directly estimating a complete demand system from time-series data. Huang then applied the procedures to an estimation of a U.S. food demand system including 40 food items and 1 nonfood item. The estimated demand system gives information about the independent nature of demand for foods in terms of price and income effect.

Combined Model Specification

The choice of a mathematical form for relation between particular food commodities and income (of course prices are also included) is a matter of great concern. As Prais [38] has shown, calculated income elasticities depend on the type of function that has been fitted. Practical considerations limit the choice of function in the present study to two types: double-logarithmic and log-reciprocal.

In this section, specific demand equations emphasizing cases where there is a changing income response will be presented. The discussion begins with the double-logarithmic function and will be followed by the log-inverse relation.

(a) Constant Income Elasticity Model

The demand for a food product i, (Q_i), is hypothesized to be a function of its own price, price of close substitutes, (complements) and income. For constant elasticity, the hypothesized model takes the following specification (for three goods market)

$$
\begin{aligned}
Q_{1t} &= a\ (P_{1t}/PNF_t)^{b1}\ (P_{2t}/PNF_t)^{b2}\ (P_{3t}/PNF_t)^{b3}\ (Y_t/PNF_t)^{c} \\
Q_{2t} &= a\ (P_{1t}/PNF_t)^{b1}\ (P_{2t}/PNF_t)^{b2}\ (P_{3t}/PNF_t)^{b3}\ (Y_t/PNF_t)^{c} \qquad (2.17) \\
Q_{3t} &= a\ (P_{1t}/PNF_t)^{b1}\ (P_{2t}/PNF_t)^{b2}\ (P_{3t}/PNF_t)^{b3}\ (Y_t/PNF_t)^{c}
\end{aligned}
$$

where there are three substitutes (including complements), i.e., there are three commodities in a group. Quantity consumed, (Q_i), and income, (Y), are on the per capita basis; commodity prices and income are deflated by the nonfood price index, (PNF), to satisfy the homogeneity condition. Equations (2.17) imply constant own-price elasticity, cross-price elasticity, and income elasticity.

The constant elasticity model is chosen because of ease of computation, good fit, and automatic correction for heteroscedasticity. Interestingly enough, Engel [10] himself also used a double-logarithmic approximation in his 1857 paper (pp. 30-1).

The estimating equations are accordingly as follows

$$
\begin{aligned}
\text{Ln } Q_{1t} &= \text{Ln a} + \text{b1 Ln } (P_{1t}/PNF_t) + \text{b2 Ln } (P_{2t}/PNF_t) \\
&\quad + \text{b3 Ln } (P_{3t}/PNF_t) + \text{c Ln } (Y_t/PNF_t) \\
\text{Ln } Q_{2t} &= \text{Ln a} + \text{b1 Ln } (P_{1t}/PNF_t) + \text{b2 Ln } (P_{2t}/PNF_t) \\
&\quad + \text{b3 Ln } (P_{1t}/PNF_t) + \text{c Ln } (Y_t/PNF_t) \\
\text{Ln } Q_{3t} &= \text{Ln a} + \text{b1 Ln } (P_{1t}/PNF_t) + \text{b2 Ln } (P_{2t}/PNF_t) \\
&\quad + \text{b3 Ln } (P_{3t}/PNF_t) + \text{c Ln } (Y_t/PNF_t)
\end{aligned}
\tag{2.18}
$$

so that the regression coefficients directly provide estimates of the price and income elasticities. Note that Q_{it} and Y_t are on the per capita basis. Equations (2.18) satisfy the homogeneity and Slutsky restrictions. Notice that with estimating equations (2.18) we do not need a separate homogeneity restriction because the demand function is already satisfied (by deflating each regressor with the nonfood price index, PNF), however, we need the Slutsky restrains.

To illustrate how the Slutsky restrictions are imposed in the estimating equation (2.18), we could rewrite the equation in terms of elasticities as follows (assuming three goods market)

$$
\begin{aligned}
q_1 &= E_{11}\, p_1 + E_{12}\, p_2 + E_{13}\, p_3 + E_{1y}\, y \\
q_2 &= E_{21}\, p_1 + E_{22}\, p_2 + E_{23}\, p_3 + E_{2y}\, y \\
q_3 &= E_{31}\, p_1 + E_{32}\, p_2 + E_{33}\, p_3 + E_{3y}\, y
\end{aligned}
\tag{2.19}
$$

the lower case q_i's, p_i's, and y_i's refer to natural logarithms or percentage changes. The E_{ii}'s , E_{ij}'s, and E_{iy}'s are the own- and cross-price elasticities and the income elasticity of commodity i, respectively.

The Slutsky relationship incorporates a fundamental relationship between changes in quantities and the marginal utility of income. The effects of simultaneous changes in prices and income can be obtained by taking total derivatives of the first order conditions of the following normal equations

$$
U_j(Q_1, Q_2, \ldots, Q_n) - \lambda P_j = 0, \qquad (j=1,\ldots,n) \tag{2.20a}
$$

$$
Y - P_1Q_1 - \ldots - P_nQ_n = 0 \tag{2.20b}
$$

where $U_j = \partial U/\partial Q_j$, and λ is the Lagrange multiplier. A change in the consumption of the ith commodity as a result of a change in jth commodity price can be represented as

$$(2.21) \qquad \partial Q_i/\partial P_j = (\partial Q_i/\partial P_j)_{U=\text{constant}} - Q_j(\partial Q_i/\partial Y)$$

$$= K_{ij} - Q_j \, \partial Q_i/\partial Y.$$

The first term on the right-hand side (K_{ij}) is the substitution effect and the second term is the income effect. The compensated cross-price derivatives are symmetric.

$$(2.22) \qquad \partial Q_i/\partial P_j + Q_j(\partial Q_i/\partial Y) = \partial Q_j/\partial P_i + Q_i(\partial Q_j/\partial Y).$$

Converting (2.22) into elasticities,

$$(2.23) \qquad E_{ij} = w_j/w_i \; E_{ji} + w_j \; (E_{jy} - E_{iy})$$

where w_i's or w_j's are the expenditure share of the Saudi Riyal (SR).

When the price changes of the same commodity are considered, the substitution effect, $K_{ii} = \partial Q_i/\partial P_i + Q_i(\partial Q_i/\partial Y)$, will be negative.

In terms of elasticity, the Slutsky restraint for the three goods market can be written as follows

$$(2.24) \qquad \begin{aligned} E_{12} &= w_1/w_2 \; E_{21} + w_2 \; (E_{2y} - E_{1y}) \\ E_{13} &= w_3/w_1 \; E_{31} + w_3 \; (E_{3y} - E_{1y}) \\ E_{23} &= w_3/w_2 \; E_{32} + w_3 \; (E_{3y} - E_{2y}) \end{aligned}$$

(b) Declining Income Elasticity Model

In light of the above discussion (on the plausible Engel curve when wide ranges of income are observed) and the past studies on foods consumption, a "Modifying Demand System Estimate--the Logarithmic-Inverse Function" is constructed as follows

$$
\begin{aligned}
Q_{1t} &= a\ (P_{1t}/PNF_t)^{b1}\ (P_{2t}/PNF_t)^{b2}\ (P_{3t}/PNF_t)^{b3} \\
&\qquad e^{-c/Y}t/PNF_t \\
Q_{2t} &= a\ (P_{1t}/PNF_t)^{b1}\ (P_{2t}/PNF_t)^{b2}\ (P_{3t}/PNF_t)^{b3} \\
&\qquad e^{-c/Y}t/PNF_t \\
Q_{3t} &= a\ (P_{1t}/PNF_t)^{b1}\ (P_{2t}/PNF_t)^{b2}\ (P_{3t}/PNF_t)^{b3} \\
&\qquad e^{-c/Y}t/PNF_t
\end{aligned}
\tag{2.25}
$$

where there are three substitutes (including complements), Y's and Q_i's are on the per capita basis and are as defined in equations (2.17). Commodity prices and income are deflated by the nonfood price index, (PNF), to satisfy the homogeneity condition. Equation (2.25) implies constant own- and cross-price elasticities, and declining income elasticity. The estimating equations (for three goods market) are as follows

$$\text{Ln } Q_{1t} = \text{Ln a} + \text{b1 Ln } (P_{1t}/PNF_t) + \text{b2 Ln } (P_{2t}/PNF_t) + \text{b3 Ln } (P_{3t}/PNF_t) - \text{c } (1/Y_t/PNF_t)$$

(2.26)

$$\text{Ln } Q_{2t} = \text{Ln a} + \text{b1 Ln } (P_{1t}/PNF_t) + \text{b2 Ln } (P_{2t}/PNF_t) + \text{b3 Ln } (P_{3t}/PNF_t) - \text{c } (1/Y_t/PNF_t)$$

$$\text{Ln } Q_{3t} = \text{Ln a} + \text{b1 Ln } (P_{1t}/PNF_t) + \text{b2 Ln } (P_{2t}/PNF_t) + \text{b3 Ln } (P_{3t}/PNF_t) - \text{c } (1/Y_t/PNF_t)$$

so that the regression coefficients directly provide estimates of price elasticities, while the income elasticity is gotten by dividing the estimated - c's coefficients by the per capita real income levels.[10] As before we do not need a separate homogeneity restriction because the estimating demand equations (2.26) are already satisfied (by deflating each independent variables with nonfood price index, PNF), however, we need the Slutsky constrains.

The Slutsky restrictions are imposed to estimating equations (2.26) and they are symmetry at the per capita mean real income value as follows (for the three goods market)

---

[10] The author divided the estimated - c's coefficients with three per capita income levels, the minimum, mean, and maximum values of SR 2,069.5, SR 6,258.4, and SR 14,183.2, respectively, to get the income elasticities.

$$E_{12} = w_2/w_1\ E_{21} + w/\hat{Y}\ (E_{2y} - E_{1y})$$

(2.27) $$E_{13} = w_3/w_1\ E_{31} + w/\hat{Y}\ (E_{3y} - E_{1y})$$

$$E_{23} = w_3/w_2\ E_{32} + w/\hat{Y}\ (E_{3y} - E_{2y})$$

where $\hat{Y}$ is the per capita mean real income, and w_i's E_{ii}'s, E_{ij}'s and E_{iy} are as defined in equation (2.17).

Notice that equations (2.26) differ from equation (2.0) in the sense that in the former equations homogeneity restrictions are automatically satisfied by deflating each regressors with nonfood price index, (PNF), and also Slutsky restrictions are imposed to the former equations [see equations (2.27)] while none of these restrictions are satisfied in the latter equation.

Equations (2.17) and (2.25) form the foundation for empirical study of consumption demand for 13 food commodities in Saudi Arabia. The final results of these estimates are presented in Chapter 5.

CHAPTER 3

DATA SOURCES AND LIMITATIONS

Introduction

This chapter will provide a brief discussion on the sources of the data used and their limitations in estimating the Saudi demand for food commodities. The chapter also includes the definitions of the variables used in the demand models.

Data Sources and Limitations

Limited availability of current, accurate information has always been a major problem for researchers and others dealing with developing countries. Saudi Arabia is no exception. The lack of both quality and quantity data create a serious problem in the Kingdom's development effort. This has been recognized by both government officials and individual researchers. According to the Saudi Third Development Plan, "The data base for agriculture remains inadequate, and all estimates must be taken as an indicative rather than firm." This problem is especially acute for agriculture trade and prices data for the country. Nevertheless, most analysis on consumption in this study is undertaken using this information (plus of course information on local productions and income from other sources discussed

below). Much of it, i.e., trade and prices data, is of poor quality.

To illustrate how bad the trade data is, re-export of rice in the Kingdom, for instance, is forbidden as this is a subsidized food item. Food aid, however, including rice and wheat, may be given to neighboring countries and the Yemen Arab Republic is known to have received rice from Saudi Arabia in this way. In addition, large quantities of rice - rough estimates put it at 20,000 tons a year - are trans-shipped through the port of Gizan. Yemen merchants also buy rice from the local wholesalers and subwholesalers in Gizan on the cash-and-carry basis and transport it by truck to Sanaa. This kind of food aid and trans-shipment activities are seldom or not reported in the Saudi trade data.

On the price side, the retail prices of rice in a large supermarket in Jeddah in January 1984 were as explained in Table 3.0. In small grocery stores and in markets throughout the Kingdom, the three main types of rice are sold from open bags at SR 3 per kg in all places and on all markets. At the wholesale level, better-known brands command a higher price than the less well-known products of similar quality. The most common wholesale prices for bags containing 100 lb of American long-grain par-boiled rice, less than 4 percent broken, were as shown in Table 3.1. On the same day that these prices were noted, the retail price in Jeddah central market for rice sold to consumers in 100 lb bags was SR 5-7 more per bag than the

reported prices. This difference represents a margin of 6-8 percent. The same situation could generally happen to other food commodities.

TABLE 3.0. Retail Prices of Rice in Jeddah in January, 1984

Type of Rice	Unit Price (SR)	Equivalent Price (SR/kg)
American Parboiled Rice		
Uncle Ben's 1 lb carton	2.95	6.50
Uncle Ben's 3 lb carton	8.50	6.25
Uncle Ben's promotion, 7 lb (2 lb free) polyethylene pack	13.50	4.25
Uncle Ben's, 25 lb branded paper bag	61.50	4.25
Prepacked by Tessale Factory		
(a) American Parboiled, 1.5 kg polyethylene pack	5.80	3.86
(b) Basmati, 1.5 kg polyethylene pack	4.90	3.27
(c) Egyptian Medium-Grain 1.5 kg polyethylene pack	5.80	3.86
Taxmati (Texas Long-Grain Basmati Rice), 5 lb (2,27 kg) original branded polyethylene pack	11.85	4.28

Source: International Trade Center UNCTAD/GATT. Rice: A Survey of Selected Markets in the Middle East. Geneva, 1984 p. 44.

TABLE 3.1. Wholesale Prices of American Long-Grain Parboiled Rice

Type of Rice	Price in SR/100 kg Bag
Abu Seifin (Two Swords)	90
Abu Bent (The Girl)	90
Abu Bentin (Two Girls)	82
Abu Comete	80
Uncle Ben's 4 x 25 lb bags in one bag	92

Source: International Trade Center UNCTAD/GATT. Rice: A Survey of Selected Markets in the Middle East. Geneva, 1984 p. 44.

It is not necessary to use official country trade data to study agricultural consumption in Saudi Arabia.[1] Rather it is possible to extract the information from other "more reliable sources," such as the United States Department of Agriculture (USDA)[42], and International Monetary Fund (IMF)[18]. The data used in the current study thus come from a variety of sources. Most of the data are official country imports and exports data as translated and standardized by the Food and Agriculture Organization of the United Nations (FAO). Where information from the official publications, such as the (FAO)[11],[12], Saudi Arabia's Central Department of

[1] Exceptions to this are data on retail prices, and total productions which the author extracted from publications by Saudi Arabia's Central Department of Statistics (CDS) [25], and Ministry of Agriculture and Water (MOAW) [23], respectively.

Statistics (CDS), Ministry of Agriculture and Water (MOAW) are not available for various reasons, reports made by the USDA are utilized.

Average Retail Prices (P_{it})

Prices are the annual average retail prices of 13 food commodities in Saudi Riyals (SR) per kilogram (kg) reported in several major cities in the Kingdom for the period of 1963-86, published by the CDS [25]. The major cities are Riyadh, Jeddah, Dammam, Abha, and Buraidah. Prices in smaller cities, such as, Taif, Medina, Al Hassa, Qateif, Hail, Tabuk, Jizan, Baha, and Abha were used whenever prices were not available in the five major cities.

Prices for meat group, i.e., chicken, mutton and lamb, and beef and veal, for 1963-69 were the average retail prices reported in Jeddah city. Prices in other cities were not reported for the period. These prices are shown in Appendix Table A.1.0 through Appendix Table A.4.2.

The average retail prices are then deflated by the nonfood price index (1981 = 1.0) to satisfy the homogeneity condition. The nonfood price index is the Laspeyres index computed by dividing the total expenditure on nonfood commodities ($\Sigma\ w_{i0}\ P_{it}$), i.e., house furnishings, rent, fuel and water, medical care, transportation and communication, entertainment and education, fabric and clothing, and other expenditures (1981 figures), by their expenditure shares (Σ

w_{i0}) as follows

$$PNF = \frac{\Sigma\ w_{i0}\ P_{it}}{\Sigma\ w_{i0}} \qquad (i = 1,2,\ldots,n)$$

where t represents time period, w_{io} is the expenditure share of the Saudi Riyal for middle income Saudi population from Ministry of Finance and National Economy (MOFNE), CDS[24], P_{it} is the consumer price index for nonfood commodities from Saudi Arabian Monetary Agency (SAMA), Research and Statistics Department (RASD)[26].

Quantity Consumed (Q_{it})

Except for wheat and rice, quantity consumed data for other eleven commodities (in million kg) are the sum of domestic productions and imports (less exports). The consumption data, i.e., the sum of local productions, imports less exports and net ending stocks, for wheat and rice for 1963-86 are from USDA, Foreign Agriculture Service (FAS) [42]. Consumption figures for the rest of the food commodities are from several sources. The production, import, and export figures for 1963-86 are from FAO, Production and Trade Yearbooks [11], [12]. The production figures for 1970-85 are from the Bulletin of Agricultural Statistics, published by the Department of Economic Studies and Statistics (DOESS), MOAW [23]. The same data for 1986 are from USDA, FAS [42]. The

import and export figures for 1970-86 are from FAO [11], [12].

The consumption figures for eleven commodities, i.e., other than wheat and rice, are subject to several criticism. First, not all the eleven commodities consumed were included since the net ending stocks were not available. Second, they were from different sources. These shortcomings presumably will affect the estimated values. The consumption figures were then deflated by the population figures to get the per capita quantity consumed. The population data are from IMF, International Financial Statistics Yearbooks [18].

Per Capita Real Income (YNR_t)

The income figures, in million SR, are the private consumption expenditure data for 1963-86, from IMF, International Financial Statistics Yearbooks [18]. The figures were then deflated by population and nonfood price index to get the per capita real income.

The income growth rate for projection was compiled from Center for Food and Agricultural Policy [6]. The growth rate for 1987 was estimated at a negative value of 1.47 percent, however, for the rest of the years, the projection showed a growth rate of 0.9, 2.07, 2.23, 2.42, 2.81, 2.91 percent for 1988, 1989, 1990, 1991, 1992, and 1993, respectively.

The rate of population growth for projection purposes were estimated by the author through the analysis of the past

population growth rate from IMF [18]. The growth rate was between 4.11 and 4.21 percent per year, and was assumed to rise gradually from the lower limit to the upper limit during the projection period. The estimated figures are subject to error and might have understated or overstated the rate of growth (since the birth rate is very high and family planning is rarely practiced or nonexistent in the country). It was not believed, however, that the understatement or overstatement, if it exists, would exceed 0.5 percent per year.

TABLE 3.2. Code Names, Definitions of Variables, and Sources Used in the Saudis Consumption Demand for 13 Food Commodities Model

Variable Code Names	Definitions	Sources
Consumption		
QW_t	Consumption of wheat in Saudi Arabia in year t (million kg, mkg)	USDA, FAS
QR_t	Consumption of rice in Saudi Arabia in year t (mkg)	do
QPO_t	Consumption of Potatoes in Saudi Arabia in year t (mkg)	USDA, FAS (1986); FAO Production Yearbooks(1963-84); FAO Trade Yearbooks(1963-86); and MOAW (1970-85)
QCH_t	Consumption of chicken in Saudi Arabia in year t (mkg)	do
QML_t	Consumption of Mutton and lamb in Saudi Arabia in year t (mkg)	do
QBV_t	Consumption of beef and veal in Saudi Arabia in year t (mkg)	do
QO_t	Consumption of oranges in Saudi Arabia in year t (mkg)	do

TABLE 3.2. Continued

Variable Code Names	Definition	Sources
Consumption		
QA_t	consumption of apples in Saudi Arabia in year t (mkg)	do
QG_t	Consumption of grapes in Saudi Arabia in year t (mkg)	do
QB_t	Consumption of bananas in Saudi Arabia in year t (mkg)	do
QT_t	Consumption of tomatoes in Saudi Arabia in year t (mkg)	do
QEP_t	Consumption of eggplants in Saudi Arabia in year t (mkg)	do
QDO_t	Consumption of dry onions in Saudi Arabia in year t (mkg)	do
Commodity Prices		
PW_t	Retail wheat price in Saudi Arabia in year t (Saudi Riyals/kilogram, SR/kg)	CDS, Statistical Yearbooks (1963-86)
PR_t	Retail rice price in Saudi Arabia in year t (SR/kg)	do
PPO_t	Retail potatoes price in Saudi Arabia in year t (SR/kg)	do
PCH_t	Retail chicken price in Saudi Arabia in year t (SR/kg)	do

TABLE 3.2. Continued

Variable Code Names	Definitions	Sources
Commodity Prices		
PML_t	Retail mutton and lamb price in Saudi Arabia in year t (SR/kg)	do
PBV_t	Retail beef and veal price in Saudi Arabia in year t (SR/kg)	do
PO_t	Retail oranges price in Saudi Arabia in year t (SR/kg)	do
PA_t	Retail apples price in Saudi Arabia in year t (SR/kg)	do
PG_t	Retail grapes price in Saudi Arabia in year t (SR/kg)	do
PB_t	Retail bananas price in Saudi Arabia in year t (SR/kg)	do
PT_t	Retail tomatoes price in Saudi Arabia in year t (SR/kg)	do
PEP_t	Retail eggplants price in Saudi Arabia in year t (SR/kg)	do
PDO_t	Retail dry onions price in Saudi Arabia in year t (SR/kg)	do
PNF_t	Nonfood price index in Saudi Arabia in year t (1981 = 1.0)	See text

TABLE 3.2. Continued

Variable Code Names	Definitions	Sources
Macro Variables		
Y_t	Total private consumption expenditure (i.e., income) in Saudi Arabia in year t (million SR)	IMF
N_t	Total population in Saudi Arabia in year t (millions)	IMF
	Nominal exchange rate (SR/U.S. $)	IMF
	Total Private consumption expenditure (i.e., income) in the United States (million $)	IMF
The Error Term		
U_t	The disturbance term in time period t. It is assumed that the error term is normally and independently distributed (NID) with mean equals to zero, the variance is constant and independent of the explanatory variables, various values of U are independent of each other, and that U has normal probability distribution.	

CHAPTER 4

ESTIMATION PROCEDURES

Introduction

In this chapter a method of estimating the parameters of a set of regression equations is discussed . The procedure involved application of Aitken's generalized least-squares to the whole system of equations. To construct such Aitken estimators, the author employed estimates of the disturbance terms' variances and covariances based on the residuals derived from an equation-by-equation application of least square. The first part of this chapter discusses the efficient estimation of seemingly unrelated regression equations. The second part furnishes the discussion on imposing linear equality restrictions. The final portion of the chapter describes the estimation procedures with "SAS."

Efficient Estimation of Seemingly Unrelated Regression Equations[1]

The demand functions discussed in Chapter 2 can be written in the following M regression equations (ignoring the logarithmic terms)

---

[1] This section depends heavily on Kmenta [28].

$$
\begin{aligned}
Q_{1t} &= a_{11} + b_{11}\, X_{1t,1} + \ldots + b_{1k1}\, X_{1t,k1} + U_{1t},\\
Q_{2t} &= a_{21} + b_{21}\, X_{21,1} + \ldots + b_{2k2}\, X_{2k,k2} + U_{2t},\\
&\vdots\\
Q_{Mt} &= a_{M1} + b_{M1}\, X_{Mt,1} + \ldots + b_{MkM}\, X_{Mt,kM} + U_{Mt},
\end{aligned}
\qquad (t = 1, \ldots, T) \tag{4.0}
$$

where $X_{1t,k1}$, $X_{2t,k2}$, ... , $X_{Mt,kM}$ are income variables and other X's variables are the price variables. Using matrix notation equation (4.0) can be written as

$$
\begin{aligned}
\mathbf{Q_1} &= \mathbf{X_1}\, \mathbf{b_1} + \mathbf{U_1},\\
\mathbf{Q_2} &= \mathbf{X_2}\, \mathbf{b_2} + \mathbf{U_2},\\
&\vdots\\
\mathbf{Q_M} &= \mathbf{X_M}\, \mathbf{b_M} + \mathbf{U_M},
\end{aligned}
\tag{4.1a}
$$

or

$$
\mathbf{Q_m} = \mathbf{X_m}\, \mathbf{b_m} + \mathbf{U_m} \qquad (m = 1, \ldots, M) \tag{4.1b}
$$

where $\mathbf{Q_m}$ is a (T x 1) vector of sample values of the dependent variable, $\mathbf{X_m}$ is a (T x K_m) vector of regression coefficients, and $\mathbf{U_m}$ is a (T x 1) vector of the sample values of the disturbances. Assume that $\mathbf{U_m}$ is normally distributed with mean

$$
E\,(U_{mt}) = 0 \qquad (t = 1, \ldots, T) \tag{4.2}
$$

and that its variance-covariance matrix is given by

$$(4.3) \qquad E\ (U_m\ U_m') = \sigma_{mm}\ I_T\ ,$$

where I_T is an identity matrix of order (T x T). The explanatory variables are taken to be nonstochastic and such that $(X'X)/T$ is nonsingular matrix and its limit (for $T \to \infty$) exists. This means that each of the equations is expected to satisfy the assumptions of the classical normal linear regression model. Suppose that we cannot rule out the possibility that the regression disturbances in different equations are mutually correlated. In this case we have

$$(4.4) \qquad E\ (U_m\ U_p') = \sigma_{mp}\ I_T \qquad\qquad (m,p = 1, \ldots , M).$$

Thus σ_{mp} is the covariance of the disturbance of the mth and the pth equation, which is assumed to be constant over all observations. This covariance represents the only link between the mth and the pth equation. Because this link is rather subtle, the system of M equation is called a system of **seemingly unrelated regression (SUR)** equations. The disturbance term in wheat, for instance, is likely to be correlated with the disturbance term in demand equations for rice, potatoes, etc. The solution to the problem is the generalized least squares estimation (also known as Aitken estimation).

Assuming the elements of the variance-covariance matrix (Ω) are unknown. We can replace Ω by a consistent estimator

of Ω. The resulting estimator of β has the same asymptotic properties as Aitken's generalized least squares estimator. The problem now is to find consistent estimators of the variance and covariance of the regression disturbances. One way is to estimate these variances and covariances from ordinary least squares (OLS) residuals (e_{mt}). For this we may use

$$(4.5) \qquad \hat{\Omega} = \begin{bmatrix} s_{11}I_T & s_{12}I_T & \cdots & s_{1M}I_T \\ s_{21}I_T & s_{22}I_T & \cdots & s_{2M}I_T \\ \vdots & & & \\ s_{M1}I_T & s_{M2}I_T & \cdots & s_{MM}I_T \end{bmatrix}$$

where $s_{mp} = 1/(T - K_m) \sum_{t=1}^{T} e_{mt}\, e_{pt}$,

$$K_m \geq K_p \ ,$$

$$m,p = 1, \ \ldots \ , M.$$

s_{mm} is unbiased and consistent estimator of σ_{mm} , and it can be shown that $S_{mp}(m \neq p)$ is consistent estimator of σ_{mp}. The resulting estimator of β

$$(4.6) \qquad \tilde{\tilde{\beta}} = (X' \ \Omega^{-1} \ X)^{-1} \ (X' \ \Omega^{-1} \ Q)$$

with

$$(4.7) \qquad \text{asympt. Var-cov } (\tilde{\tilde{\beta}}) = (X' \ \Omega^{-1} \ X)^{-1}$$

is called a two-stage Aitken estimator.

To estimate $\tilde{\tilde{\beta}}$, first, obtain OLS estimates for each

equation and use the resulting residuals to estimate the variances and covariances of the disturbances. This enable us to construct $\hat{\Omega}$. The second stage is to substitute $\hat{\Omega}$ into equation (4.6) and calculate the values of the elements of β. The two-stage Aitken estimator is asymptotically equivalent to Aitken's generalized least squares estimator and, therefore, to maximum likelihood estimator of β. Thus this estimator is asymptotically efficient and its asymptotic distribution is normal. With the small sample properties, the two-stage Aitken estimator is unbiased and efficient relative to OLS estimator.

Imposing Linear Equality Restrictions[2]

In estimating a demand relation, information is available from consumer theory on the homogeneity condition or the symmetry restrictions. These restrictions may be stated in the form of the following set of linear relations or linear equality restrictions

$$\mathbf{R}\beta = \mathbf{r} \tag{4.8}$$

where $\mathbf{r}$ is a (J x 1) vector of known elements and $\mathbf{R}$ is a (J x K) known prior information design matrix that expresses the structure of the information on the individual parameters β_i or some linear combination of the elements of the β vector.

---

[2] This section draws on Judge, et. al. [21, pp. 56-8].

Information concerning the parameters such as β_1 equal to some scaler k, the sum of the coefficients equal to unity and β_2 equal to β_3 may be specified in the $\mathbf{R\beta = r}$ format as

$$(4.9) \qquad \begin{bmatrix} 1 & 0 & 0 & 0 & \dots & 0 \\ 1 & 1 & 1 & 1 & \dots & 1 \\ 0 & 1 & -1 & 0 & \dots & 0 \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta_2 \\ \vdots \\ \beta_K \end{bmatrix} = \begin{bmatrix} k \\ 1 \\ 0 \end{bmatrix}$$

where J = 3. If the first J elements of the coefficient vector were specified to be equal to the vector $\mathbf{k}_j$, then this information could be specified as

$$(4.10) \qquad [I_J, 0_{(K-J)}] \begin{bmatrix} \beta_J \\ \beta_{K-J} \end{bmatrix} = \mathbf{k}_J$$

where I_J is a Jth order identity matrix and $\mathbf{k}_J$ is a (J x 1) known vector.

Given information in the form of (4.8), the question is how to combine it with the information contained in the sample observations thereof if specified to be known with certainty, that is, no sampling variability from sample to sample, linear equality relation (4.8) may be taken as given or restrictions in any estimation process. In the general linear statistical model (4.1b)[3] , when using the least square rule, i.e., $\mathbf{b} = (X'X)^{-1}X\mathbf{y}$, the least squares estimate **b** has mean vector ß

[3] $\mathbf{Q = Xb + U}$ in equation (4.1b) may equivalently be written as $\mathbf{y = X\beta + e}$. This will allow the author to follow the procedure adopted by Judge et. al.[21] closely.

and covariance $\zeta_b = \sigma^2(X'X)^{-1}$. Consequently, the coefficients are not independent and the restrictions on particular coefficients or their combinations reflected by (4.8) condition the values that other coefficients may take on. Therefore, if one uses the least squares criterion applied to both the sample information (4.1b) and the outside information (4.8), we are faced with problem of finding the vector **b*** that minimizes the quadratic form

$$q = (\mathbf{y} - X\beta)'(\mathbf{y} - X\beta) \tag{4.11}$$

subject to

$$R\beta = \mathbf{r} \quad \text{or} \quad R\beta - \mathbf{r} = \mathbf{0} \tag{4.12}$$

Since (4.8) appears as linear equality restrictions, classical Lagrangean procedure may be applied to yield the minimizing solution

$$\begin{aligned} \mathbf{b}^* &= \mathbf{b} + (X'X)^{-1}R'(R(X'X)^{-1}R')^{-1}(\mathbf{r} - R\mathbf{b}) \\ &= \mathbf{b} + S^{-1}R'(RS^{-1}R')^{-1}\boldsymbol{\delta}. \end{aligned} \tag{4.13}$$

The covariance matrix of the restricted least squares estimator is

$$E[(\mathbf{b}^* - E[\mathbf{b}^*])(\mathbf{b}^* - E[\mathbf{b}^*])'] = \zeta_{b^*} = \sigma^2[S^{-1} - S^{-1}R'(RS^{-1}R')^{-1}RS^{-1}]$$

$$= \sigma^2[S^{-1} - C] \qquad (4.14)$$

where $C = S^{-1} R'(RS^{-1}R')^{-1}RS^{-1}$ is a positive semidefinite matrix. This means, among other things, that the diagonal elements of the covariance matrix of the restricted least squares estimator (4.14) are equal to or less than the corresponding elements on the diagonal of the covariance matrix of the unrestricted least squares estimator. Furthermore, the difference between the covariance matrices is $\zeta_b - \zeta_{b^*} = C$, where C is positive semidefinite matrix. Therefore, if **b*** is unbiased, it is best within the class of unbiased estimators that are a linear function of both types of information **y** and **r**.

Estimation Procedure with "SAS"

When the equations are 'seemingly unrelated,' there is a technique that uses estimates of the covariance of the residuals across equations to increase the efficiency of the estimates. This technique is called "seemingly unrelated regression" (SUR), joint generalized least squares, or Zellner's method. PROC SYSREG of "SAS" can produce all of these estimates.

First specify the equation with MODEL statements for OLS estimation, using a label on each MODEL statement. Then

specify a "SYSTEM" statement referring to those equations by their labels, and finally, specify a "RESTRICT" statement for restrictions imposed. For the constant elasticity model the step by step "PROC SYSREG" procedures are as follows

PROC SYSREG;

M1: MODEL Ln Q_1 = Ln X_{11} Ln X_{12} ... Ln X_{1K};

M2: MODEL Ln Q_2 = Ln X_{21} Ln X_{22} ... Ln X_{2K};

⋮

MM: MODEL Ln Q_M = Ln X_{M1} Ln X_{M2} ... Ln X_{MK};

RESTRICT M1.Ln X_{12} = w_3/w_1 * M2.Ln X_{11} - w_2 * M_1.Ln X_{1K} + w_2 * M2.Ln X_{1K} ,

M1.Ln X_{13} = w_3/w_1 * M3.Ln X_{11} - w_3 * M1.Ln X_{1K} + w_3 * M3.Ln X_{1K} ,

⋮

MM-1.Ln X_{MM} = w_M/w_{M-1} * MM.Ln X_{MM-1} - w_M * MM.LN X_{MK} + w_M * MM.Ln X_{MK} ;

where X_{1K}, X_{2K}, ... , X_{MK} are income variables, and other X's are the price variables, and w's are mean value expenditure shares.

The step by step "PROC SYSREG" procedures for declining income elasticity are as follows

PROC SYSREG;

M1: MODEL Ln Q_1 = Ln X_{11} Ln X_{12} ... Ln X_{1K};

M2: MODEL Ln Q_2 = Ln X_{21} Ln X_{22} ... Ln X_{2K1};

⋮

.

MM: MODEL Ln Q_M = Ln X_{M1} Ln X_{M2} ... Ln X_{MK};

RESTRICT M1.Ln X_{12} = w_2/w_1 * M2.Ln X_{11} - $w_2/\hat{Y}$ * M1.Ln X_{1K} + $w_2/\hat{Y}$ * M2.Ln X_{1K} ,

M1.Ln X_{13} = w_3/w_1 * M3.Ln X_{11} - $w_3/\hat{Y}$ * M1.Ln X_{1K} + $w_3/\hat{Y}$ * M3.Ln X_{1K} ,

⋮

MM-1.Ln X_{MM} = w_M/w_{M-1} * MM.Ln X_{MM-1} - $w_M/\hat{Y}$ * MM-1.Ln X_{MK} + $w_M/\hat{Y}$ * MM.Ln X_{MK} ;

where X_{12}, X_{2K}, ... , X_{MK}, other X's, and w's are as defined in the constant income elasticity procedures. Note that for the declining income model, the symmetry restrictions are imposed at the mean per capita real income level ($\hat{Y}$), i.e., SR 6,258.4.

Finally, there are several versions of SAS. The PROC SYSREG procedures could be found in the SAS/ETS USER'S GUIDE: Econometrics and Time Series Library, 1982 Edition.

CHAPTER 5

RESULTS

Introduction

Price, cross-price, income elasticities of demand for a commodity are called demand elasticities. Demand elasticities define the nature of products from the standpoint of consumers' preferences: whether the products are complements or substitutes, superior or inferior, and necessities or luxuries. An understanding of such a nature of demand for commodities is essential as a guide for decision making and program operations by producers, traders and other public or private agencies.

In this chapter, an attempt has been made to find out the different demand elasticities, i.e., price, cross-price and income elasticities for the thirteen food products. A brief discussion on various food groups is offered. The setup of the regression estimates tables is presented and the criterion for selection of the final regression models is furnished. The regression estimates results for every commodity in every groups are also discussed. The final section includes the summary and overview of the results.

Grouping of the 13 Commodities

13 food commodities were included in the investigation: wheat, rice, potatoes, chicken, mutton and lamb, beef and veal, oranges, apples, grapes, bananas, tomatoes, eggplants, and dry onions. Together, these commodities account for a large proportion of the typical Saudi's food budget. And their expenditure share of the Saudi Riyal are 2.02, 2.51, 0.39, 1.82, 5.86, 0.37, 1.47, 1.11, 0.36, 0.93, 2.95, 0.19, and 0.31 percent, respectively. These figures added together form about 20.3 percent of the total budget.

To ease the estimation problem, the 13 food products were placed into four groups; wheat, rice, and potatoes are under staple foods; the meats group is comprised of chicken, mutton and lamb, and beef and veal; oranges, apples, grapes, and bananas are under fresh fruits category; and finally tomatoes, eggplants, and dry onions are grouped under fresh vegetables.

Preliminary specifications follow Huang's [17] procedure in the present inquiry. The author tried to aggregate the price and quantity variable using data from individual food commodities so that aggregate demand could be developed and used as framework for estimating the demand parameters of disaggregate food demand system. However, the work was abandoned because the price of individual food commodities in each group are closely related, i.e., the relative prices of

a subset do not remain constant, thus violating Hicks definition of commodity group.[1]

In an attempt to further simplify the estimation problem, the author considered only within group substitution. Estimations under constant and declining elasticity models were done to all groups. The empirical results (one for each group) are presented in the Appendix Tables A. 5.0 - A. 5.3.

Criterion for Selecting Final Models

The final models were chosen from these empirical results, based on the coefficient of multiple determination (R^2) and Durbin-Watson (D-W) value.[2] Models with high R^2 values approaching the upper limit of 1.0 were generally desirable since they indicate good fit. However, it is not necessarily true that a higher R^2 value alone suggests that the model is

---

[1] For more discussion on price linkage test, see Monke and Petzel [30].

[2] Another relevent selection criterion is the minimum mean square error (MSE) estimator. The mean square error criterion is a combination of unbiasedness and the minimum variance properties. An estimator is a minimum MSE estimator if it has the smallest mean squre error defined as the expected value of the squared differences of the estimator around the true population parameter b

$$MSE\ (\hat{b}) = E\ [\ \hat{b} - b\ ]^2.$$

Thus a model with smallest MSE was generally desirable. Note that it is only the relative values of the MSE's that matter, not their absolute values, and that in some cases a biased estimator can be better than an unbiased one because the estimates generated by its particular formula (or estimation approach) are more likely to be near the true parameter value (than those from an unbiased estimator are), but it need not always be so.

acceptable, because R^2 value generally increases as more explanatory variables (which may not necessarily be relevant variables) are included. In the present inquiry, however, the R^2 values were used to compare two demand models (constant and declining income elasticities) for the same commodity which have the same number of explanatory variables.

D-W values were used to detect the autocorrelation problem. The author chose models with D-W values close to 2.0 and R^2 values close to 1.0 as the final models for for projections.[3] Since the selection criterions were based on R^2 and D-W values, the final models in each food group may contain both functions, i.e., constant and declining elasticity functions. The final models for staple foods, for instance, have wheat and rice with constant income elasticity, and potatoes with declining income elasticity. The empirical results for the final models (one for each group) are presented in this chapter.

The Set up of the Regression Estimates Tables

The results of the final estimates are presented in several tables in the following sections. Each table

---

[3] Note also that if the D-W values in each model is not less than or equal to 1.3 then the model selection will be based on the R^2 values, however, if the R^2 values are the same in the two models, i.e., constant or declining income elasticities, the the selection criterion will be based on D-W values.

(representing specific commodity group) is divided into five columns. First columns (from left to right) list dependent variables; expenditure share in the 1981 food budget is listed in the column number two; explanatory variables start in column three; subsequent columns four display the R^2 and D-W values; and right-hand side columns list the income elasticity estimates. Each commodity has superscript number either 1 or 2 indicating the type of final model adopted, i.e., constant or declining elasticity model, respectively. In each set of results, the calculated t-values are written in parentheses below the coefficients. The declining income elasticity figures in column five were computed by dividing the coefficients for 1/YNR, i.e., - c's variables by per capita real minimum, mean, and maximum income, i.e., SR 2,069.5, SR 6,258.4, and SR 14,183.2, respectively. The coefficients for constant income elasticity models were also reported as a constant value at each per capita real income level.

An Illustration on the Selection of the Final Models

In this section, a general explanation on the selection of the final models for staple foods group is offered. The procedure could generally be applied to the other food groups, i.e., meat, fresh fruits, and fresh vegetables groups.

Appendix Tables A.5.0a and A.5.0b report regression estimates for staples for constant and declining elasticities

models, respectively. These two tables are compared together for the selection of the final models. To reiterate, the selection criterions are the R^2 and D-W values.

(a) Wheat Model Selection

The R^2 and D-W values of 0.96 and 1.58, respectively, for wheat are more superior, i.e., better fit and less autocorrelation problem, respectively in the constant elasticity model than their counterparts in the declining income elasticity equation. Thus the constant elasticity model was chosen as the final model for wheat.

(b) Rice Model Selection

Again the R^2 value of 0.72 in constant elasticity model for rice shows that it has a better fit than its counterpart in the declining elasticity model. However, there was a close call as far as the D-W statistic was concerned. The declining elasticity says that the model has less autocorrelation problem, i.e., the D-W statistic of 1.42 is closer to 2 than its counterpart in the constant elasticity model. The final model was, however, chosen from constant elasticity relation since it had a superior fit, even though the declining income elasticity exhibited less autocorrelation problem.

(c) Potatoes Model Selection

Both the constant and declining income elasticities models for potatoes showed the same R^2 values, i.e, 0.99; however, the declining income model had a better D-W values at 1.50. Accordingly the final model for potatoes was chosen from the declining income elasticity function.

To recapitulate, the final models for the staple foods group comprise the combinations of constant and declining income elasticity relations, i.e., constant elasticity models for wheat and rice, and declining elasticity for potatoes. These models are presented in Table 5.0.

Results for Staple Foods Group

The preliminary estimates are given in Appendix Tables A.5.0a and A.5.0b.[4] Table 5.0 contains regression results for final model for staple foods. Potatoes are relatively high priced, and thus relatively small quantities are sold and consumed in Saudi Arabia. Note that potatoes are considered a less important staple food in the Kingdom, and are consumed

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[4] The same selection procedures for staple foods was applied to the staple foods group, i.e., the selection was based on R^2, D-W, and minimum MSE values. Similar preliminary models for meats, fresh fruits, and fresh vegetables groups are shown in Appendix Tables A.5.1a. and A.5.1b., Appendix Tables A.5.2a. and A.5.2b., and Appendix Tables A.5.3a. and A.5.3b., respectively.

as complements. In contrast, wheat and rice are important diet staples, are relatively very low priced, and relatively large quantities are sold. They are important substitute goods. Wheat and wheat products form a major part of the Saudi diet. The traditional Arab pita bread and the Western-style loaf bread, as well as a growing amount of pastry products are consumed widely in Saudi Arabia.

Rice is another very important staple diet in the country. In fact, rice is the main staple food in the Kingdom accompanied by meat. Rice and wheat, however, are important substitutes. And one may argue that wheat was the main meal, the taste for the last 25 years has changed toward rice [9].

Saudi Arabia produces an excess of wheat, but very little rice, about 1,000,000 kg per year. As demand rises because of income and population increases, less wheat and more rice will be imported. An indicative calculation of per capita apparent consumption of staple foods in the Kingdom varied between 106 to 133 kg, 42 to 48 kg, and 5 to 6 kg for wheat, rice, and potatoes, respectively, during the 1978-86 periods. The high figure for wheat may be the result of increased productions and unrecorded re-exports.

Table 5.0 shows the direct-price elasticities for staples, wheat - 0.3969; rice - 0.4370; and potatoes - 0.4574. The t-statistics show that all coefficients for these variables are significant. As expected *a priori*, potatoes are

more price elastic than wheat and rice.

The estimated cross-price elasticities show significant substitution between wheat and rice. As expected *a priori*, potatoes are complements for wheat and rice, and show significant complement for rice but rather poorly for wheat. Thus, for instance, the quantity demanded for rice and wheat could increase by 0.0584, and 0.0243 percent, respectively, because of a 1-percent decrease in potatoes' price.

Table 5.0 also shows that all the estimated income elasticities had the expected positive signs and are all statistically significant. Perhaps what is worth noting is that the validation of Engel's law concerning decreasing income elasticity for increases in income is confirmed (in all of the functions, i.e., declining and constant elasticities relations).[5] The income elasticities for potatoes (with declining income elasticity model), for instance, are 1.8643, 0.6165, and 0.2720 at per capita real income levels of SR 2,069.5, SR 6,258.4, and SR 14,183.2, respectively. Note also that the constant income elasticity for wheat and rice, are 0.2887, and 0.3176, respectively. The R^2 and D-W values of 0.96 and 1.59, 0.72 and 1.40, and 0.99 and 1.48, respectively for wheat, rice, and potatoes indicate that the models have

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[5] In each model (perhaps, the more obvious is the declining income elasticity function) the income elasticity is less than one and, thus confirm the Engel's law abundantly.

TABLE 5.0. Regression Estimates of Demand for Staple Foods (3SLS)

Dependent Variable	Expenditure Share (percent)	Explanatory Variables						R^2	DW	Income Elasticity		
		Constant	PW/PNF	PR/PNF	PPO/PNF	YNR	1/YNR			y(min)[a]	y(mean)[b]	y(max)[c]
QW/N [1]	2.0200	2.1757 (5.2753)[d]	-0.3969 (-5.2893)	0.0894 (0.9845)	-0.0243 (-1.0315)	0.2887 (6.8400)	-	0.96	1.59	0.2887	0.2887	0.2887
QR/N [1]	2.5100	1.3367 (2.1918)	0.0725 (0.9893)	-0.4370 (-2.9357)	-0.0584 (-2.1873)	0.3176 (5.4051)	-	0.72	1.40	0.3176	0.3176	0.3176
QPO/N [2]	0.3900	3.4977 (13.0156)	-0.1440 (-1.1834)	-0.3991 (-2.3241)	-0.4574 (-2.5078)	-	-3858.1700 (-12.9481)	0.99	1.48	1.8643[e]	0.6165	0.2720

[1] $\text{Ln } Q_{it}/N_t = \text{Ln } a + b1 \text{ Ln } PW_t/PNF_t + b2 \text{ Ln } PR_t/PNF_t + b3 \text{ Ln } PPO_t/PNF_t + c1 \text{ Ln } YNR_t + U_t$

[2] $\text{Ln } QPO_t/N_t = \text{Ln } a + b1 \text{ Ln } PW_t/PNF_t + b2 \text{ Ln } PR_t/PNF_t + b3 \text{ Ln } PPO_t/PNF_t - c2\ 1/ynr_t + U_t$

Endogenous variables : Q_{it}/N_t - per capita consumption of wheat or rice, kilograms(kg); QPO_t/N_t - per capita consumption of potatoes, kg

Explanatory variables: PW_t/PNF_t - real retail wheat price, SR/kg; PR_t/PNF_t - real retail rice price, SR/kg; PPO_t/PNF_t - real retail potatoes price, SR/kg; YNR_t - per capita real private consumption expenditure (income), SR; $1/YNR_t$ - inverse per capita real private consumption expenditure (income), SR; and U_t - disturbance term

[a,b,c] Minimum,mean, and maximum per capita real income (y), SR 2,069.5, SR 6,258.4, and SR 14,183.2, respectively

[d] Numbers in parentheses are t-statistics

[e] Elasticities are computed by dividing c2 values by income levels in a, b, and c, respectively

Figure 5.0a. Actual and Estimated Per

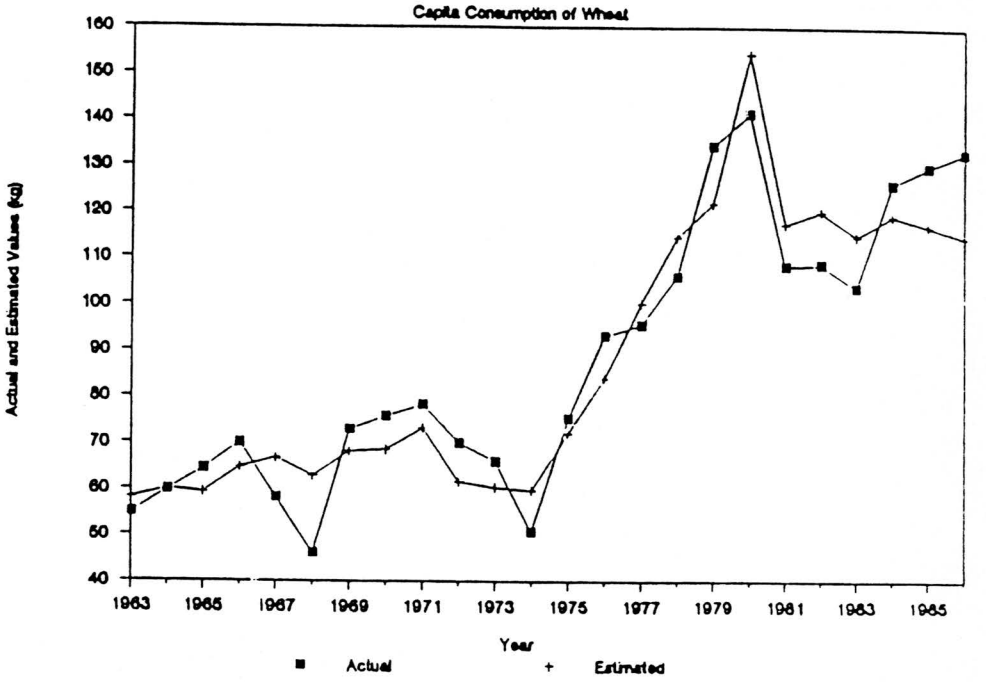


Figure 5.0b. Actual and Estimated Per

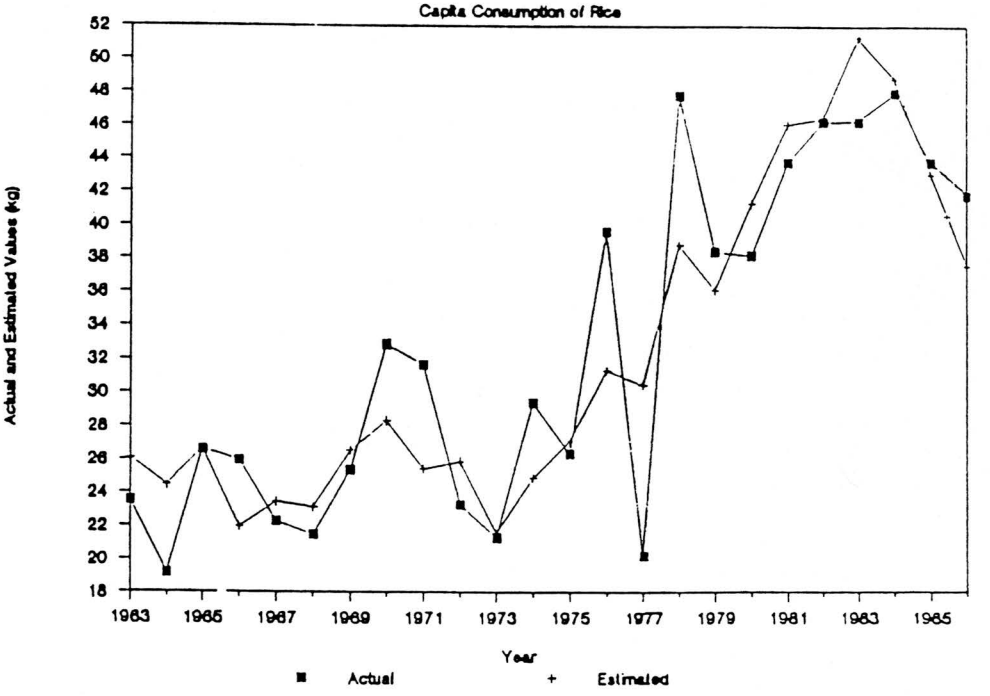
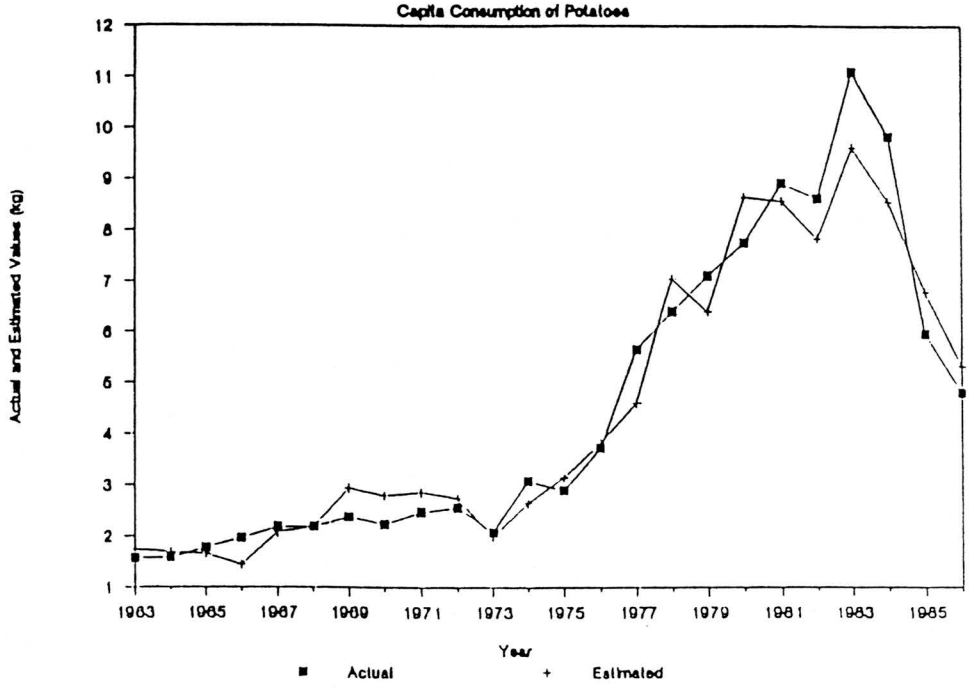


Figure 5.0c. Actual and Estimated Per



good fit and that there is no serious autocorrelation problem.

Figures 5.0a, 5.0b, and 5.0c compare the actual and estimated per capita consumption values for staples group. The estimated consumption approximated the actual consumption level fairly well.

Results for Meats Group

Meat is becoming the number one important part of the Saudi diet. Rising per capita income has stimulated demand for livestock products. The Saudis are by tradition lamb and mutton consumers, however, many consumers in Saudi Arabia are

induced to buy poultry rather than red meat, since chicken is almost one-third to one-half the price of red meat at retail level. Of the total meat imports since 1978, about 45 percent was imports of poultry; fish accounted for about 5 percent; and the remaining 50 percent comprised red meat. Much of the Saudis meat is imported live, partly because of the preference of fresh meat, lack of refrigeration in rural areas and partly because of Islamic slaughter practices. Economic reasons are also important. Live animals are fed in Saudi Arabia at a 50 percent feed subsidy. They are fed in facilities funded by highly subsidized loans, and they are purchased on trips financed by the government.

Since 1978 imports of small ruminant meat and beef have accounted for at least 90 percent of all red meat imports. Imports and local production of poultry, mutton and lamb, and beef and veal supplied consumers in Saudi Arabia 26, 120, 23 kg of meat per capita in 1986, respectively (Figures 5.1), comparable to the western country standard.

The most important characteristics of the Saudi market for meat that is illustrated by the retail price data is the preference of fresh mutton and lamb over all other types of meat. The retail prices for mutton and lamb are higher than the retail prices for fresh beef and veal, and poultry. The demand for fresh beef is strong among non-Saudi consumers, contributing to higher prices than poultry meat. Beef and veal could be considered as complements rather than substitutes for

mutton and lamb for Saudis. However, the consumption of beef is growing rapidly among Saudis. Changing tastes and rising incomes are responsible. Hamburgers and steak have become much more popular, partly because of the growing numbers of fast food chains in the country.

With the continuous increase in mutton and lamb prices, Saudi consumers might have to adjust their consumption habit by consuming more chicken since they are traditionally non-beef consumers.[6] The easy access of Saudi population to poultry meat from local farms, especially in the 1980's, makes chicken an important substitute for mutton and lamb.

Table 5.1 shows the regression estimates of Saudis' demand for meats. The direct-price elasticities of meats are chicken, - 0.8122; mutton and lamb, - 0.6531; and beef and veal, - 0.6914. The estimated cross-price elasticities show significant substitution between chicken and mutton and lamb. The table shows quantity of chicken demanded could increase by 0.7653 percent because a 1-percent increase in mutton and lamb price. On the other hand, a 1-percent increase in the price of chicken could increase the quantity demanded for mutton and lamb by 0.2073 percent. The estimated cross-price elasticities between beef and veal and chicken show significant complement relationship at - 0.4170. The results

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[6] The Saudis consume less beef as compared to mutton and lamb, and chicken, partly due to the difference in taste and preferences.

TABLE 5.1. Regression Estimates of Demand for Meats (3SLS)

Dependent Variable	Expenditure Share (percent)	Explanatory Variables						R^2	DW	Income Elasticity		
		Constant	PCH/PNF	PML/PNF	PBV/PNF	YNR	1/YNR			y(min)[a]	y(mean)[b]	y(max)[c]
QCH/N [2]	1.8200	3.3841	-0.8122	0.7653	0.0251	-	-7736.2400	0.99	1.41	3.7382[e]	1.2361	0.5455
		(4.4948)[d]	(-4.6570)	(2.3353)	(1.0020)		(-14.5374)					
QML/N [1]	5.8600	1.7758	0.2073	-0.6531	-0.0258	0.4326	-	0.84	1.43	0.4326	0.4326	0.4326
		(0.7371)	(2.0617)	(-1.4731)	(-1.5766)	(2.9278)						
QBV/N [1]	0.3700	0.6570	0.0907	-0.4170	-0.6914	0.5675	-	0.97	1.58	0.5675	0.5675	0.5675
		(0.3937)	(0.7422)	(-1.6235)	(-2.2311)	(6.2962)						

[1] $\text{Ln } Q_{it}/N_t = \text{Ln } a + b1 \text{ Ln } PCH_t/PNF_t + b2 \text{Ln } PML_t/PNF_t + b3 \text{ Ln } PBV_t/PNF_t + c1\ 1/YNR_t + U_t$

[2] $\text{Ln } QBV_t/N_t = \text{Ln } a + b1 \text{ Ln } PCH_t/PNF_t + b2 \text{ Ln } PML_t/PNF_t + b3 \text{ Ln } PBV_t/PNF_t - c2 \text{ Ln } YNR_t + U_t$

Endogenous variables: Q_{it}/N_t - per capita consumption of mutton and lamb or beef and veal, kg ; QCH_t/N_t - per capita consumption of chicken, kg

Explanatory variables: PCH_t/PNF_t - real retail chicken price, SR/kg; PML_t/PNF_t - real retail mutton and lamb price, SR/kg; PBV_t/kg_t - real retail beef and veal price, SR/kg; YNR_t - per capita real private consumption expenditure (income), SR; $1/YNR_t$ - inverse per capita real private consumption expenditure (income), SR; and U_t - disturbance term

[a,b,c] Minimum, mean, and maximum per capita real income (y), SR 2,069.5, SR 6,258.4, and SR 14,183.2, respectively

[d] Numbers in parentheses are t-statistics

[e] Elasticities are computed by dividing c2 values by income levels in a, b, and c, respectively

Figure 5.1a. Actual and Estimated Per

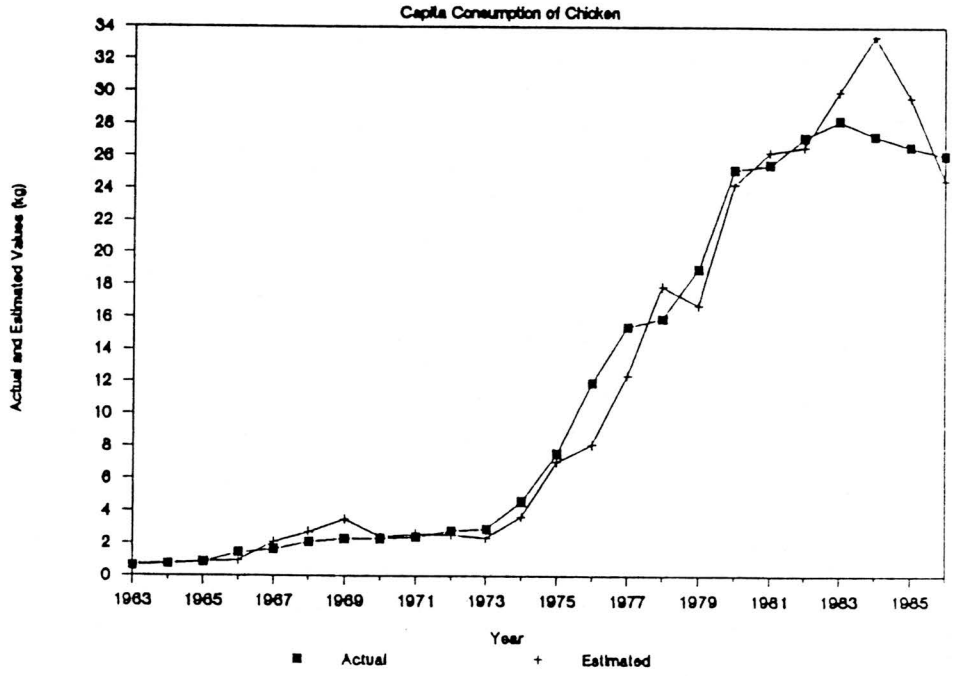


Figure 5.1b. Actual and Estimated Per

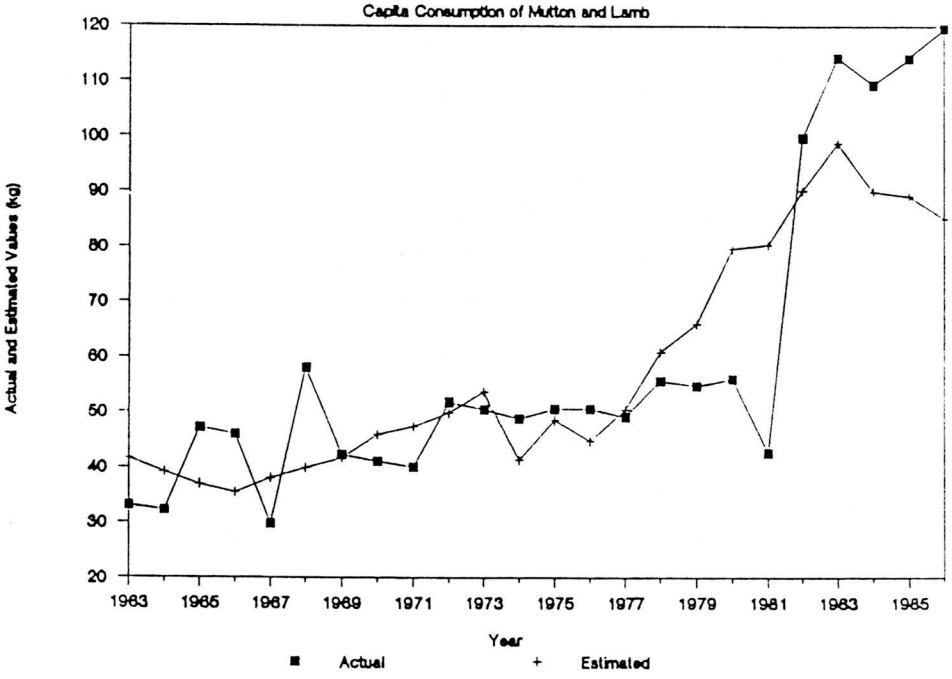
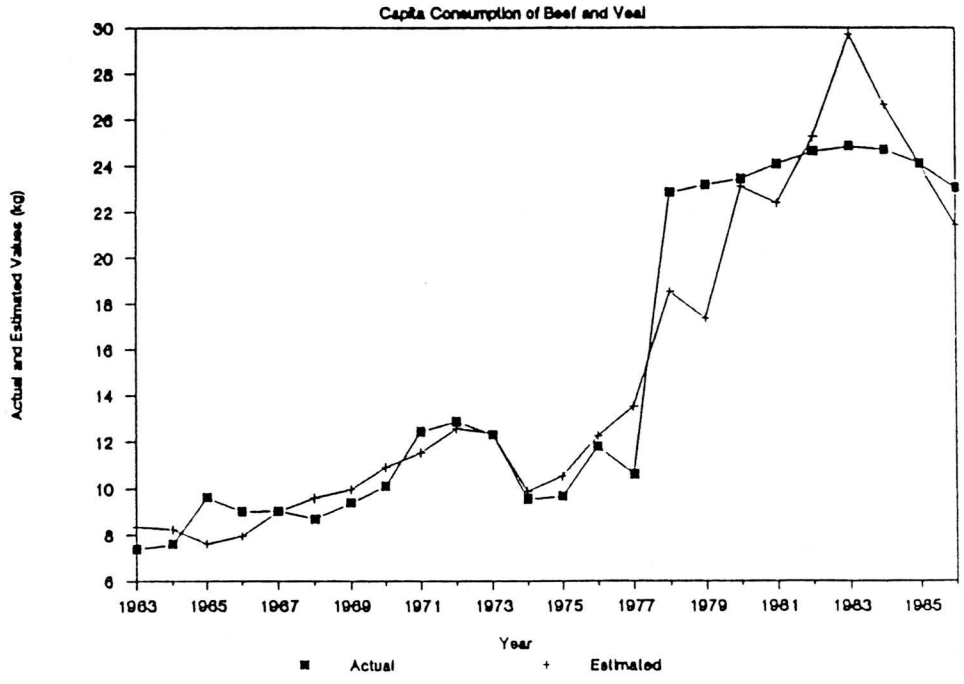


Figure 5.1c. Actual and Estimated Per



support the earlier discussion about the substitution between chicken and mutton and lamb, and the complement between mutton and lamb, and beef and veal.

The income elasticities for chicken (declining income elasticity model), mutton and lamb (constant income elasticity model), and beef and veal (constant income elasticity model) are 0.5455, 0.4326, and 0.5675, respectively. The income elasticity for beef and veal is higher than the rest of the meats because beef and veal are highly priced and less quantities are sold, and also due to the fact that beef and veal are less popular among the Saudis, their demand is strong among non-Saudi consumers, contributing to higher prices than

the poultry meat. Again, the coefficients have the right signs and are statistically significant, and they illustrate the validation of the Engels's law concerning decreasing income elasticity for increase in income.

The R^2 and D-W values indicate that the models have good fit and that there is no serious autocorrelation problem. Figures 5.1a, 5.1b, and 5.1c compare the actual and estimated per capita consumption values for meats group. The estimated consumption approximates the actual consumption level fairly well.

Results for Fresh Fruits Group

Fresh fruit was once considered exotic in Saudi Arabia. Fresh apples imported from Lebanon for a short period each year were in high demand. Only small amount of citrus was available in other seasons, and that was imported. Fruit production has expanded steadily since the early seventies, however. Total production was 84,000,000 kg in 1980. New orchards, vineyards and increased application of fertilizer have contributed to the increase.

Citrus (mainly oranges) makes up the largest part of Saudi imports with 222,166,000 kg imported in 1984. Oranges consumption is high at 25 kg per capita average 1978-86 (per capita U.S. consumption is about 14 kg). Oranges are important substitute for apples, grapes, and bananas in the Kingdom.

Apples and bananas are another fresh fruit diet of the Saudis. Apples were originally imported from Lebanon, but they also now come from the United States, Chile and European Economic Community (EC) assuring year-round supplies. There are some locally grown apples, however, they are relatively more expensive at the retail level and are not always available year-round.

Bananas are imported in large quantities from the Philippines and Central American countries. The per capita consumption of apples and bananas are 9.5 and 9.7 kg, respectively. Bananas and apples could be complement goods in this country. However, oranges are usually substitute fruits for bananas and apples.

Another important substitute for oranges is grapes. The consumption of grapes is mainly domestic. Local production of grapes was 76,777,000 kg in 1984 and its per capita consumption at 9.0 kg.

Oranges and bananas are always available at relatively lower prices than apples and grapes, and relatively large quantities are sold. One would expect to see apples and grapes to be more price elastic and have higher income elasticities than oranges and bananas.

Table 5.2 contains the empirical results of regression estimates of demand for fresh fruits. The price responses of apples and to a lesser extent grapes are elastic with direct-price elasticities of - 1.1798 and - 0.9232, respectively. The

TABLE 5.2. Regression Estimates of Demand for Fresh Fruits (3SLS)

Dependent Variable	Expenditure Share (percent)	Explanatory Variables									Income Elasticity		
		Constant	PO/PNF	PA/PNF	PG/PNF	PB/PNF	YNR	1/YNR	R^2	DW	y(min)[a]	y(mean)[b]	y(max)[c]
QO/N [2]	1.4700	3.4273	-0.5660	0.1222	0.0963	0.0581	-	-3764.8100	0.99	1.60	1.8192[d]	0.6016	0.2654
		(12.6714)[e]	(-3.4059)	(0.9310)	(1.8400)	(0.5972)		(-12.4382)					
QA/N [1]	1.1100	-3.3332	0.1409	-1.1798	-0.0915	-0.0614	0.8121	-	0.99	1.39	0.8122	0.8122	0.8122
		(-3.6917)	(0.8143)	(-4.4613)	(-1.3561)	(-0.4888)	(10.4456)						
QG/N [1]	0.3600	-3.0539	0.3735	-0.2833	-0.9232	0.0887	0.7377	-	0.97	1.50	0.7377	0.7377	0.7377
		(-3.6163)	(1.7538)	(-1.3603)	(-6.2636)	(0.7007)	(9.5030)						
QB/N [2]	0.9300	3.4851	0.0898	-0.0875	0.0300	-0.7306	-	-2881.5600	0.99	1.41	1.3924[f]	0.4604	0.2032
		(9.9876)	(0.5822)	(-0.5842)	(0.6132)	(-4.7254)		(-6.5677)					

[1] $\text{Ln } Q_{it}/N_t = \text{Ln a} + b1 \text{ Ln } PO_t/PNF_t + b2 \text{ Ln } PA_t/PNF_t + b3 \text{ Ln } PG_t/PNF_t + b4 \text{ Ln } PB_t/PNF_t + c1\ YNR_t + U_t$

[2] $\text{Ln } Q_{it}/N_t = \text{ln a} + b1 \text{ Ln } PO_t/PNF_t + b2 \text{ Ln } PA_t/PNF_t + b3 \text{ Ln } PG_t/PNF_t + b4 \text{ Ln } PB_t/PNF_t - c2\ 1/YNR_t + U_t$

Endogenous variables: $^1Q_{it}/N_t$ - per capita consumption of apples or grapes, kg ; $^2Q_{it}/N_t$ - per capita consumption of oranges or bananas, kg

Explanatory variables: PO_t/PNF_t - real retail oranges price, SR/kg ; PA_t/PNF_t - real retail apples price, SR/kg ; PG_t/PNF_t - real retail grapes price, SR/kg ; PB_t/PNF_t - real retail bananas price, SR/kg ; YNR_t - real per capita private consumption expenditure (income), SR; $1/YNR_t$ - inverse real per capita private consumption expenditure (income), SR; and U_t - disturbance term

[a,b,c] Minimum, mean, and maximum per capita real income (y), SR 2,069.5, SR 6,258.4, and SR 14,183.2, respectively

[d,f] Elasticities are computed by dividing c2 values by income levels in a, b, and c, respectively

[e] Numbers in parentheses are t-statistics

Figure 5.2a. Actual and Estimated Per

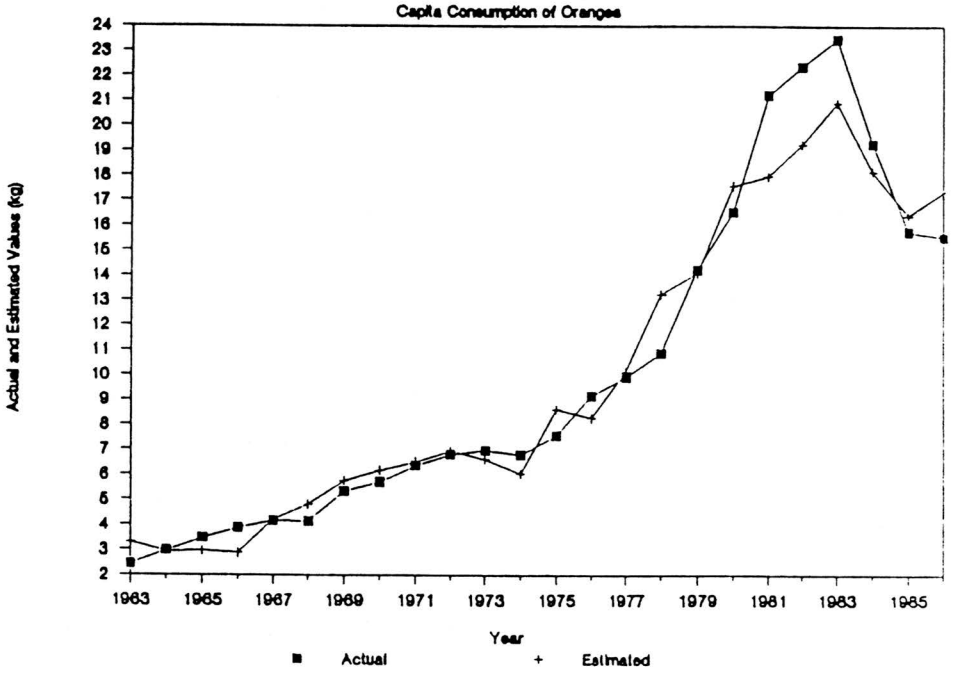


Figure 5.2b. Actual and Estimated Per

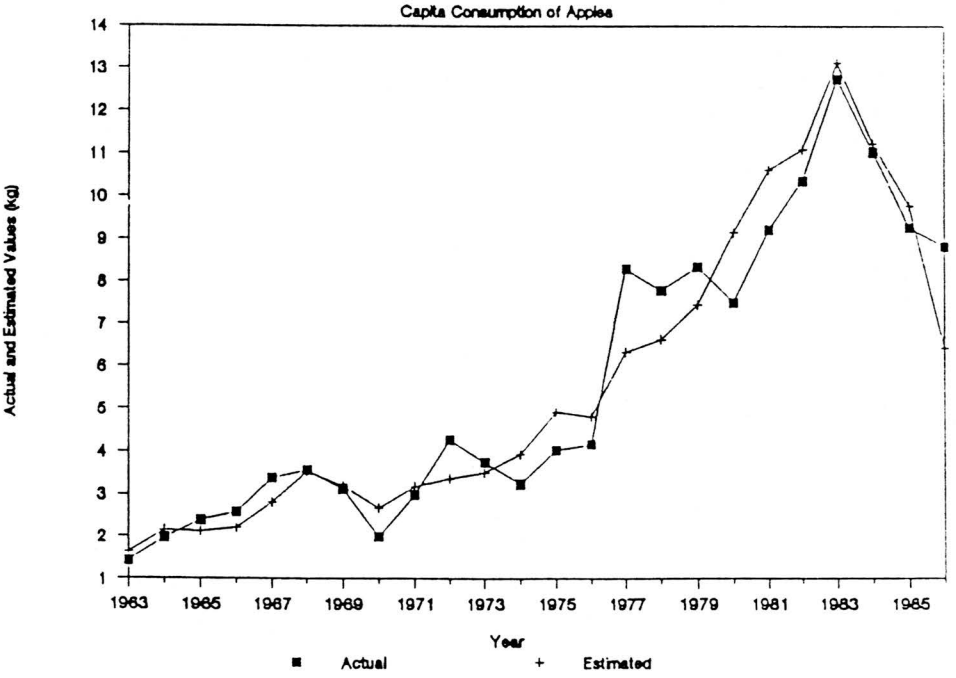


Figure 5.2 c. Actual and Estimated

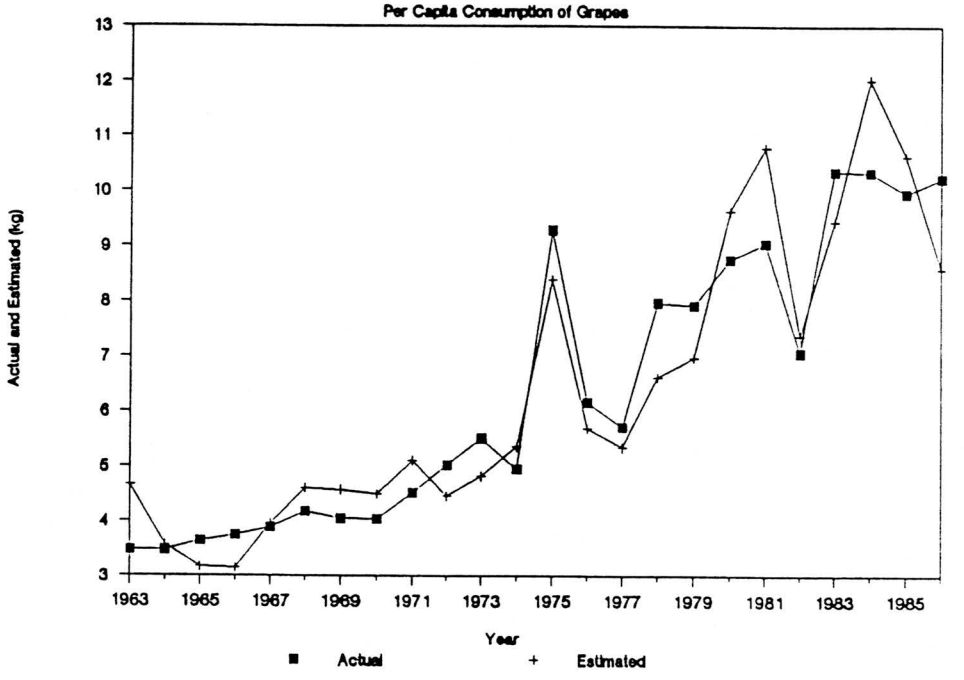
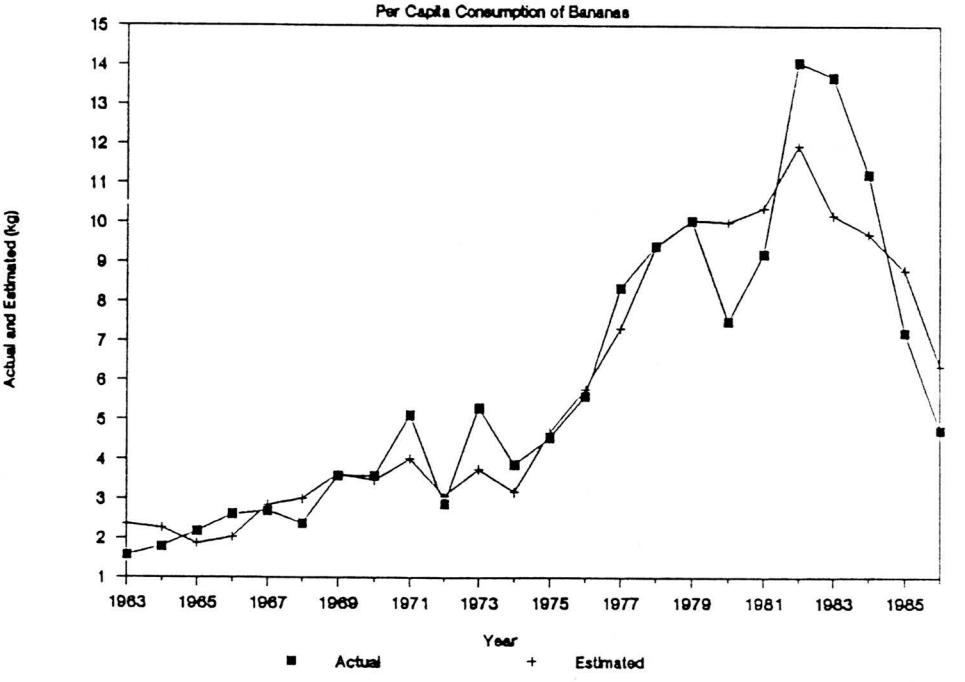


Figure 5.2 d. Actual and Estimated



direct-price elasticities for bananas and oranges are - 0.7306 and - 0.5660, respectively.

The estimates of cross-price response indicate that oranges are a strong substitute for apples, but weak substitute for grapes and bananas, and that grapes and bananas are less significant complements for apples.

The income elasticities as expected *a priori*, are significantly higher for apples (constant income elasticity model) and grapes (constant income elasticity model), and much lower for oranges (declining income elasticity model) and bananas (declining income elasticity model); they are 0.8122, 0.7377, 0.2654, and 0.2032, for apples, grapes, oranges, and bananas, respectively. Oranges and bananas have relatively lower income elasticities mainly due to the fact that they are available at much lower prices and thus larger quantities are sold than apples and grapes. In other words, relative prices may have influenced the elasticities; it has sometimes been suggested that the income elasticity of a commodity is an increasing function of its price relative to other commodities.

Another reason might be that apples and grapes used constant income elasticities while oranges and bananas utilized the declining income elasticity models in the regression analysis. The constant income elasticity function can only be satisfied approximately and over a limited range

of total income. This is a well-known defect of double-logarithmic Engel curves which has to be offset against their many advantages such as good fit, ease of computation, and automatic correction for heteroscedasticity. The constant income elasticities, even though higher than the declining elasticity values, are all significantly less than one and therefore confirm Engel's law abundantly.

In all cases the R^2 and D-W values indicate that the models have good fit and that there is no serious autocorrelation problem. Figures 5.2a, 5.2b, 5.2c, and 5.2d compare the estimated and the actual per capita consumption values for fresh fruits group. The estimated consumption once again approximates the actual level fairly well.

Results for Fresh Vegetables Group

Fresh vegetables are now in year-round demand. The Saudis have been quite successful in their own production, employing some of the world's most advanced irrigation and greenhouse technology. Output of horticultural crops has soared so that most fresh vegetables sold in the country are now locally produced. New irrigation facilities and improved marketing centers caused many farmers in the Jizan, Qassim, and Buraidah areas to shift from grain to vegetables. Use of excellent seeds as a result of generous subsidies and heavy use of fertilizers has resulted in some of the world's highest yields for tomatoes and perhaps cucumbers grown under

irrigation. Because of extremely harsh climate, most vegetables, i.e., eggplants, dry onions, and others can only be grown during the cool season. Fresh vegetables other than tomatoes and cucumbers must be imported at other times. The decade will see weak growth in these imports because locally produced vegetables, even though seasonal, are quite adequate to meet the year-round demand with the help of better storage and refrigeration facilities.

Tomatoes are the single most important fresh vegetable in Saudi Arabia. They are used in almost every important dish preparation. They are used in salad, traditional food like *kabsa*, *machbous*, i.e., spiced lamb and rice, kebab, soups and many other dishes. The Saudis prefer fresh tomatoes to canned tomato paste. One would expect to see the per capita consumption of this vegetable to be very high. And indeed it is one of the world highest at 30 kg.

Another very important ingredient in Saudi dishes is onions. They are used in salad and in making almost every major dish and soup. The per capita consumption of dry onions in Saudi Arabia is high at 15 kg. One would expect to see tomatoes and dry onions to be important complements since they are almost used together in every dish preparation.

Eggplants are, to a certain degree, important vegetables in the Kingdom. They are used for making dishes such as *Sheikh al Mihshi*, i.e., stuffed eggplant, eggplant dip, and mixed

TABLE 5.3. Regression Estimates of Demand for Fresh Vegetables (3SLS)

Dependent Variable	Expenditure Share (percent)	Explanatory Variables						R^2	DW	Income Elasticity		
		Constant	PT/PNF	PEP/PNF	PDO/PNF	YNR	1/YNR			y(min)[a]	y(mean)[b]	y(max)[c]
QT/N [1]	2.9500	0.7701 (0.9686)[d]	-1.1930 (-4.7429)	0.0030 (0.1416)	0.0034 (0.0716)	0.4802 (7.0001)	-	0.91	0.93	0.4802	0.4802	0.4802
QEP/N [2]	0.1900	3.9376 (7.1331)	0.0166 (0.0507)	-1.2068 (-3.5483)	-0.5456 (-1.8545)	-	-3350.1200 (-6.3266)	0.79	1.49	1.6188[e]	0.5353	0.2362
QDO/N [2]	0.3100	4.2200 (5.7776)	0.0032 (-0.0071)	-0.3344 (-1.8537)	-0.7082 (-1.8176)	-	-3238.8700 (-5.1429)	0.59	1.27	1.5650[f]	0.5175	0.2284

[1] $\text{Ln } QT_t/N_t = \text{Ln } a + b1 \text{ Ln } PT_t/PNF_t + b2 \text{ Ln } PEP_t/PNF_t + b3 \text{ Ln } PDO_t/PNF_t + c1\ 1/YNR_t + U_t$

[2] $\text{Ln } Q_{it}/N_t = \text{Ln } a + b1 \text{ Ln } PT_t/PNF_t + b2 \text{ Ln } PEP_t/PNF_t + b3 \text{ Ln } PDO_t/PNF_t - c2\ YNR_t + U_t$

Endogenous variables: Q_{it}/N_t - per capita consumption of eggplants, or dry onions, kg ; QT_t/N_t - per capita consumption of tomatoes, kg

Explanatory variables: PT_t/PNF_t - real retail tomatoes price, SR/kg ; $_pEP_t/PNF_t$ - real retail eggplants price, SR/kg ; PDO_t/PNF_t - real retail dry onions price, SR/kg ; YNR_t - per capita real private consumption expenditure (income), SR; $1/YNR_t$ - inverse real private expenditure (income) per capita, SR ; and Ut - disturbance term

[a,b,c] Minimum, mean, and maximum per capita real income (y), SR 2,069.5, SR 6,258.4, and SR 14,183.2, respectively

[d] Numbers in parentheses are t-statistics

[e,f] Elasticities are computed by dividing c2 values by income levels in a, b, and c, respectively

Figure 5.3a. Actual and Estimated Per

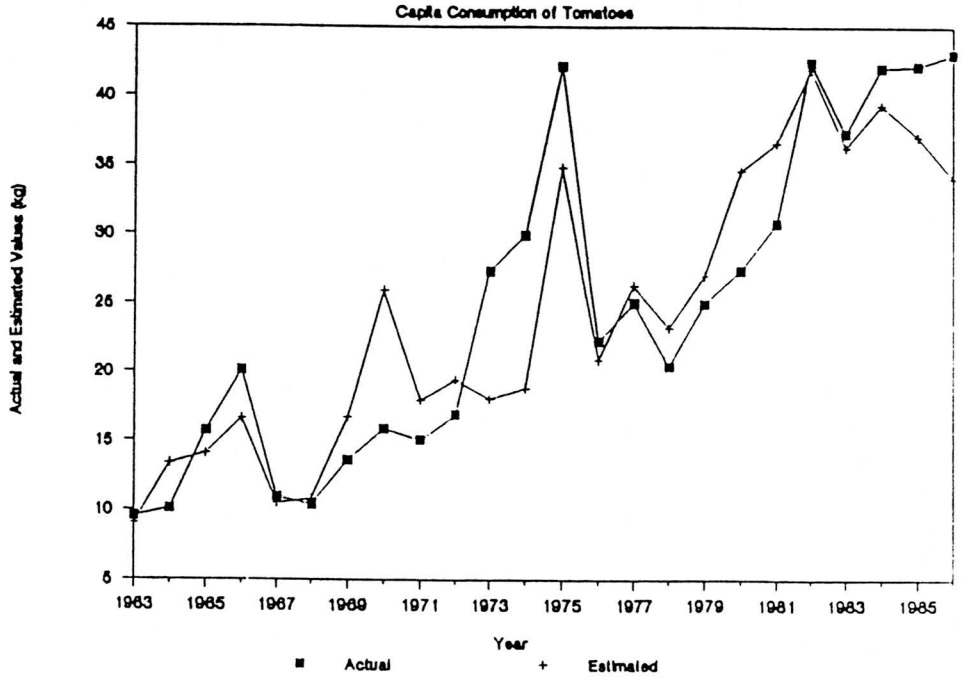


Figure 5.3b. Actual and Estimated Per

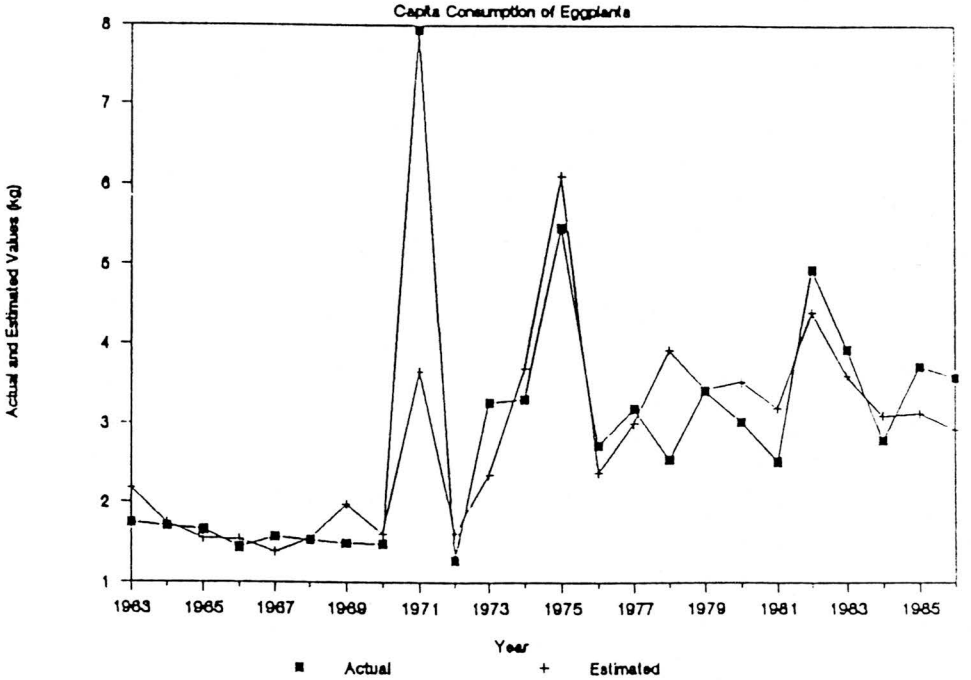
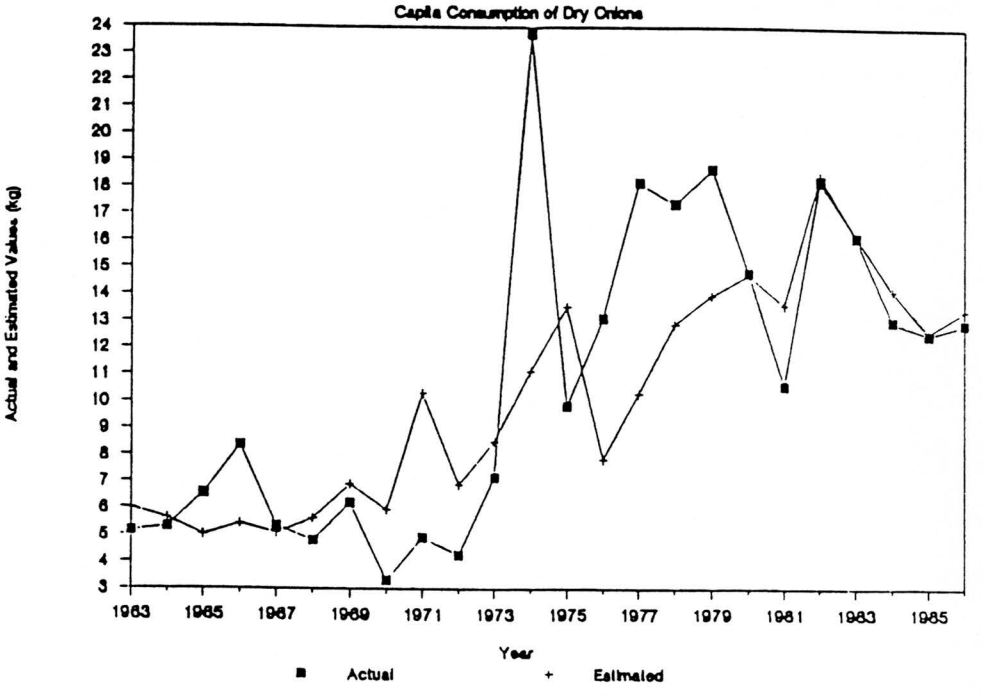


Figure 5.3c. Actual and Estimated Per



vegetable soup. The per capita eggplants consumption in Saudi Arabia is at 3.4 kg. One would expect to see eggplants and dry onions to be important complements since they are used together in the preparation of eggplants dishes.

Table 5.3 shows the regression estimates of demand for fresh vegetables. Tomatoes were the major item in the vegetable group with an expenditure share of 2.95 percent. Tomatoes and eggplants showed significant sensitive effect to price changes. The estimated direct-price elasticities for tomatoes and eggplants were 1.1930, and 1.2068, respectively. Dry onions also showed significant effect to prices changes, however, the degree of sensitivity was a little bit less than

that of tomatoes and eggplants at - 0.7082. The estimated cross-price elasticities showed significant interdependent between eggplants and dry onions, i.e., eggplants and dry onions are important complements. However, there is no significant interdependent relationships among tomatoes, eggplants, and dry onions.

The estimated income elasticities for tomatoes (constant income elasticity model), eggplants (declining income elasticity model) and dry onions (declining income elasticity model) again confirm the validity of the Engel's law at 0.4802, 0.2362,and 0.2284 for each commodity, respectively. All the income elasticities have the right signs and are significant. The only problem is with tomatoes. The D-W of 0.93 shows that there is an autocorrelation problem. The R^2 and the D-W values for the rest of the regression models are otherwise acceptable. Figures 5.3a, 5.3b, and 5.3c compare the estimated and the actual per capita consumption values. The estimated consumption approximates the actual values fairly well.

Summary and Overview of the Results

The estimation results were interesting. The fits of all equations were good. All income variables exhibited signs consistent with *a priori* expectations. The income variable turned out to be significant in every version of the equation.

The price variables also showed signs consistent with *a priori* expectations and were significant. Some of the cross-price variables, however, did not turn out to be statistically significant even though they had the right signs. Nevertheless, this does not do any damage to the analysis because our main focus is on the income variable - the price variables are held constant in the calculation of Engel curves. What is worth noting in this inquiry is the validation of Engel's law concerning decreasing product expenditures for increases in income is confirmed. The most visible confirmation of the law could be traced out from the declining income elasticity models. On the other hand, the coefficients for the income variables in the constant income elasticity variables were also all significantly less than one and therefore confirm Engel's law abundantly.

Another finding worth noting from this study is that at gradually increasing income, a substantial improvement in the standard of food diet among the Saudis was noticed, i.e., higher consumption (based on weighted average of the income elasticities) of expensive items such as chickens, mutton and lamb, beef and veal, fruits, and vegetables, at the expense of cereals and potatoes. In other words, with regard to the composition of consumption of food purchases as income rises, meat and poultry were the most important, followed by fresh fruits, vegetables and then cereals and potatoes. Meat and

poultry has a particularly high elasticity (on the average weight) undoubtedly accounting for the rapid increase in imports of this item.

The results fall into three groups with respect to estimated income response

1. Results which R^2 (and D-W) values **clearly** suggest declining income elasticity model. These commodities are potatoes, chicken, bananas, eggplants and dry onions. The income consumption, i.e., the per capita consumption growth curves, assuming 1986 prices are shown in Figures 5.4c., 5.5a., 5.6d., 5.7b. and 5.7c. for potatoes, chicken, bananas, eggplants, and dry onions respectively.

The figures show that the point at which $E_{Q.Y}=1$, i.e., the income level at which goods switched from luxury to necessity varies from one commodity to another depending on the asymptotic nature of the per capita consumption level of the commodity in question. Thus for potatoes, chicken, bananas, eggplants, and dry onions the income level at which good switches from luxury to necessity is at SR 3858.0, SR 7736.0, SR 2882.0, SR 3350.0 and SR 3239.0, respectively.

2. The results which R^2 (and D-W) values neither clearly confirm nor refute that they belong to the declining or constant income elasticity response. The commodities are oranges, apples and tomatoes. The per capita consumption growth curves for oranges, apples and tomatoes are shown in Figures 5.6a, 5.6b and 5.7a, respectively. The figure shows

the point at which good switches from luxury to necessity at per capita income level of SR 3765.0 for oranges.

3. The results which R^2 (and D-W) values clearly suggest constant income elasticity relationship. These commodities are grapes, beef and veal, wheat, mutton and lamb and rice .

The Engel curve for a particular commodity in question must pass through the origin since it is not defined for negative values of consumption. As usual in economic material, the results are not entirely uniform; it seems, however, clear that the double logarithmic curves (in most cases) only compensate the curvature partially, while the log-inverse forms are generally satisfactory.[7] The appropriateness of the log-inverse function accords with the nature of the income growth in the period under investigation in Saudi Arabia.

The price response is the secondary point the present investigation wants to take into account. The direct-price elasticities were very sensible, all coefficients were highly significant except for mutton and lamb (t statistics = -1.4731) and all had signs as expected *a priori*. The cross-elasticities with few exceptions were highly significant and often confirmed expectations.

The first impressions of the Saudis' food, particularly

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[7] Although the log-inverse function passes through the origin, it has a logistic form which makes it attractive.

in the *suk* (market) quash any notion originally held that the staple diet of Saudis was boiled meat (lamb, mutton, or camel) served on a huge mound of spiced rice. While this is true for the nomadic Bedouins, camped far from places which could provide anything else, it is not so for the food of townspeople. The variety of fresh vegetables, fruits, spices, meats, poultry and fish from which to choose would delight any serious cook.

As a matter of fact Saudis are known for their hospitality and when comes to a real meal, guests are served with large trays of steaming rice and baby lamb, i.e., a traditional dish called *khouzi*, stuffed with nuts and raisins surrounded by pieces of sauteed chicken, eggs, tomatoes, cucumbers, and onions. Another main or very popular dish is *kabsa*, i.e., lamb or chicken sauteed with onions, garlic, fresh tomatoes, grated carrots, lemon rind, then seasoned further with cloves, cumin, and cinammon. It is garnished with raisins and almonds and served on a bed of hot rice in big trays. The exotic aroma of cinammon, cloves, onions, and tumeric usually greet guests with each tray. Smaller plates of cooked pumpkins, mixed vegetables, hot sauce, and salads surround the large trays.

After having the delicious traditional meals the guests are further served with locally grown or imported fruits such as oranges, apples, grapes, bananas, and melons. Thus, in the

country, onions could be important complement for eggplants and tomatoes since in some dishes they are often included together as main ingredients. And one would expect to see bananas, apples, grapes and oranges to be important complements, while chicken and lamb are important substitutes, and that beef is not a popular meat in this country. It might sound exotic and foreign to western style of consumption and eating habit. But, this is the way it is in Saudi Arabia. The Saudis say, "if you are our guests we will surely honor you and entertain you the Saudis style."[8]

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[8] The aspect of Saudis life that impresses one most is as mentioned at the outset, their hospitality, and the single food (if it could be called such) with which this is expressed is (cardamom flavored) coffee. The coffee pot is ever present, though nowadays coffee is likely to be prepared early in the day and kept hot in vacuum flask ready for any person who comes by. The unsweetened coffeee is usually served with dates, the traditional staple food for generations. What follows is the serving of hot tea.

Figure 5.4a. The Per Capita Consumption

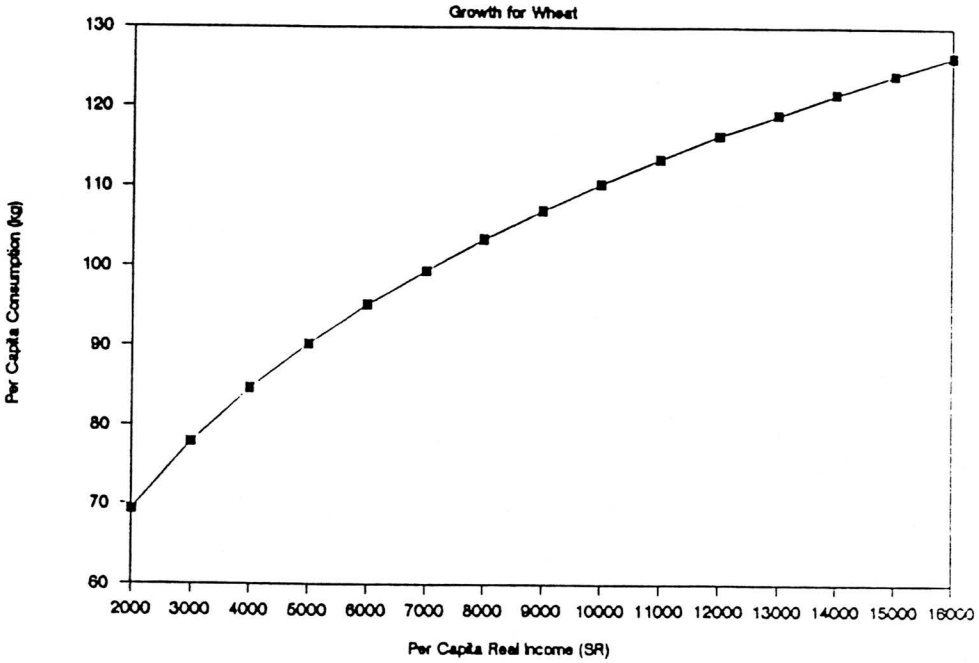


Figure 5.4b. Per Capita Consumption

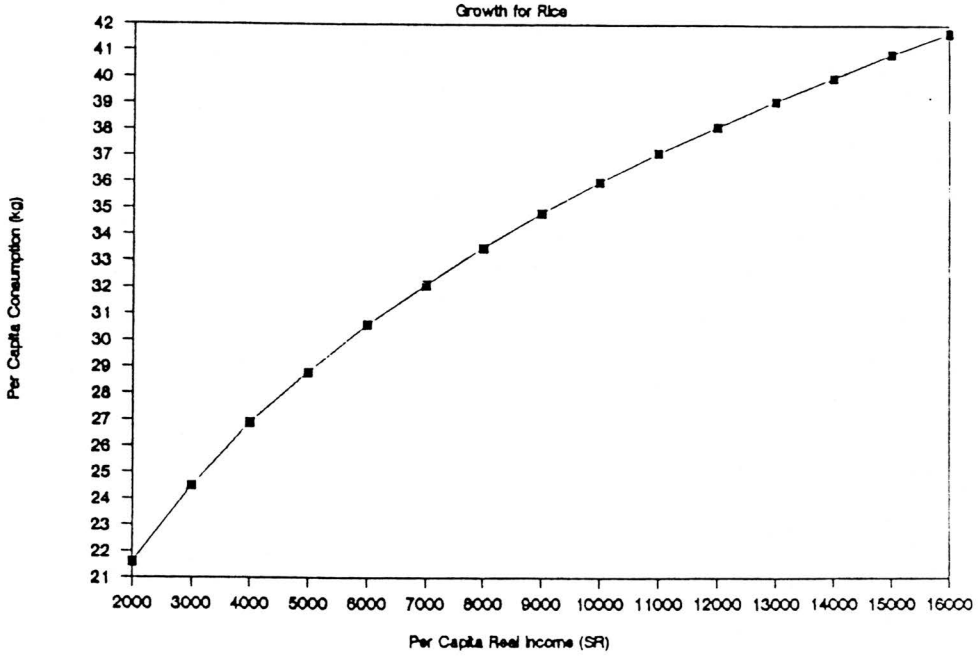


Figure 5.4c. Per Capita Consumption

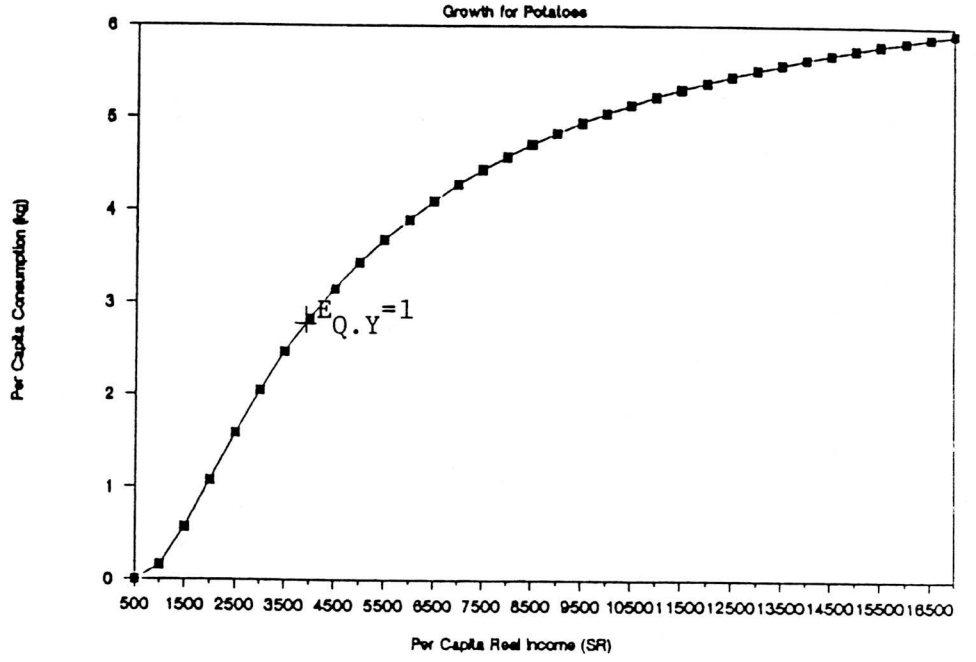


Figure 5.5a. Per Capita Consumption

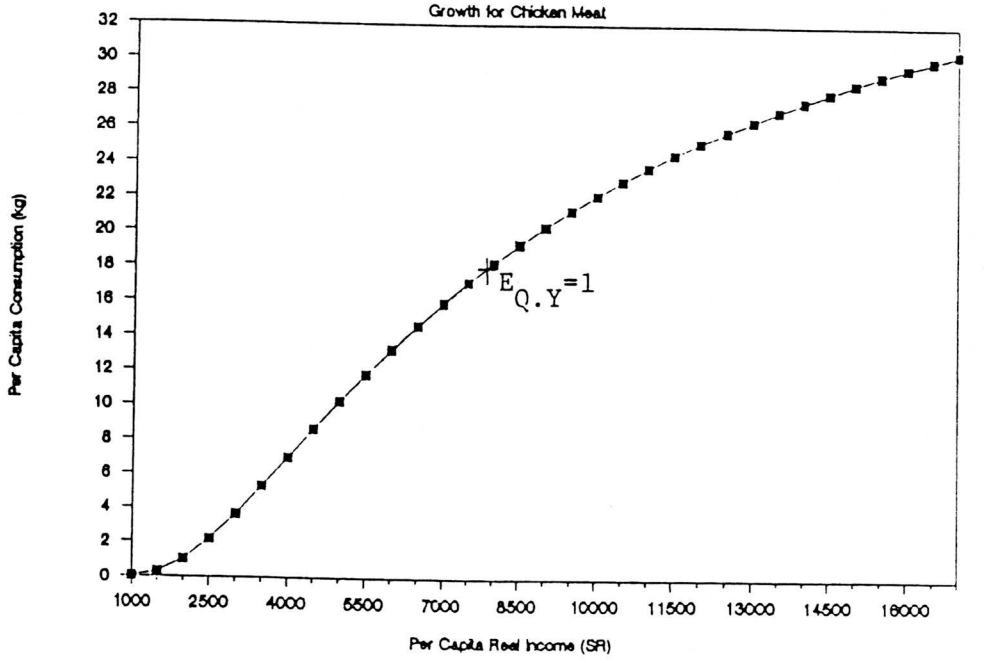


Figure 5.5b. Per Capita Consumption

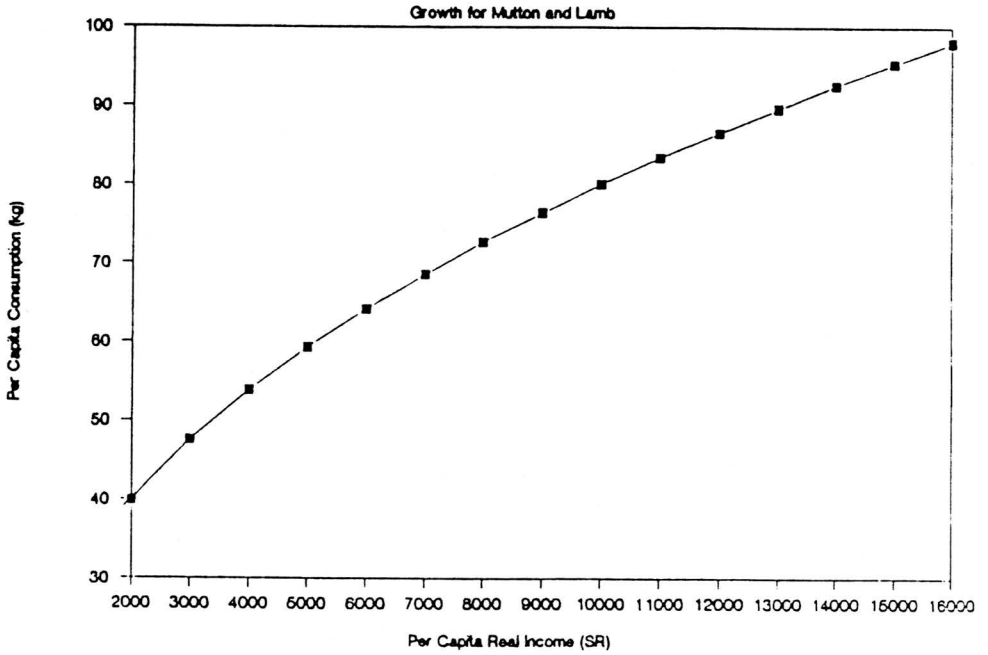


Figure 5.5c. Per Capita Consumption

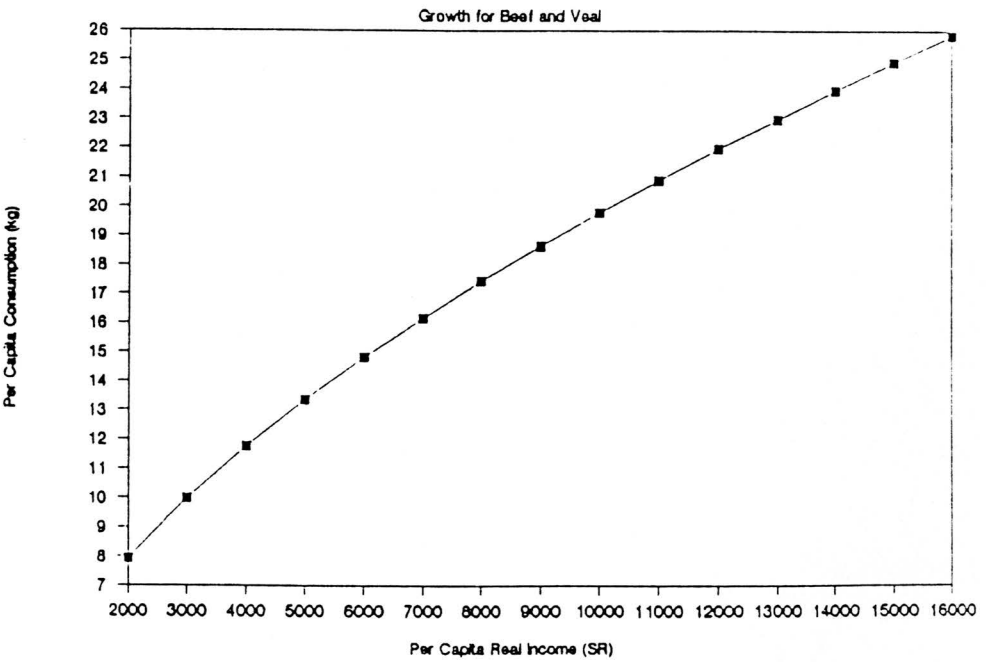


Figure 5.6a. Per Capita Consumption

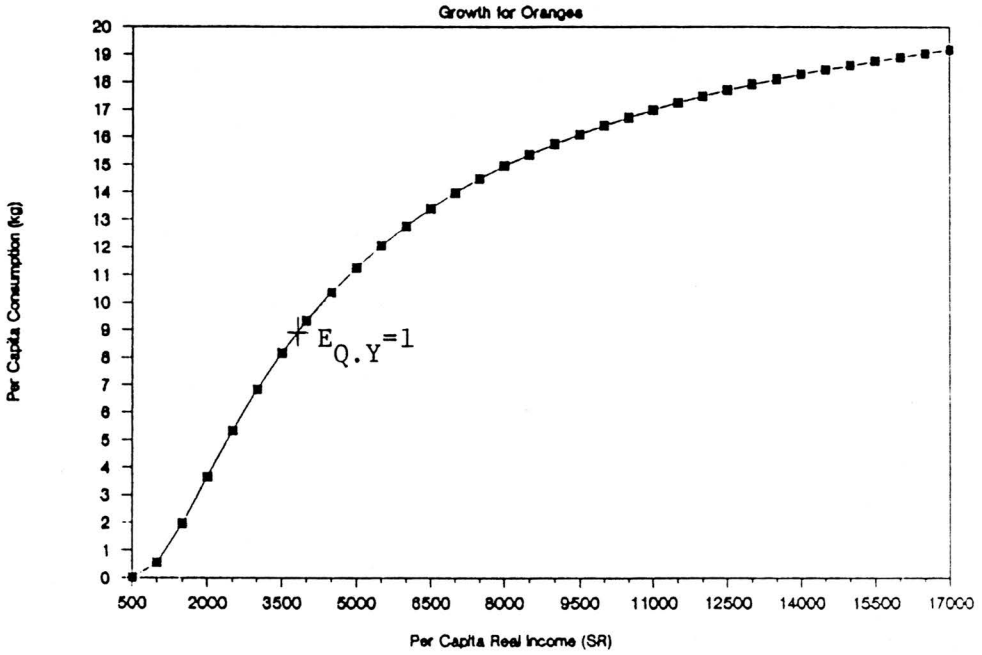


Figure 5.6b. Per Capita Consumption

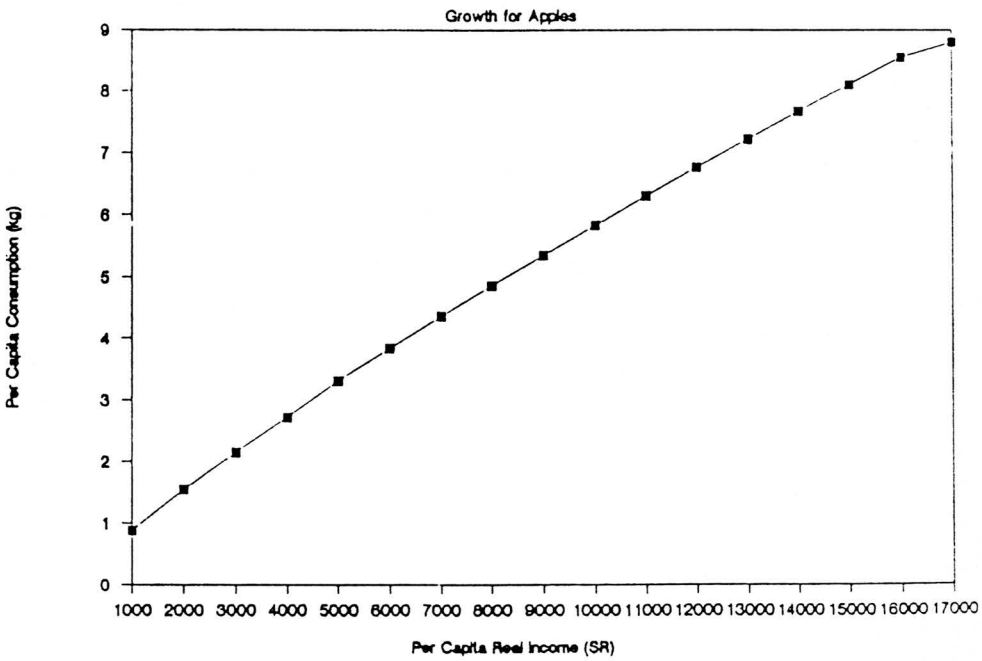


Figure 5.6c. Per Capit Consumption

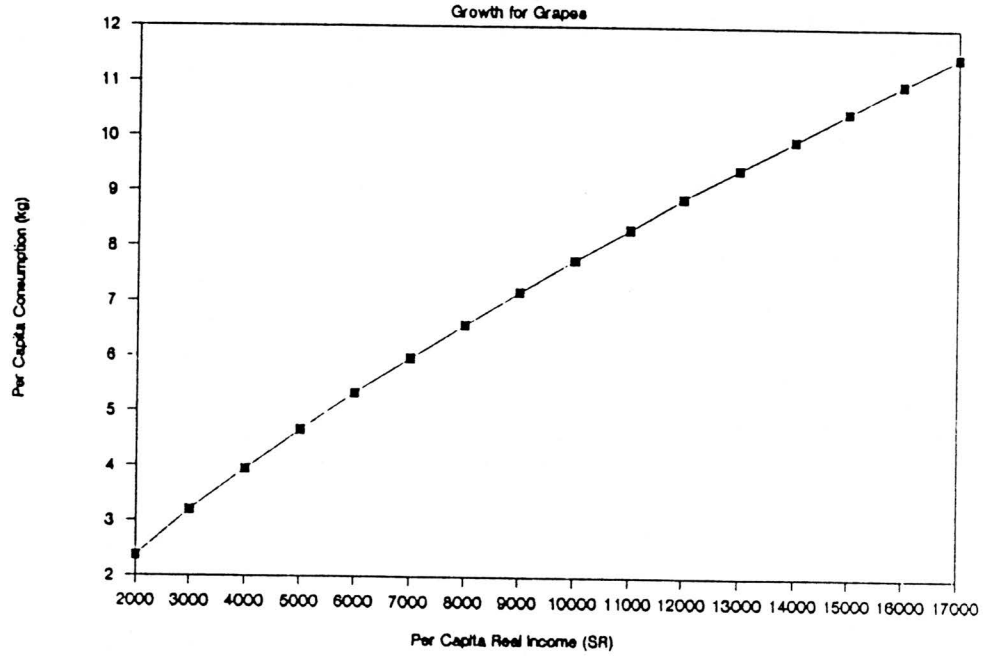


Figure 5.6d. Per Capita Consumption

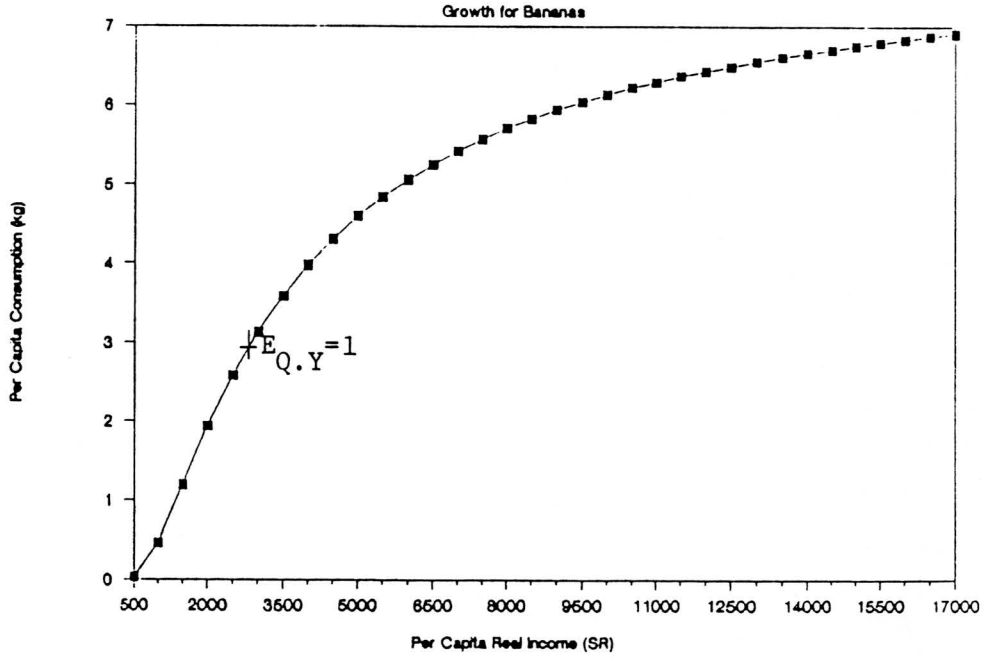


Figure 5.7a. Per Capita Consumption

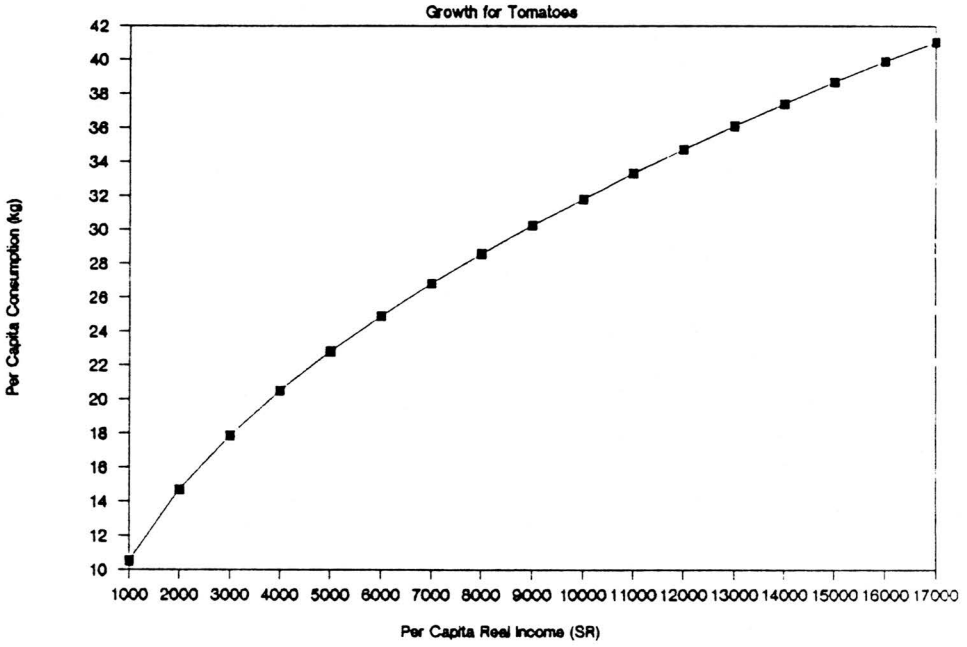


Figure 5.7b. Per Capita Consumption

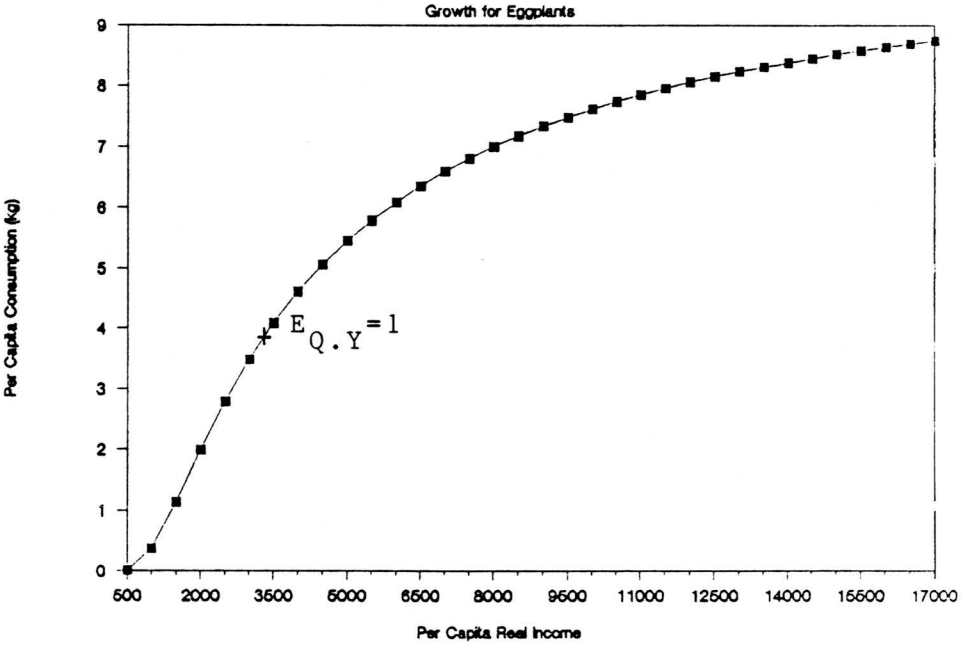
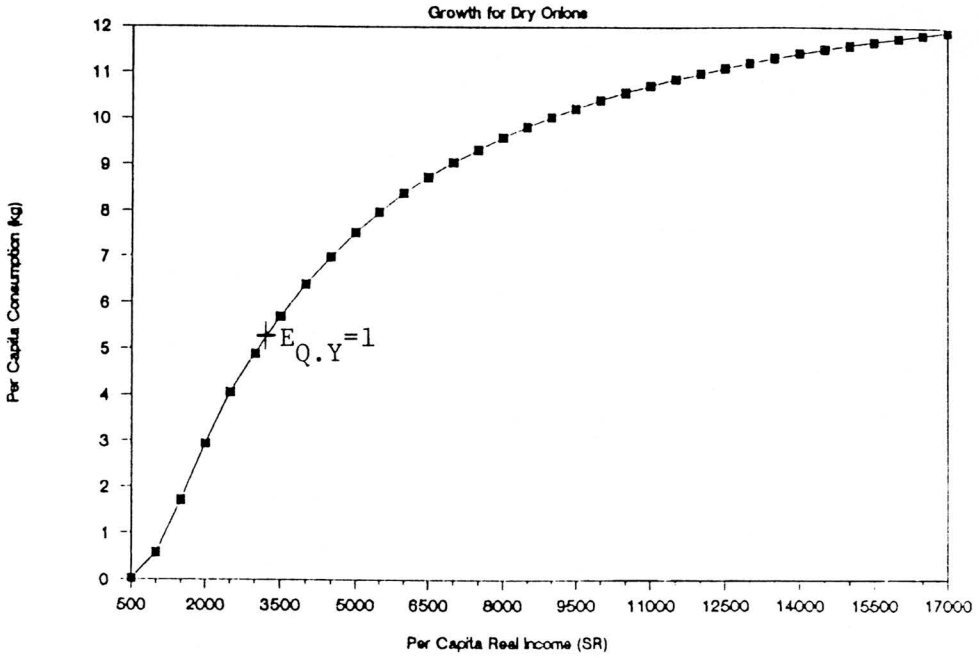


Figure 5.7c. Per Capita Consumption



CHAPTER 6

DEMAND PROJECTIONS

Introduction

For projection purposes, it is necessary to estimate quantitatively those factors which affect the demand for food products. Time-series data from 1963 through 1986 are used. Taking 1986 as an historical year, projections are worked out for years up to 1993. Wheat, rice, potatoes, chicken, mutton and lamb, beef and veal, oranges, apples, grapes, bananas, tomatoes, eggplants, and dry onions are considered individually.

Total consumptions projection made here are the estimates expected if the present consumption trends continue. These estimates are based on explicit assumptions about relevant variables and follow from the model selected to determine them (see Chapters 2 and 5). They should not be interpreted as forecasts or target; a forecast reflects the opinion of the forecasters and is not necessarily based on scientific procedure, while a target refers to a desired level envisaged by economic planners and is usually optimistic. For example, when demand exceeds supply, production targets are generally greater than actual supply, but in the case of a surplus, they tend to be less than actual supply.

This chapter is presented in two parts. The first part briefly describes how the projections are made. The final part

discusses the projected estimates of total consumption of individual food commodities.

DEMAND PROJECTION PROCEDURES FOR INDIVIDUAL FOOD COMMODITIES

Relevant Variables

The variables considered relevant to estimating individual demand for food were per capita real income, population, prices and government policies. The prices, and government policies in the present inquiry, however, are held constant. The yearly growth rate of real income (i.e., real private consumption expenditures) were provided by the Center for Food and Agricultural Policy [6]. The growth rate for 1987 was estimated at a negative rate of 1.47 percent. However, for the rest of the years, the projections show real growth rates of 0.9, 2.07, 2.23, 2.42, 2.81, and 2.91 percent for 1988 through 1993.

The population growth rate was estimated by the author with the help of the analysis of the past population growth rate, i.e., the rate estimated by the IMF. The growth rate was between 4.11 and 4.21 percent per annum, and was assumed to rise gradually from the lower limit to the upper limit during the projection period. The estimated figures might understate or overstate the actual future rates of growth, perhaps with an error that would not exceed 0.5 percentage point per year.

Income Elasticities

Income elasticities for the 13 food commodities were obtained from the estimated models in Chapter 5 -- or rather, models in Tables 5.0, 5.1, 5.2, and 5.3 are used for projection purposes. Real prices were held at constant 1986 historical year. Income elasticities for the selected items are generally low for cereals and potatoes, but high for meat, fresh vegetables and fresh fruits. This means that increases in income will not alter greatly the individual demand for cereals and potatoes. However, it will have some significant effect on meats, fresh fruits and vegetables.

The projection procedure adopted here assumes that the quantity consumed and income values in the historical period (1986) constitute a point on the consumption function. Using estimates obtained in Chapter 5 for the base year period, future consumption for each commodity was estimated for other income levels by applying the Engel curve relationships.[1]

---

[1] An Engel curve demonstrates how the consumption level varies with the level of income.
The two functions used were:
(1) double-logarithmic, and
(2) log-inverse
Tables 5.0-5.3 show what functional form each commodity was assigned, i.e., either (1) or (2). To illustrate, in Table 5.0., wheat and rice were assigned (1) and potatoes (2), accordingly, double-logarithmic models were used for wheat and rice, while potatoes used the log-inverse relationship. The same procedure was followed for other commodities.

Results

Essential to projections of domestic demand for food are the projection figures for income and population. Real income growth is very moderate by historical standards at an average value of 1.70 percent per year for the seven-year-period (beginning 1987). This figure is 10 fold lower than the average 1963-86 figure. The population growth rate, on the other hand, remains high at some 4 percent per year for the same 7 year-period. The projections (Table 6.0) show that consumption changes very differently with different commodity; the most significant change occurs in bananas (at 36.1 percentage growth over 1986-93), followed by oranges (28.2 percentage), potatoes (27.8 percentage), dry onions (27.3 percentage), rice (23.4 percentage), wheat (23.0 percentage), eggplants (21.4 percentage), beef and veal (19.4 percentage), tomatoes (17.9 percentage), mutton and lamb (16.8 percentage), chicken (16.5 percentage), grapes (14.7 percentage), and the least significant change is observed in apples (11.6 percentage).

The results also show that consumption change or the percentage growth over 1986-93 depends on the type of model used and the trend of the real income growth after the oil-boom years, i.e., after 1982. Commodities with high income elasticities would supposedly record significantly high consumption growth, however, due to the very moderate real

Table 6.0. Saudi Food Consumption for Selected Commodities: Actual 1986 Consumption Level, Consumption Change, and Percentage Growth over 1986-93

Year	Wheat	Rice	Potatoes	Chicken	Mutton and Lamb	Beef and Veal	Oranges	Apples	Grapes	Bananas	Tomatoes	Eggplants	Dry Onions
						-Million Kilograms[1]							
1986													
	1600.02	502.0	57.6	313.2	1436.8	277.0	186.5	106.0	123.0	57.1	517.0	43.0	155.0
Consumption Change: 1986-1993													
	367.7	117.6	16.0	51.7	241.6	53.7	52.6	12.3	18.1	20.6	92.6	9.2	42.3
Percentage Growth over 1986-1993													
	23.0	23.4	27.8	16.5	16.8	19.4	28.2	11.6	14.7	36.1	17.9	21.4	27.3

[1] 1,000 kilograms = 1 metric ton

[2] Actual (historical) 1986 values

income growth (averaging at 1.7 percentage -- compared with about 17 percent per annum for the 24 year-period starting 1963), the expected growth in the commodity demand does not confirm with *a priori* expectations. Perhaps the main fault was the very high population growth rate at some 4 percent per year for the seven-year-period.

Regression results in Tables 5.0-5.3 show that meats, fresh fruits, and vegetables groups have the highest income elasticities (on the weighted average basis). If real incomes were allowed to grow more rapidly, say more than 3 percent per year, then demand for these commodities would grow much more rapidly.

CHAPTER 7

SUMMARY AND CONCLUSIONS

The main objective of this study was to develop a sensible consumption income relation for major food commodities, taking into consideration the price effect; to use this demand relation to estimate the income and price elasticities for major food commodities in Saudi Arabia; and to utilize the estimated equations for demand projections of major food commodities up to 1993. In estimating demand (or the Engel curve) it was assumed that the per capita consumption of a particular food commodity is determined by income, its price, and prices of substitutes (including complements). The homogeneity and Slutsky restrictions were imposed to the estimating equations.

To get around the multicollinearity problem, the 13 food commodities were separated into four groups, viz., staple foods, meats group, fresh fruits, and fresh vegetables based on the texture characteristics, marketing periods, and taste of the products. And to further simplify the estimation problem, the author considered only within group substitution. Estimations under constant and declining income elasticity models were performed on each commodity within the group using time-series data for the 24 year-period, 1963-86.

The results showed both models give better fits. The results also indicated that food consumption is significantly affected by income level and that the effect of income on consumption varied among individual food commodities. The income elasticities were 0.8122, 0.7377, 0.5675, 0.5455, 0.4802, 0.4326, 0.3176, 0.2887, 0.2720, 0.2654, 0.2362, 0.2284 and 0.2032, for apples, grapes, beef and veal, chicken, tomatoes, mutton and lamb, rice, wheat, potatoes, oranges, eggplants, dry onions, and bananas, respectively. In each food category, the income elasticity was below zero, confirming the validation of the Engel's law abundantly. On the weighted average of the food group, the income elasticity was found to be highest in the meat group, followed closely by fresh fruits and vegetables, and lastly, the cereals and potatoes. Accordingly, an increase in income would likely have significant effect on the consumption of meats, fresh fruits, and vegetables, and less significant effect on cereals and potatoes consumption.

Meat has a particularly high income elasticity undoubtedly accounting for the rapid increase in import of this item. The results of the study implied that the rapid rise in food demand was due to an increase in income. They also implied that changing eating habit and improve diets (signify by increasing consumption of proteins, fruits, and vegetables at the expense of cereals and potatoes) modify the consumption patterns of the Saudi population, and that future

needs for all agricultural products will be very dependent on the magnitude of population growth.

The results fell into three groups with respect to income response, namely, results which R^2 (and D-W) values clearly suggest declining income elasticity model and the commodities were potatoes, chicken, bananas, eggplants and dry onions; results which R^2 (and D-W) values neither clearly confirm nor refute that they belonged to the declining or constant income elasticity response, and the commodities were oranges, apples and tomatoes; and finally, results which R^2 (and D-W) values clearly suggest constant income elasticity relationship, and the commodities were grapes, beef and veal, wheat, mutton and lamb and rice.

As usual, in economic material, the results were not entirely uniform; it seemed, however, clear that the double-logarithmic curves (in most cases) only compensate the curvature partially, while the logarithmic-inverse forms were generally satisfactory. The appropriateness of the logarithmic-inverse accords with the nature of the income growth in the period under investigation in Saudi Arabia.

The (direct-)price elasticities were all significant and have signs as expected *a priori*. The elasticities were quite high, range between -1.2068 to -0.3969. These high values were expected. The magnitude of price elasticity depends crucially on the availability and the quality of substitutes. If there

was a large number of substitutes, the elasticity of demand would be high. In the case of apples (own-price elasticity is at -1.1798), for instance, there was a number of substitutes. The list of substitutes include oranges, bananas, grapes, (mangoes, prunes, apricots, etc., -- not included in this study). Thus, a very high price elasticity was not surprising at all.

The inclusion of relative prices in the regression analysis might also have had some significant effect on the outcomes of the income elasticities for different food commodities; thus it has sometimes been suggested that the income elasticity of a commodity is an increasing function of its price, relative to other commodities. This in part helps explain the differences in the income elasticities among several food commodities in the present inquiry. The cross-price elasticities, with few exceptions, were also highly significant and often confirm expectations.

In the predictions, both the constant and declining elasticities models were used. The real price level and the price relations for different foodstuffs were taken as constant. A projection based on the results of a demand analysis can at best give an approximate picture of the future course of consumption on the assumption of specified changes in income. This is a consequence of the obvious fact that there are a host of factors other than income which influence demand, and also due to the fact that several sources of

observational errors disturb the analysis (Chapter 3). Thus the projection results must be considered as an indication rather than an accurate prediction of future outcomes.

It is clear from the preceding analysis, i.e., Chapter 6 that the consumption development was primarily dependent on the rate at which real income (and population) level changes. In the present prediction, the author is skeptical in relying on the results since the real income growth is allowed at a very modest rate of about 1.7 percent per year (for the seven-year-period beginning 1987) -- compared with 17 percent per year for the 1963-86 period. This has produced serious damage to the analysis since at the same time the population growth is allowed at an alarming rate of some 4 percent per year for the same time span. However, it was believed that as income increases and the society progress, more high value products will be consumed at the expense of cereals and potatoes as shown in Tables 5.0 - 5.3, in Chapter 5. One reason for favoring this consumption pattern stems from the idea of "permanent income hypothesis".[1] This approach was based on the hypothesis that the same nation become accustomed to the given consumption level, and -- for various reasons find it difficult to sharply curtail consumption, even if their income drops, because of rising expectations of the populace.

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[1] See Gardner [13].

There are several underlying factors which make the above argument sensible. One is due to the wise investment policy of the Saudi government during a time of peak interest rates, led to the accrual of much larger reserve of foreign investments (about $150 billion) during the heyday of the Organization of Petroleum Exporting Countries (OPEC) profits (1978-81). Second, interest alone from this portfolio has yielded about $15 billion income annually. And finally, Saudi Arabia has been absorbing its surplus income at a relatively constant rate, investing much of it in an ambitious and expensive program of infrastructure development.

Saudi Arabia continues to import food products (especially the high valued food products like meat, fruits, and vegetables) at a relatively high rate, in spite of falling oil revenues for several other reasons. One is due to the fact that the country is surrounded by instability in a volatile region of the world, to make domestic political stability a high priority, the government will have to elaborate the consumer subsidies to distribute the national income derived almost entirely from petroleum. These consumer benefits include large direct subsidies on many basic food items.

Furthermore, about 65 percent of the Saudi labor are expatriate workers whose wages are many times higher than those in their homelands. Food subsidies are available to them, and their consumption levels are high. In fact, per capita consumption of high valued food products is increasing

rapidly. Because of its large petroleum reserve (about one-third of the world reserve) and its role as the "swing producer" in OPEC, Saudi Arabia can now afford to (and does) have longer planning horizons. The Saudis can therefore continue to consume at the current level (despite of budgetary deficit) while forecasting when their income will rise sharply again, estimated to be 1988.

Since the projected income grows very lightly or moderately (at about 1.7 percent per annum for the 7 year-period) and is overshadowed by the population growth (some four percent per year for the same time span) no shifting in the demand composition has occurred. However, if income were allowed to increase more rapidly (say, about 3 percent annually for the next 10 years), changes in the demand composition could be observed more clearly. Table 7.0 illustrates this changes. The table indicates that saturation levels have been reached for the consumption of potatoes, chicken, bananas, eggplants and dry onions in Saudi Arabia. On the other hand, the percentage increase in real income is expected to increase the consumption of wheat, rice, mutton and lamb, beef and veal, and grapes by the same amount since their saturation levels have not yet been reached.

Table 7.0 also shows that the consumption of oranges, apples and tomatoes falls under undecided category, i.e., we cannot tell whether they have reached the saturation levels or not since the R^2 (and D-W) values (see Chapter 5) neither

clearly confirm nor refute that they belong to the declining or constant income elasticity response. The results in Table 7.0 also do not indicate that the saturation levels have been reached for the consumption of mutton and lamb, rice and wheat as expected *a priori*, and that the differences in the income elasticities for these commodities are small. The present author suspects that as real income increases the richer and middle-income Saudi population would consume more mutton and lamb at the expense of rice and wheat, while the poor people would continue to eat more rice and wheat and less mutton and lamb. However, this is subject to further research and is beyond the scope of the present inquiry.

Table 7.0 Income Elasticity Estimates by Commodity if Per Capita Real Income were Allowed to Increase at 3 Percent Annually for the Next 10 Years.

Commodity	Income Elasticity			Income Elasticity with 3% Growth in Real Income[d]
	y(min)[a]	y(mean)[b]	y(max)[c]	
Wheat[1]	0.2887	0.2887	0.2887	0.2887
Rice[1]	0.3176	0.3176	0.3176	0.3176
Potatoes[2]	1.8643	0.6165	0.2720	0.2024[e]
Chicken[2]	3.7382	1.2361	0.5455	0.4059[e]
Mutton and Lamb[1]	0.4326	0.4326	0.4326	0.4326
Beef and Veal[1]	0.5675	0.5675	0.5675	0.5675
Oranges[2*]	1.8192	0.6016	0.2654	0.1975[e]
Apples[1*]	0.8122	0.8122	0.8122	0.8122
Grapes[1]	0.7377	0.7377	0.7377	0.7377
Bananas[2]	1.3924	0.4604	0.2032	0.1512[e]
Tomatoes[1*]	0.4802	0.4802	0.4802	0.4802
Eggplants[2]	1.6188	0.5353	0.2362	0.1758[e]
Dry Onions[2]	1.5650	0.5175	0.2284	0.1699[e]

[1] Constant income elasticity models

[2] Declining income elasticity models

[1*,2*] Undecided categories

[a,b,c]Minimum, mean, and maximum real income (y), SR 2,069.5, SR 6,258.4, SR 14,183.2, respectively

[d]Real income level = [SR 14,183.2(1.03)^{10}]= SR 19,061

[e]Elasticities are computed by dividing the c2 values (see Tables 5.0-5.3) by income level at SR 19,061

BIBLIOGRAPHY

[1] Aitchison, J. and Brown, J. A. C. The Lognormal Distribution. Cambridge University Press, Cambridge, 1957, Chapter 12.

[2] Asfour, Y. Edmond. Saudi Arabia: Long-Term Projections of Supply and Demand for Agricultural Products. Economic Research Institute, American University of Beirut, Beirut, Lebanon, 1965.

[3] Blanciforti, L. A. , Green, R. D., and King, G. A. U.S. Consumer Behavior over the Postwar Period: an Almost Ideal Demand System Analysis, Giannini Foundation Monograph, Number 40, University of California, Berkley, August, 1986.

[4] Brandow, G. E. Interrelationships Among Demand for Farm Products and Implication for Control of Market Supply. Technical Bulletin 680. Pennsylvania State University, 1961.

[5] Caves, D. W. and Christensen, L. R. " Global Properties of Flexible Functional Forms." American Economic Review, 70(1980), 233-40.

[6] Center for National Food and Agricultural Policy, Department of Agricultural Economy, University of Missouri, Columbia, 1988.

[7] Cooper, R. J. and McLaren, K. R. " Atemporal, Temporal and Intemporal Duality in Consumer Theory. International Economic Review, 21(1980), 599-610.

[8] Deaton, A. S. , and Muellbaur, J. " An Almost Ideal Demand System." American Economic Review, 70(1980), 312-26.

[9] Duwais, Abdul-Aziz M. Factors Affecting Rice Consumption in Saudi Arabia. Unpublished Research Paper (Plan B) MS, Michigan State University, 1983.

[10] Engel, Earnest. Die Lebenshaltung Belgischer Arbeiter-Familien Fruher und Jetzt. Bulletin Institute of International Statistics 9(1895),1-124; with an Appendix, 1-54.

[11] Food and Agricultural Organization of the United Nations (FAO), FAO Production Yearbook, various issues, Rome Italy.

[12] _____. FAO Trade Yearbook, various issues, Rome, Italy.

[13] Gardner, George R." SAudi Arabia's Food Imports: A case of Permanent Income Hypothesis at Work". In Middle East and North Africa : Situation Outlook Report, United States Department of Agriculture, Economic Research Service (April 1986), 41-2.

[14] George, P.S. and King, G.A. Consumer Demand for Food Commodities in the United States with Projections for 1980. Monograph Number 26, Giannini Foundation, University of California, Berkley, March, 1971.

[15] Hein, D.M. "The Structure of Demand for Food: Interrelatedness and Duality." American Journal of Agricultural Economics, 64(May, 1982):2,

[16] Henderson, J. M. and Quandt, R. E. Macroeconomic Theory: A Mathematical Approach. McGraw Hill Book Co., Inc., New York, 1980.

[17] Huang, K. S. U.S. Demand for Food: A Complete System of Price and Income Effects. Technical Bulletin Number 1714, United States Department of Agriculture, Economic Research Service, Technical Bulletin Number 1714, December, 1985.

[18] International Monetary Fund (IMF), International Financial Statistics Yearbooks, various issues, Washington, D.C.

[19] James R. Coyle, et al. Food Import Demand of Eight OPEC Countries. United States Department of Agriculture, Economic Research Service, Foreign Agricultural Economic Report, Number 182, Washington, D.C., 1983.

[20] Johnston, J. Econometric Methods. Third Edition, MCGraw Hill Book Co. Inc., New York, 1984.

[21] Judge, George G. et al. The Theory and Practice of Econometrics. John Wiley and Sons, Inc., New York, 1980.

[22] Keynes, J. M. The General Theory of Employment, Interest and Money. Harcourt, Brace and Co., New York, 1936.

[23] Kingdom of Saudi Arabia, Ministry of Agriculture and Water, Department of Economic Studies and Statistics. Bulletin of Agricultural Statistics:

Current Sample Survey, various issues, Riyadh, Saudi Arabia.

[24] _____, Ministry of Finance and National Economy, Central Department of Statistics. Cost of Living Middle-Income Saudi Population. Riyadh, Saudi Arabia, 1984.

[25] _____, Ministry of Finance and National Economy, Central Department of Statistics. Statistical Yearbook, various issues, Riyadh, Saudi Arabia.

[26] _____, Saudi Arabian Monetary Agency.Annual Report, Research and Statistics Department, various issues, Riyadh, Saudi Arabia.

[27] Klein, L. R. and Rubin, H. " A constant Utility Index of the Cost of Living." Review of Economic Studies, 15(1947-8), 84-7.

[28] Kmenta, Jan. Elements of Econometrics. The Macmillan Company, New York, 1971.

[29] Leser, C. E. V. "Forms of Engel Functions." Econometrica, 31(October, 1963), 694-703.

[30] Monke, E. , and Petzel, T. " Market Integration: An Application to International Trade in Cotton." American Journal of Agricultural Economics, 66 (November, 1984)4: 481-87.

[31] Pasour, E. C., " An Analysis of Interseasonal Apple Price Movement." Agricultural Economic Research, 17 (1965), 19-30.

[32] Phlips, Louis. Applied Consumption Analysis. Revised and Enlarged Edition, North-Holland Publishing Company, Amsterdam, 1983.

[33] Prais, S. J. "Non-Linear Estimates of the Engel Curves." Review of Economic Studies, 20 (1953):2, 87-104.

[34] Prais, S. J. and Houthakker, H. S. The Analysis of Family Budgets. Cambridge University Press, Cambridge, 1955.

[35] Pureell, J. C. and Ranikar, R., "Quality Income Elasticities for Food Level of Income." Journal of Farm Economics, XLIX (december, 1967):6, 1410-14.

[36] Schultz, H. The Theory and Measurement of Demand. Chicago University Press, Chicago, 1938.

[37] Slater, J. M. "Regional Consumer Expenditure Studies Using National Food Survey Data." Journal of Farm Economics, 20 (1969):2, 197-216.

[38] Stone, J. R. N. " Linear Expenditure System and Demand Analysis: An Application to the Pattern of British Demand." Economic Journal 64 (1954), 511-27.

[39] Stone, J. R. N. The Measurement of Consumers' Expenditure Behavior in the United Kingdom 1820-1938. Vol. 1, Cambridge University Press, Cambridge, 1953.

[40] Theil, H. and A. S. Goldberger, " On Pure and Mixed Statistical Estimation in Economics." International Economic Review, 2(1961), 65-78.

[41] Tryphos, P. and Tryphonopoulos, N. " Consumer Demand for Meat in Canada." American Journal of Agricultural Economics, 55(1973):4, 647-52.

[42] United States Department of Agriculture, Foreign Agriculture Service, various issues, Washington, D.C.

[43] Weymark, J. A. " Duality Results in Demand Theory." European Economic Review, 14(1980), 377-95.

APPENDIX A

DATA SET USED IN ESTIMATING THE STRUCTURAL EQUATIONS OF THE CONSUMPTION DEMAND FOR FOOD COMMODITIES IN SAUDI ARABIA

APPENDIX TABLE A.0.0 Price Index, Population, Private Consumption Expenditure, and Nominal Exchange Rates, 1963-86

Year	Nonfood Price Index (1981=1.0)	Cosumer Price Index (1981=1.0)	Population	Private Consumption Expenditure	Nominal Exchange Rate	Private Consumption Expenditure
			(million)	(SR million)	(SR/U.S.$)	($ million)
1963	0.2571	0.2735	5.14	2,740	4.500	608.89
1964	0.2604	0.2805	5.27	2,840	4.500	631.11
1965	0.2589	0.2823	5.41	2,910	4.500	646.67
1966	0.2607	0.2862	5.55	3,030	4.500	637.33
1967	0.2640	0.2921	5.70	4,000	4.500	888.89
1968	0.2656	0.2970	5.86	4,590	4.500	1,020.00
1969	0.2723	0.3077	6.03	5,360	4.500	1,191.11
1970	0.2862	0.3077	6.20	5,860	4.500	1,302.22
1971	0.2974	0.3212	6.38	6,410	4.500	1,424.44
1972	0.3097	0.3360	6.57	6,910	4.145	1,667.07
1973	0.3545	0.3914	6.76	7,900	3.689	2,141.50
1974	0.4230	0.4751	6.97	9,830	3.550	2,769.01
1975	0.5681	0.6387	7.25	18,040	3.518	5,127.91
1976	0.7596	0.8413	7.62	23,900	3.530	6,770.54
1977	0.8255	0.9366	8.06	34,370	3.525	9,750.35
1978	0.9435	0.9221	8.49	54,610	3.400	16,061.76
1979	0.9677	0.9386	8.93	63,510	3.361	18,896.16
1980	0.9872	0.9736	9.37	102,390	3.327	30,775.47
1981	1.0000	1.0000	9.80	114,910	3.383	33,966.89
1982	1.0072	0.9942	10.23	126,510	3.427	36,915.67
1983	1.0197	0.9883	10.66	151,290	3.455	43,788.71
1984	1.0005	0.9766	11.09	157,370	3.524	44,656.64
1985	0.9182	0.9445	11.54	145,990	3.622	40,306.46
1986	0.8828	0.9163	12.01	122,070	3.703	32,965.16

Sources: The nonfood price index figures are the Laspyres index (see Table 2.0 in Chapter 2 for source and computation). The consumer price index, population, private consumption expenditures, and nominal exchange rate figures are from International Monetary Fund (IMF), International Financial Statistics. Yearbook, various issues, Washington, D.C.

APPENDIX TABLE A.1.0 Wheat: Beginning Stocks, Production, Total Imports, Total Exports, Domestic for Feed, Total Consumption, and Retail Price, 1963-86

Year	Beginning Stocks (millions kg, mkg)	Production (mkg)	Total Imports (mkg)	Total Exports (mkg)	Domestic For Feed (mkg)	Total Consumption (mkg)	Retail Price (SR/kg)
1963	-	135	147	-	-	282	0.7025
1964	-	125	190	-	-	315	0.6775
1965	-	148	200	-	-	348	0.6486
1966	-	149	240	-	-	389	0.5800
1967	-	150	182	-	-	332	0.6550
1968	-	130	140	-	-	270	0.8578
1969	-	150	290	-	-	440	0.7300
1970	-	150	320	-	-	470	0.7150
1971	-	150	350	-	-	500	0.6900
1972	-	150	310	-	-	460	1.1350
1973	-	63	383	-	-	446	1.4350
1974	-	90	264	-	-	354	1.7000
1975	-	193	353	-	-	546	1.6500
1976	-	205	505	-	-	710	1.2960
1977	-	150	620	-	-	770	1.1150
1978	-	175	725	-	-	900	1.0340
1979	-	200	1,000	-	-	1,200	0.9900
1980	-	225	1,100	-	-	1,325	0.7500
1981	292	187	682	-	-	1,061	1.5600
1982	100	412	700	-	-	1,112	1.5000
1983	100	710	336	-	-	1,105	1.8867
1984	41	1,300	300	-	-	1,400	1.7150
1985	241	1,980	100	100	-	1,500	1.6800
1986	721	2,200	100	400	-	1,600	1.5000

Sources: Beginning Stocks, Production, Total Imports, Total Exports, Domestic for Feed, and Total Consumption are from United States Dapartment of Agriculture (USDA), Foreign Agricultural Service (FAS). World Grain Situation and Outlook, Washington, D.C. various issues; and Retail Prices are from Kingdom of Saudi Arabia, Ministry of Finance and National Economy (MOFNE), Central Department of Statistics (CDS). Statistical Yearbooks, Riyadh, Saudi Arabia, various issues.

APPENDIX TABLE A.1.1. Rice: Beginning Stock, Production, Total Imports, Total Exports, Domestic for Feed, Total Consumption, and Retail Price, 1963-86

Year	Beginning Stocks	Rough Production	Milled Production	Total Imports	Total Exports	Total Consumption	Retail Price
	(millions kg, mkg)	(mkg)	(mkg)	(mkg)	(mkg)	(mkg)	(SR/kg)
1963	-	2	1	120	-	121	0.8367
1964	-	3	2	99	-	101	0.9786
1965	-	4	3	141	-	144	0.7640
1966	-	3	2	142	-	144	1.1800
1967	-	3	2	125	-	127	1.2489
1968	-	3	2	124	-	126	1.4644
1969	-	3	2	151	-	153	1.1582
1970	-	3	2	202	-	204	1.0033
1971	-	3	2	200	-	202	1.3755
1972	-	3	2	151	-	153	1.5050
1973	-	3	2	142	-	144	2.5167
1974	-	3	2	203	-	205	2.2775
1975	-	3	2	189	-	191	2.7500
1976	-	3	2	300	-	302	2.3100
1977	-	3	2	161	-	163	3.0700
1978	-	3	2	404	-	406	2.4267
1979	-	3	2	341	-	343	3.0000
1980	-	3	2	356	-	358	2.9400
1981	-	3	2	427	-	429	2.7667
1982	-	3	2	471	-	473	2.7100
1983	-	3	2	491	-	493	2.6100
1984	-	3	2	530	-	532	2.7900
1985	-	3	2	503	-	505	3.2700
1986	-	3	2	500	-	502	3.5520

Sources: Beginning Stocks, Rough Production, Milled Production, Total Imports, Total Exports, and Total Consumption are from United States Department of Agriculture (USDA), Foreign Agricultural Service (FAS). World Grain Situation and Outlook, various issues, Washington, D.C.; and Retail Prices are from Kingdom of Saudi Arabia, Ministry of Finance and National Economy (MOFNE), Central Department of Statistics (CDS). Statistical Yearbook, Riyadh, Saudi Arabia, various issues.

APPENDIX TABLE A.1.2. Potatoes: Total Production, Total Imports, Total Exports, Total Consumption, and Retail Price, 1963-86

Year	Total Production	Total Imports	Total Exports	Total Consumption	Retail Price
	(million kg, mkg)	(mkg)	(mkg)	(mkg)	(SR/kg)
1963	0.650	7.372	-	8.022	0.7107
1964	0.700	7.615	-	8.315	0.6900
1965	0.700	8.939	-	9.639	0.9100
1966	0.750	10.105	-	10.855	0.9200
1967	0.780	11.666	-	12.466	0.9150
1968	0.780	12.047	-	12.827	0.9100
1969	0.780	13.512	-	13.512	0.8500
1970	0.598	13.240	-	13.838	1.2300
1971	0.800	14.973	-	15.773	1.0469
1972	0.807	16.006	-	16.813	1.0000
1973	0.422	13.602	-	14.024	1.4906
1974	1.554	19.912	-	21.410	1.2500
1975	0.187	20.786	-	20.973	2.5600
1976	1.007	27.397	-	28.404	3.5233
1977	0.000	45.550	-	45.550	3.4700
1978	4.579	49.781	-	54.360	3.4200
1979	3.635	59.811	-	63.446	4.1080
1980	2.277	70.361	-	72.638	3.6450
1981	3.570	84.535	-	87.287	3.3400
1982	3.260	86.362	1.517	88.105	4.3975
1983	8.769	111.176	1.500	118.445	3.0000
1984	8.313	102.290	1.500	109.103	3.6567
1985	5.518	61.621	1.500	68.639	4.3500
1986	25.000	38.599	6.000	57.599	5.8000

Sources: Total Productions, 1963-69, and 1986 are from Food and Agriculture Organization of the United Nations (FAO), Production Yearbook, Rome, various issues; Total Production, 1970-85 are from Kingdom of Saudi Arabia, Ministry of Agriculture and Water (MOAW), Department of Economic Studies and Statistics (DOESS). Bulletin of Agricultural Statistics: Current Sample Survey. Riyadh, Saudi Arabia, various issues; Total Imports and Total Exports are from FAO, Trade Yearbook, Rome, various issues; and Retail Prices are from Kingdom of Saudi Arabia, Ministry of Finance and National Economy (MOFNE), Central Department of Statistics (CDS). Statistical Yearbook, Riyadh, Saudi Arabia, various issues.

APPENDIX TABLE A.2.0. Chicken Meat: Total Ptoduction, Total Imports, Total Exports, Total Consumption, and Retail Price 1963-86

Year	Total Production	Total Imports	Total Exports	Total Consumption	Retail Price
	(million kg, mkg)	(mkg)	(mkg)	(mkg)	(SR/kg)
1963	2.600	0.350	0.000	2.950	4.0300
1964	2.945	0.774	0.000	3.719	4.0300
1965	3.400	1.035	0.000	4.435	4.0000
1966	5.500	2.356	0.000	7.856	3.9100
1967	5.500	3.678	0.000	9.178	4.0000
1968	6.000	6.181	0.000	12.181	4.0800
1969	6.500	7.238	0.000	13.738	4.2100
1970	7.000	7.257	0.000	14.257	7.3917
1971	7.500	7.777	0.000	15.277	7.1920
1972	8.000	10.106	0.001	18.105	7.0625
1973	8.105	11.412	0.000	19.517	7.0188
1974	14.000	17.990	0.000	31.990	6.9000
1975	18.000	36.542	0.011	54.531	7.0436
1976	21.000	69.777	0.000	90.777	6.8375
1977	23.000	101.131	0.000	124.131	6.5000
1978	26.000	109.068	0.043	135.025	6.4375
1979	29.000	140.368	0.036	169.328	7.7375
1980	42.000	193.894	0.205	235.689	7.5000
1981	67.549	182.280	0.050	249.779	7.2880
1982	81.619	196.271	0.010	277.880	6.2042
1983	118.825	181.951	0.000	300.776	5.3867
1984	135.435	164.508	2.245	302.188	5.4722
1985	153.365	151.641	2.110	307.116	6.0000
1986	152.000	163.161	2.000	313.161	6.2200

Sources: Total Productions, 1963-81, and 1986 are from Food and Agriculture Organization of the United Nations (FAO), Production Yearbook, Rome, various issues; Total productions, 1982-85, are from Kingdom of Saudi Arabia, Saudi Arabian Monetary Agency (SAMA), Research and Statistics Department (RSD). Annual Report, Riyadh, Saudi Arabia, various issues. Total Imports and Total Exports are from FAO, Trade Yearbook, Rome, various issues; and Retail Prices are from Kingdom of Saudi Arabia, Ministry of Finance and National Economy (MOFNE), Central Department of Statistics (CDS). Statistical Yearbook, Riyadh, Saudi Arabia, various issues.

APPENDIX TABLE A.2.1. Mutton and Lamb: Total Production, Total Imports, Total Exports, Total Consumption, and Retail Price, 1963-86

Year	Total Production	Total Imports	Total Exports	Total Consumption	Retail Price
	(million kg, mkg)	(mkg)	(mkg)	(mkg)	(SR/kg)
1963	170.000	0.0000	0.000	170.000	4.355
1964	170.000	0.0000	0.000	170.000	4.840
1965	255.000	0.0000	0.000	255.000	5.250
1966	255.000	0.0000	0.000	255.000	5.000
1967	170.000	0.0000	0.000	170.000	6.000
1968	340.000	0.3770	0.000	340.377	6.040
1969	255.000	0.0000	0.000	255.000	6.210
1970	255.000	0.1540	0.000	255.154	6.272
1971	255.000	0.6000	0.000	255.600	6.595
1972	340.000	0.6550	0.000	340.655	6.280
1973	340.000	1.0260	0.000	341.026	6.000
1974	340.000	0.5230	0.000	340.523	10.080
1975	365.134	1.8540	0.000	366.988	11.530
1976	381.367	4.3740	0.000	385.741	15.330
1977	386.123	10.5310	0.030	396.654	15.390
1978	458.880	14.4430	0.020	473.303	15.250
1979	469.926	19.3270	0.024	489.229	15.165
1980	501.275	24.0880	0.016	525.347	15.000
1981	385.834	32.8010	0.010	418.625	15.300
1982	995.814	26.1340	0.183	1021.765	12.635
1983	1181.373	37.5720	0.000	1218.945	11.570
1984	1180.003	33.0990	0.150	1212.952	13.355
1985	1293.774	24.2930	0.019	1318.048	12.867
1986	1419.222	17.5830	0.000	1436.805	12.060

Source: Total Productions, 1963-69, are from Food and Agriculture Organization of the United Nations (FAO), Production Yearbook, Rome, various issues; Total Productions, 1970-86, are from Kingdom of Saudi Arabia, Saudi Arabian Monetary Agency (SAMA), Research and Statistics Department (RSD). Annual Report, Riyadh, Saudi arabia, various issues, and Kingdom of Saudi Arabia, Ministry of Agriculture and Water (MOAW), Department of Economic Studies and Statistics. Bulletin of Agricultural Statistics: Current Sample Survey, Riyadh, Saudi Arabia, various issues; Total Imports and Total Exports are from FAO, Trade Yearbook, Rome, various issues; and Retail Prices are from Kingdom of Saudi Arabia, Ministry of Finance and National Economy (MOFNE), Central Department of Statistics (CDS). Statistical Yearbook, Riyadh, Saudi Arabia, various issues.

APPENDIX TABLE A.2.2. Beef and Veal: Total Production, Total Imports, Total Exports, Total consumption, and Retail Price, 1963-86

Year	Total Production	Total Imports	Total Exports	Total Consumption	Retail Price
	(million kg, mkg)	(mkg)	(mkg)	(mkg)	(SR/kg)
1963	38.0000	0.0000	0.0000	38.0000	4.2500
1964	40.0000	0.0000	0.0000	40.0000	4.1400
1965	52.0000	0.0000	0.0000	52.0000	4.3800
1966	50.0000	0.0000	0.0000	50.0000	4.0000
1967	51.4670	0.0000	0.0000	51.4670	4.0000
1968	50.3190	0.5510	0.0000	50.8700	4.0000
1969	56.2270	0.3440	0.0000	56.5710	4.2100
1970	62.7200	0.0000	0.0000	62.7200	4.1450
1971	79.4170	0.0000	0.0000	79.4170	4.1250
1972	84.1050	0.0000	0.0000	84.7240	4.0000
1973	82.9810	0.3340	0.0000	83.3150	5.0000
1974	65.5440	1.0490	0.0120	66.5810	6.6250
1975	68.2970	1.8030	0.0000	70.1000	10.7500
1976	87.1290	2.8790	0.0110	89.9970	10.5730
1977	77.4830	8.1780	0.0000	85.6610	12.3300
1978	175.0000	19.3040	0.0000	194.3040	12.0000
1979	175.0450	32.1340	0.0450	207.1340	15.0000
1980	180.4490	39.7810	0.4490	219.7810	14.3300
1981	190.2640	45.9090	0.2640	235.9090	15.7920
1982	200.6500	51.9680	0.6500	251.9680	15.2930
1983	210.0000	55.0900	0.0000	265.0900	14.1470
1984	220.7330	53.2670	0.0000	274.0000	15.0000
1985	230.8860	47.1140	0.0000	278.0000	15.5050
1986	232.8930	44.1070	0.0000	277.0000	15.5975

Sources : Total Productions, 1963-69 are from Food and Agricculture Organization of the United Nations (FAO), Production Yearbook, Rome, various issues; Total Productions, 1970-86 are from Kingdom of Saudi Arabia, Saudi Arabian Monetary Agency (SAMA), Research and Statistics Department (RSD). Annual Report, Riyadh, Saudi Arabia, various issues, and Kingdom of Saudi Arabia, Ministry of Agriculture and Water (MOAW), Department of Economic Studies and Statistics (DOESS). Bulletin of Agricultural Statistics: Current Sample Survey, Riyadh, Saudi Arabia, various issues; Total Imports and Total Exports are from FAO, Trade Yearbook, Rome, various issues; and Retail Prices are from Kingdom of Saudi Arabia, Ministry of Finance and National Economy (MOFNE), Central Department of Statistics (CDS).

APPENDIX TABLE A.3.0. Oranges: Total Production, Total Imports, Total Exports, Total Consumption, and Retail Price, 1963-86

Year	Total Production	Total Imports	Total Exports	Total Consumption	Retail Price
	(million kg, mkg)	(mkg)	(mkg)	(mkg)	(SR/kg)
1963	0.0000	12.4930	0.0000	12.4930	1.2467
1964	0.0000	15.6000	0.0000	15.6000	1.5933
1965	0.0000	18.7160	0.0000	18.7160	1.6821
1966	0.0000	21.3750	0.0000	21.3750	1.8177
1967	0.0000	23.6500	0.0000	23.6500	1.7931
1968	0.0000	24.1830	0.0000	24.1830	1.7792
1969	0.0000	32.0720	0.0000	32.0720	1.6840
1970	0.0000	35.3190	0.0200	35.2990	1.6418
1971	0.0000	40.4920	0.0000	40.4920	1.5135
1972	0.0000	44.9060	0.2610	44.6450	1.4982
1973	0.0000	47.8560	0.7850	47.0710	1.6547
1974	0.0000	51.3100	4.0000	47.3100	2.4200
1975	0.0000	59.0370	4.3040	54.7330	2.5258
1976	0.0000	80.7240	10.9230	69.8010	3.3900
1977	0.0000	80.4750	0.6570	79.8180	3.5770
1978	0.0000	92.4560	0.2400	92.2160	3.4390
1979	0.0000	131.8760	4.9130	126.9630	3.3360
1980	0.0000	161.7690	6.6800	155.0890	3.2000
1981	0.0000	215.1230	7.2140	207.9090	3.1250
1982	0.0000	233.9950	5.0030	228.9920	3.0000
1983	0.0000	254.2390	4.0000	259.2390	2.7500
1984	0.0000	218.8060	5.0000	213.8060	3.5500
1985	0.0000	190.7130	5.0000	181.7130	4.1300
1986	0.0000	191.5000	5.0000	186.5000	3.5380

Sources: Total Production are from Food and Agriculture Organization of the United Nations (FAO), Rome, various issues; Total Imports, 1963-79 are from FAO, Trade Yearbook, Rome, various issues; Total Imports, 1980-86, are from United States Department of Agriculture (USDA), Economic Research Service (ERS), Middle East and North Africa--Situation and Outlook Report, Washington, D.C., various issues; Total Exports are from FAO Trade Yearbook, Rome, various issues; and Retail Prices are from Kingdom of Saudi Arabia, Ministry of Finance and National Economy (MOFNE), Central Department of Statistics (CDS). Statistical Yearbook, Riyadh, Saudi Arabia, various issues.

APPENDIX TABLE A.3.1. Apples: total Production, Total Imports, Total Exports, Total Consumption, and Retail Price, 1963-86

Year	Total Production	Total Imports	Total Exports	Total Consumption	Retail Price
	(million kg, mkg)	(mkg)	(mkg)	(mkg)	(SR/kg)
1963	0.0000	7.3550	0.0000	7.3550	1.9200
1964	0.0000	10.3880	0.0000	10.3880	1.5200
1965	0.0000	12.9120	0.0000	12.9120	1.5000
1966	0.0000	14.3290	0.0000	14.3290	1.4900
1967	0.0000	19.2690	0.0000	19.2690	1.4500
1968	0.0000	20.9300	0.0000	20.9300	1.2900
1969	0.0000	18.8440	0.0000	18.8440	1.5400
1970	0.0000	12.3410	0.0000	12.3410	1.8880
1971	0.0000	19.0280	0.0000	19.0280	1.7260
1972	0.0000	28.3150	0.2350	28.0800	1.6530
1973	0.0000	26.4490	1.1180	25.3310	1.8340
1974	0.0000	23.3050	0.7600	22.5450	2.0090
1975	0.0000	31.0930	1.8760	29.2170	2.7390
1976	0.0000	39.7720	8.0470	31.7250	3.5470
1977	0.0000	67.1300	0.2030	66.9270	3.5000
1978	0.0000	66.9740	0.7730	66.2010	4.6680
1979	0.0000	76.3770	1.7700	74.6070	4.5480
1980	0.0000	74.5490	4.1770	70.3720	5.1120
1981	0.0000	93.2320	2.8670	90.3650	4.7630
1982	0.0000	106.9460	0.8250	106.1210	4.6250
1983	0.0000	138.0090	4.2000	135.9650	4.3763
1984	0.0000	124.7200	2.3220	122.3980	5.1825
1985	0.0000	111.0000	4.0870	106.9130	5.2770
1986	0.0000	109.0000	3.0000	106.0000	6.2000

Sources: Total Productions are from Food and Agriculture Organization of the United Nations (FAO), Rome, various issues; Total Imports, 1963-84, are from FAO, Trade Yearbook, Rome, various issues; Total Imports, 1985-86, are from United States Department of Agriculture (USDA), Economic Research Service (ERS), Middle East and North Africa--Situation Outlook Report, Washington, D.C., April 1987; and Retail Prices are from Kingdom of Saudi Arabia, Ministry of Finance and National Economy (MOFNE), Central Department of Statistics (CDS). Statistical Yearbook, Riyadh, Saudi Arabia, various issues.

APPENDIX TABLE A.3.2. Grapes: Total Production, Total Imports, Total Exports, Total Consumption, and Retail Price, 1963-86

Year	Total Production	Total Imports	Total Exports	Total Consumption	Retail Price
	(million kg, mkg)	(mkg)	(mkg)	(mkg)	(SR/kg)
1963	17.0000	0.8640	0.0000	17.8640	0.9544
1964	17.0000	1.2540	0.0000	18.2540	1.5510
1965	18.0000	1.6860	0.0000	19.6860	1.8508
1966	19.0000	1.7940	0.0000	20.7940	1.9400
1967	20.0000	2.1540	0.0000	22.1540	1.8474
1968	22.0000	2.4780	0.0000	24.4780	1.7803
1969	22.0000	2.3860	0.0000	24.3860	1.8168
1970	24.0000	1.0670	0.0090	25.0580	1.8231
1971	26.0000	2.8500	0.0000	28.8500	1.6352
1972	28.7950	4.2100	0.0010	33.0040	2.0675
1973	34.9730	2.2810	0.0070	37.2470	2.0500
1974	30.6820	3.9250	0.0600	34.5470	2.5209
1975	61.2620	6.0850	0.0920	67.2550	2.2625
1976	41.6650	5.2930	0.0000	46.9580	4.3100
1977	42.3290	3.7760	0.0000	46.1050	6.0350
1978	55.8770	9.7160	0.0000	65.5930	5.9575
1979	52.8930	17.8350	0.0250	70.7280	6.0690
1980	56.6990	25.6480	0.5640	81.7830	5.8100
1981	60.5370	28.3130	0.6080	88.2420	5.5000
1982	44.1180	28.7190	0.5700	72.2670	8.4736
1983	85.0000	25.0550	0.0000	110.0550	7.2760
1984	79.0000	37.0000	1.3040	114.6960	5.9250
1985	92.0000	24.0000	1.0570	114.9430	6.5700
1986	105.0000	19.0000	1.0000	123.0000	6.4000

Sources: Total Productions, 1963-83, are from Food and Agriculture Organization of the United Nations (FAO), Production Yearbook, Rome,various issues; Total Productions and Total Imports, 1984-86, are from United States Department of Agriculture (USDA), Economic Research Service (ERS), Middle East and North Africa: Situation and Outlook Report, Washington, D.C., April, 1987; Total Imports, 1963-83, and Total Exports, 1963-86 are from FAO, Trade Yearbook, Rome, various issues; and Retail Prices are from Kingdom of Saudi Arabia, Ministry of Finance and National Economy (MOFNA), Central Department of Statistics (CDS). Statistical Yearbook, Riyadh, Saudi Arabia, various issues.

APPENDIX TABLE A.3.3. Bananas: Total Production, Total Imports, Total Exports, Total Consumption, and Retail Price, 1963-86

Year	Total Production	Total Imports	Total Exports	Total Consumption	Retail Price
	(million kg, mkg)	(mkg)	(mkg)	(mkg)	(SR/kg)
1963	0.0000	8.1150	0.0000	8.1150	1.4100
1964	0.0000	9.4680	0.0000	9.4680	1.6240
1965	0.0000	11.7980	0.0000	11.7980	2.1427
1966	0.0000	14.5400	0.0000	14.5400	1.9833
1967	0.0000	15.5290	0.1570	15.3720	1.8812
1968	0.0000	14.1420	0.0390	14.1030	2.0528
1969	0.0000	21.7880	0.0420	21.7460	1.7920
1970	0.0000	22.3720	0.0290	22.3430	1.9776
1971	0.0000	32.7160	0.0300	32.6860	1.7248
1972	0.0000	18.8640	0.0850	18.7790	2.6200
1973	0.0000	35.8620	0.1180	35.7440	2.2000
1974	0.0000	28.3110	0.2250	28.0860	3.4744
1975	0.0000	36.5720	3.6250	32.9470	3.4700
1976	0.0000	44.8690	2.1200	42.7490	3.3500
1977	0.0000	68.0660	0.7220	67.3440	3.2500
1978	0.0000	81.0360	1.0560	79.9800	3.0400
1979	0.0000	91.8160	1.9690	89.8470	2.9500
1980	0.0000	78.6430	8.2710	70.3720	3.5500
1981	0.0000	96.1090	5.7440	90.3650	3.5000
1982	0.0000	145.6870	1.6240	144.0630	3.0000
1983	0.0000	147.6260	1.7000	145.9260	3.8800
1984	0.0000	126.2440	1.6120	124.6320	4.1022
1985	0.0000	85.1580	1.6270	83.5310	4.3733
1986	0.0000	58.0910	1.0000	57.0910	5.9750

Source: Total Productions , bananas are not grown in Saudi Arabia, they are imported from other countries (see discussions in Chapter 5); Total Imports and Total Exports are from Food and Agriculture Organization of the United Nations (FAO), Trade Yearbook, Rome, various issues; and Retail Prices are from Kingdom of Saudi Arabia, Ministry of Finance and National Economy (MOFNA), Central Department of Statistics (CDS). Statistical Yearbook, Riyadh, Saudi Arabia, various issues.

APPENDIX TABLE 4.0. Tomatoes: Total Productions, Total Imports, Total Exports, Total Consumption, and Retail Price, 1963-86

Year	Total Production	Total Imports	Total Exports	Total Consumption	Retail Price
	(million kg, mkg)	(mkg)	(mkg)	(mkg)	(SR/kg)
1963	46.0000	3.0000	0.0000	49.0000	1.6875
1964	50.0000	3.1380	0.0000	53.1380	1.2283
1965	81.9000	3.1270	0.0000	85.0270	1.1714
1966	108.0000	4.1730	0.4210	111.7520	1.0283
1967	60.0000	3.6730	1.2900	62.3830	1.6875
1968	58.0000	3.7640	0.8070	60.9570	1.7275
1969	80.0000	2.9120	1.0240	81.8880	1.2800
1970	100.0000	1.7760	3.3930	98.3830	0.9367
1971	97.5300	2.4450	3.9450	96.0300	1.3329
1972	110.9500	5.6470	5.6060	110.9910	1.3040
1973	181.6420	4.6360	1.6100	184.6680	1.5700
1974	201.0320	8.1720	0.6540	208.5500	1.8150
1975	301.4140	5.8720	1.6650	305.6210	1.6233
1976	164.8500	5.6970	0.9000	169.6470	3.2570
1977	196.5960	5.4630	0.3740	201.6850	3.1950
1978	166.5250	7.0000	0.2480	173.2770	4.5275
1979	212.0000	11.7600	0.8880	222.8720	4.2200
1980	200.1210	60.0530	3.5610	256.6130	4.1306
1981	232.0420	72.8870	3.2430	301.6860	4.0800
1982	310.0000	113.4490	4.1010	419.3480	3.7300
1983	263.9730	135.6090	2.0000	399.5820	4.4900
1984	328.4760	139.8250	4.0420	466.3010	4.1500
1985	429.3710	110.3010	4.1430	486.8490	3.9600
1986	428.1350	92.9650	4,1000	517.0000	3.8000

Sources: Total Productions, 1963-82, are from Food and Agriculture Organization of the United Nations (FAO), Production Yearbook, Rome, various issues; Total Productions, 1983-86, are from Kingdom of Saudi Arabia, Ministry of Agriculture and Water (MOAW), Department of Economic Studies and Statistics. Bulletin of Agricultural Statistics: Current Sample Survey, Riyadh, Saudi Arabia, various issues; Total Imports and Total Exports are from FOA, Trade Yearbook, Rome, various issues; and Retail Prices are from Kingdom of Saudi Arabia, Ministry of Finance and National Economy (MOFNE), Central Department Statistics (CDS). Statistical Yearbook, Riyadh, Saudi Arabia, various issues.

APPENDIX TABLE A.4.1. Eggplants: Total Productions, Total Imports, Total Exports, Total Consumption, and Retail Price, 1963-86

Year	Total Production	Total Imports	Total Exports	Total Consumption	Retail Price
	(million kg, mkg)	(mkg)	(mkg)	(mkg)	(SR/kg)
1963	9.0000	0.0000	0.0000	9.0000	0.6650
1964	9.0000	0.0000	0.0000	9.0000	0.8030
1965	9.0000	0.0000	0.0000	9.0000	0.8210
1966	8.0000	0.0000	0.0000	8.0000	0.8920
1967	9.0000	0.0000	0.0000	9.0000	1.0580
1968	9.0000	0.0000	0.0000	9.0000	1.0610
1969	9.0000	0.0000	0.0000	9.0000	1.0192
1970	9.0000	0.1980	0.0010	9.1970	1.1779
1971	50.4620	0.2100	0.0400	50.6320	0.8142
1972	8.2560	0.2510	0.0940	8.4130	1.4400
1973	21.5320	0.5390	0.0000	22.0710	1.3094
1974	22.6900	0.4520	0.0770	23.0650	1.2115
1975	39.1980	0.5620	0.1250	39.6350	1.1940
1976	20.5300	0.3570	0.0690	20.8180	2.7527
1977	25.3150	0.4260	0.0000	25.7410	3.0400
1978	21.2710	0.4030	0.0000	21.6740	3.2908
1979	30.2610	0.2200	0.0000	30.4810	4.1727
1980	24.6850	3.6520	0.0000	28.3370	4.5063
1981	19.9590	4.7750	0.0000	24.7340	4.7470
1982	43.4600	7.1820	0.0000	50.6420	4.3830
1983	34.2560	7.7350	0.0000	41.9910	4.9920
1984	30.9900	0.0000	0.0000	30.9900	5.1400
1985	35.2040	7.7960	0.0000	43.0000	4.2500
1986	37.0000	6.0000	0.0000	43.0000	4.5580

Sources: Total Productions, 1963-81,and 1986, are from Food and Agriculture Organization of the United Nations (FAO), Production Yearbook, Rome, various issues; Total Productions, 1982-85, are from Kingdom of saudi Arabia, Ministry of Agriculture and Water (MOAW), Department of Economic Studies and Statistics (DOESS). Bulletin of Agricultural Statistics: Current Sample Survey, Riyadh, Saudi Arabia, various issues; Total Imports and Exports are from FAO, Trade Yearbook, Rome, various issues; and Retail Prices are from Kingdom of Saudi Arabia, Ministry of Finance and National Economy (MOFNE), Central Department of Statistics (CDS). Statistical Yearbook, Riyadh, Saudi Arabia, various issues.

APPENDIX TABLE A.4.2. Dry Onions: Total Production, Total Imports, Total Exports, Total Consumption, and Retail Price, 1963-86

Year	Total Production	Total Imports	Total Exports	Total Consumption	Retail Price
	(million kg, mkg)	(mkg)	(mkg)	(mkg)	(SR/kg)
1963	15.0000	11.4550	0.0000	26.4550	0.5630
1964	15.0000	12.9610	0.0000	27.9610	0.5700
1965	21.5000	13.9270	0.0000	35.4270	0.6660
1966	29.5000	17.0260	0.0000	46.5260	0.5890
1967	15.0000	15.4580	0.0000	30.4580	0.9660
1968	15.0000	13.1460	0.0000	28.1460	1.0000
1969	15.0000	22.4660	0.0000	37.4660	0.9125
1970	15.0000	5.4660	0.0000	20.4660	1.1514
1971	22.4000	8.8460	0.0000	31.2460	0.6885
1972	14.5660	13.6690	0.2820	27.9530	0.9950
1973	42.9400	7.8820	2.4540	48.3680	0.9077
1974	152.0030	13.6810	0.0096	165.5880	0.8889
1975	50.4890	21.0740	0.2470	71.3160	1.3795
1976	74.4490	25.5840	0.0650	99.9680	2.8889
1977	106.0820	40.4120	0.0000	146.4940	2.6575
1978	95.0320	52.4670	0.0000	147.4990	2.8159
1979	101.0480	65.6350	0.0000	166.6830	2.4560
1980	59.4780	79.1090	0.0000	138.5870	2.7850
1981	14.0600	91.7480	2.1340	103.6740	3.1820
1982	80.0000	108.7030	2.4240	186.2790	2.2067
1983	57.0000	117.8530	3.1000	171.7530	2.6520
1984	19.8440	126.8120	2.6550	144.0010	3.1000
1985	17.0290	130.0000	3.0000	147.0290	3.4900
1986	18.0000	140.0000	3.0000	155.0000	2.7267

Sources: Total Productions, 1963-81 are from Food and Agriculture Organization of the United Nations (FAO), Production Yearbook, Rome, various issues; Total Productions, 1982-83 and 1986, and Total Imports, 1985-86, are from United States Department of Agriculture (USDA), Economic Research Service (ERS), Middle East and North Africa : Situation and Outlook Report, Washington, D.C., April, 1987; Total Productions, 1984 are from Kingdom of Saudi Arabia, Ministry of Agriculture and Water (MOAW), Department of Economic Studies and Statistics (DOESS). Bulletin of Agricultural Statistics: Current Sample Survey, Riyadh, Saudi Arabia, 1984/85; Total Imports, 1963-84, and total Exports, 1963-86 are from FOA, Trade Yearbook, Rome, various issues; and Retail Prices are from Kingdom of Saudi Arabia, Ministry of Finance and National Economy (MOFNE), Central Department of Statistics (CDS). Statistical Yearbook, Riyadh, Saudi Arabia, various issues.

APPENDIX TABLES A5.0-A5.3
PRELIMINARY REGRESSION ESTIMATE RESULTS

APPENDIX TABLE A.5.0a. Regression Estimates of Demand for Staple Foods (3SLS)- Constant Income Elasticity

Dependent Variable	Expenditure Share (percent)	Explanatory Variables						R^2	DW	Income Elasticity		
		Constant	PW/PNF	PR/PNF	PPO/PNF	YNR	1/YNR			y(min)[a]	y(mean)[b]	y(max)[c]
QW/N [1]	2.0200	2.1949	-0.4078	0.1027	-0.0464	0.2888	-	0.96	1.58	0.2888	0.2888	0.2888
		(5.3178)[d]	(-5.4625)	(1.1429)	(-1.7577)	(6.8230)						
QR/N [1]	2.5100	1.3492	0.0831	-0.4550	-0.0175	0.3117	-	0.72	1.38	0.3117	0.3117	0.3117
		(2.2137)	(1.1454)	(-3.0818)	(-0.5584)	(5.3080)						
QPO/N [1]	0.3900	-4.8084	-0.2300	-0.1004	-0.3296	0.8054		0.99	1.14	0.8054	0.8054	0.8054
		(-7.0229)	(-1.6745)	(-0.4956)	(-1.6096)	(10.9540)						

[1] $\text{Ln } Q_{it}/N_t = \text{Ln a} + b1 \text{ Ln } PW_t/PNF_t + b2 \text{ Ln } PR_t/PNF_t + b3 \text{ Ln } PPO_t/PNF_t + c1 \text{ Ln } YNR_t + U_t$

Endogenous variables : Q_{it}/N_t - per capita consumption of wheat, rice, or potatoes, kilograms (kg)

Explanatory variables: PW_t/PNF_t- real retail wheat price, SR/kg; PR_t/PNF_t - real retail rice price, SR/kg; PPO_t/PNF_t - real retail potatoes price, SR/kg; YNR_t- per capita real private consumption expenditure (income), SR; and U_t - disturbance term

[a,b,c] Minimun, mean, and maximum per capita real income (y), SR 2,069.5, SR 6,258.4, and SR 14,183.2, respectively

[d] Numbers in parentheses are t-statistics

APPENDIX TABLE A.5.0b. Regression Estimates of Demand for Staple Foods (3SLS) - Declining Income Elasticity

Dependent Variables	Expenditure Share (percent)	Explanatory Variables								Income Elasticity		
		Constant	PW/PNF	PR/PNF	PPO/PNF	YNR	1/YNR	R^2	DW	y(min)[a]	y(mean)[b]	y(max)[c]
QW/N [2]	2.0200	5.0300	-0.4074	0.0395	-0.0300	-	-1280.1200	0.95	1.38	0.6186[d]	0.2045	0.0903
		(45.5488)[e]	(-5.0073)	(0.4189)	(-1.2593)		(-6.0162)					
QR/N [2]	2.5100	4.4827	0.0315	-0.4910	-0.0570	-	-1391.3200	0.50	1.42	0.6723[f]	0.2223	0.0981
		(27.3856)	(0.4156)	(-3.4982)	(-2.1057)		(-5.2368)					
QPO/N [2]	0.3900	3.5916	-0.1640	-0.3768	-0.5344	-	-3888.5700	0.99	1.50	1.8790[g]	0.6213	0.2742
		(13.1885)	(-1.3315)	(-2.1665)	(-2.8803)		(-13.0308)					

[2] $\text{Ln}Q_{it}/N_t = \text{Ln } a + b1 \text{ Ln } PW_t/PNF_t + b2 \text{ Ln } PR_t/PNF_t + b3 \text{ Ln } PPO_t/PNF_t - c2\ 1/YNR_t + U_t$

Endogenous variables : Q_{it}/N_t - per capita consumption of wheat, rice, or potatoes, kilograms(kg)

Explanatory variables: PW_t/PNF_t - real retail wheat price, SR/kg; PR_t/PNF_t - real retail rice price, SR/kg; PPO_t/PNF_t - real retail potatoes price, SR/kg; $1/YNR_t$ - inverse per capita real private consumption expenditure (income), SR; and U_t - disturbance term

[a,b,c] Minimum, mean, and maximum per capita real income (y), SR 2,069.5, SR 6,258.4, and SR 14,183.2, respectively

[d] Numbers in parentheses are t-statistics

[e] Elasticities are computed by dividing c2 values by income levels in a, b, and c, respectively

APPENDIX TABLE A.5.1a. Regression Estimates of Demand Equations for Meats (3SLS) - Constant Income Elasticity

Dependent Variables	Expenditure Share (percent)	Explanatory Variables						R^2	DW	Income Elasticity		
		Constant	PCH/PNF	PML/PNF	PBV/PNF	YNR	1/YNR			y(min)[a]	y(mean)[b]	y(max)[c]
QCH/N [1]	1.8200	-16.0514	-0.6327	1.3448	0.0200	1.8133	-	0.99	0.58	1.8133	1.8133	1.8133
		(-5.3682)[d]	(-2.1875)	(2.8104)	(0.8085)	(8.3568)						
QML/N [1]	5.8600	1.3453	0.3937	-0.8421	-0.0269	0.4944	-	0.89	1.39	0.4944	0.4944	0.4944
		(0.5515)	(2.6535)	(-1.8527)	(-1.6703)	(3.2055)						
QBV/N [1]	0.3700	0.8145	0.0753	-0.4220	-0.6914	0.5551	-	0.97	1.58	0.5551	0.5551	0.5551
		(0.4853)	(0.6162)	(-1.6413)	(-2.2059)	(6.1498)						

[1] $\text{Ln } Q_{it}/N_t = \text{Ln a} + \text{b1 Ln } PCH_t/PNF_t + \text{b2 Ln } PML_t/PNF_t + \text{b3 LN } PBV_t/PNF_t + \text{c1 Ln } YNR_t + U_t$

Endogenous variables : Q_{it}/N_t - per capita consumption of chicken, mutton and lamb, and beef and veal, kilograms (kg)

Explanatory variables: PCH_t/PNF_t - real retail chicken price, SR/kg; PML_t/PNF_t - real retail mutton and lamb price, SR/kg; PBV_t/PNF_t - real retail beef and veal price, SR/kg; YNR_t - per capita real private consumption expenditure (income), SR; and U_t - disturbance term

[a,b,c] Minimun, mean, and maximum per capita real income (y),SR 2,069.5, SR 6,258.4, and SR 14,183.2, respectively

[d] Numbers in parentheses are t-statistics

APPENDIX TABLE A.5.1b. Regression Estimates of Demand Equations for Meats (3SLS) - Declining Income Elasticity

Dependent Variables	Expenditure Share (percent)	Explanatory Variables								Income Elasticity		
		Constant	PCH/PNF	PML/PNF	PBV/PNF	YNR	1/YNR	R^2	DW	y(min)[a]	y(mean)[b]	y(max)[c]
QCH/N [2]	1.8200	3.6465	-0.7928	0.6725	0.0039	-	-7673.2600	0.99	1.38	3.7078[d]	1.2261	0.5410
		(4.8246)[e]	(-4.4824)	(2.0419)	(0.1441)		(-14.4203)					
QML/N [2]	5.8600	7.2104	0.2268	-1.1236	-0.0540	-	-1490.8400	0.89	1.36	0.7204	0.2382	0.1051
		(7.6068)	(2.2213)	(-3.0135)	(-3.2476)		(-2.6276)					
QBV/N [2]	0.3700	6.9886	0.0358	-0.8591	-0.5452	-	-1992.5800	0.96	1.48	0.9628	0.3184	0.1405
		(6.0021)	(0.2687)	(-3.2731)	(-1.5192)		(-5.2599)					

[2] $\text{Ln } Q_{it}/N_t = \text{Ln a} + b1 \text{ Ln } PCH_t/PNF_t + b2 \text{ Ln } PML_t/PNF_t + b3 \text{ Ln } PBV_t/PNF_t - c2\ 1/YNR_t + U_t$

Endogenous variables : Q_{it}/N_t - per capita consumption of chicken, mutton and lamb, or beef and veal, kg

Explanatory variables: PCH_t/PNF_t - real retail chicken price, SR/kg; PML_t/PNF_t - real retail mutton and lamb price, SR/kg; PBV_t/PNF_t - real retail beef and veal price, SR/kg; 1/YNR - inverse per capita real private consumption expenditure (income), SR; and U_t - disturbance term

[a,b,c] Minimum, mean, and maximum per capita real income (y), SR 2,069.5, SR 6,258.4, and SR 14,183.2, respectively

[d] Elasticities are computed by dividing c2 values by income levels in a, b, and c respectively

[e] Numbers in parentheses are t-statistics

APPENDIX TABLE A.5.2a. Regression Estimates of Demand for Fresh Fruits (3SLS) - Constant Income Elasticity

Dependent Variables	Expenditure Share (percent)	Explanatory Variables							R^2	DW	Income Elasticity		
		Constant	PO/PNF	PA/PNF	PG/PNF	PB/PNF	YNR	1/YNR			y(min)[a]	y(mean)[b]	y(max)[c]
QO/N [1]	1.4700	-4.1096	-0.3976	-0.0786	0.0339	0.0094	0.8085	-	0.99	1.24	0.8085	0.8085	0.8085
		(-4.9296)[d]	(-2.4641)	(-0.6370)	(0.6784)	(0.0959)	(11.2566)						
QA/N [1]	1.1100	-2.6474	-0.1050	-1.1006	-0.0571	-0.0067	0.7420	-	0.99	1.29	0.7420	0.7420	0.7420
		(-2.7518)	(-0.6393)	(-4.1586)	(-0.8637)	(-0.0549)	(9.1928)						
QG/N [1]	0.3600	-2.5063	0.1364	-0.1767	-0.8567	0.1340	0.6717	-	0.95	1.41	0.6717	0.6717	0.6717
		(-2.9316)	(0.6655)	(-0.8677)	(-6.0292)	(1.0808)	(8.7390)						
QB/N [1]	0.9300	-1.5542	0.0107	-0.0104	0.0513	-0.8149	0.5195	-	0.95	1.03	0.5195	0.5195	0.5195
		(-1.2259)	(0.0683)	(-0.0721)	(1.0702)	(-5.1041)	(4.8080)						

[1] $\text{Ln } Q_{it}/N_t = \text{Ln a} + b1 \text{ Ln } PO_t/PNF_t + b2 \text{ Ln } PA_t/PNF_t + b3 \text{ Ln } PG_t/PNF_t + b4 \text{ Ln } PB_t/PNF_t + c1 \text{ Ln } YNR_t$

Endogenous variables : Q_{it}/N_t - per capita consumption of oranges, apples, grapes, or bananas, kilograms (kg)

Explanatory variables: PO_t/PNF_t - real retail oranges price, SR/kg; PA_t/PNF_t - real retail apples price, SR/kg; PG_t/PNF_t - real retail grapes price, SR/kg; PB_t/PNF_t - real retail bananas price, SR/kg; YNR_t - real per capita private consumption expenditure (income), SR; and U_t - disturbance term

[a,b,c] Minimum, mean, and maximum per capita real income (y), SR 2,069.5, SR 6,258.4, and SR 14,183.2, respectively

[d] Numbers in parentheses are t-statistics

APPENDIX TABLE A.5.2b. Regression Estimates of Demand for Fresh Fruits (3SLS) - Declining Income Elasticity

Dependent Variables	Expenditure Share (percent)	Explanatory Variables									Income Elasticity		
		Constant	PO/PNF	PA/PNF	PG/PNF	PB/PNF	YNR	1/YNR	R^2	DW	y(min)[a]	y(mean)[b]	y(max)[c]
QO/N [2]	1.4700	3.6794	-0.5216	0.0044	0.0423	0.0489		-3801.1600	0.99	1.57	1.8368[d]	0.6074	0.2680
		(12.4054)[e]	(-3.2146)	(0.0340)	(0.8540)	(0.4983)	-	(-12.4769)					
QA/N [2]	1.1100	3.6588	0.0067	-0.5713	0.0504	-0.2425	-	-3431.2600	0.98	1.03	1.6580	0.5483	0.2419
		(6.9294)	(0.0392)	(-1.8845)	(0.6791)	(-1.7226)		(-8.2799)					
QG/N [2]	0.3600	3.5406	0.1741	0.1741	-0.8413	0.0240	-	-3186.0500	0.90	1.14	1.5395	0.5091	0.2246
		(6.9294)	(0.8634)	(0.8634)	(-6.2237)	(0.1763)		(-8.6136)					
QB/N [2]	0.9300	3.7842	0.0793	-0.2884	0.0095	-0.6747	-	-2896.5100	0.99	1.51	1.3996	0.4628	0.2042
		(10.0094)	(0.5134)	(-1.7141)	(0.1794)	(-4.2359)		(-6.5903)					

[2] $\text{Ln } Q_{it}/N_t = \text{Ln a} + b1 \text{ Ln } PO_t/PNF_t + b2 \text{ Ln } PA_t/PNF_t + b3 \text{ Ln } PG_t/PNF_t + b_4 \text{ Ln } PB_t/PNF_t - c2\ 1/YNR_t + U_t$

Endogenous variables : Q_{it}/N_t - per capita consumption of oranges, apples, grapes, and bananas, kg

Explanatory variables: PO_t/PNF_t - real retail oranges price, SR/kg; PA_t/PNF_t - real retail apples price, SR/kg; PG_t/PNF_t - real retail grapes price, SR/kg; PB_t/PNF_t - real retail bananas price, SR/kg; $1/YNR_t$ - inverse per capita real private consumption expenditure (income), SR; and U_t - disturbance term

[a,b,c] Minimum, mean, and maximum per capita real income (y), SR 2,069.5, SR 6,258.4, and SR 14,183.2, respectively

[d] Elasticities are computed by dividing c2 values by income levels in a, b, and c, respectively

[e] Numbers in parentheses are t-statistics

APPENDIX TABLE A.5.3a. Regression Estimates of Demand for Fresh Vegetables (3SLS) - Constant Income Elasticity

Dependent Variables	Expenditure Share (percent)	Explanatory Variables						R^2	DW	Income Elasticity		
		Constant	PT/PNF	PEP/PNF	PDO/PNF	YNR	1/YNR			y(min)[a]	y(mean)[b]	y(max)[c]
QT/N [1]	2.9500	0.7743 (0.9662)[d]	-1.1820 (-4.6969)	-0.0113 (-0.4908)	-0.0294 (-0.5994)	0.4841 (6.9630)	-	0.92	0.91	0.4841	0.4841	0.4841
QEP/N [1]	0.1900	-2.4820 (-2.0541)	-0.1693 (-0.4712)	-1.4466 (-3.3877)	-0.2930 (-0.8830)	0.6957 (5.2101)	-	0.69	1.68	0.6957	0.6957	0.6957
QDO/N [1]	0.3100	-1.5276 (-1.0057)	-0.2767 (-0.5915)	-0.1798 (-0.8846)	-0.5586 (-1.3975)	0.5863 (4.2486)	-	0.40	1.17	0.5863	0.5863	0.5863

[1] $\text{Ln } Q_{it}/N_t = \text{Ln } a + b1 \text{ Ln } PT_t/PNF_t + b2 \text{ Ln } PEP_t/PNF_t + b3 \text{ Ln } PDO_t/PNF_t + c1 \; YNR_t + U_t$

Endogenous variables : Q_{it}/N_t - per capita consumption of tomatoes, eggplants, or dry onions, kilograms (kg)

Explanatory variables: PT_t/PNF_t - real retail tomatoes price SR/kg; PEP_t/PNF_t - real retail eggplants price, SR/kg; PDO_t/PNF_t - real retail dry onions price, SR/kg; YNR_t - per capita real private consumption expenditure (income), SR; and U_t - disturbance term

[a,b,c] Minimum, mean, and maximum per capita real income (y), SR 2,069.5, SR 6,258.4, and SR 14,183.2, respectively

[d] Numbers in parentheses are t-statistics

APPENDIX TABLE A.5.3b. Regression Estimates of Demand for Fresh Vegetables (3SLS) - Declining Income Elasticity

Dependent Variables	Expenditure Share (percent)	Explanatory Variables								Income Elasticity		
		Constant	PT/PNF	PEP/PNF	PDO/PNF	YNR	1/YNR	R^2	DW	y(min)[a]	y(mean)[b]	y(max)[c]
QT/N [2]	2.9500	5.2936	-1.1111	0.0050	-0.0054	-	-2230.7400	0.92	0.79	1.0779[d]	0.3564	0.1573
		(13.0218)[e]	(-4.1035)	(0.2335)	(-0.1125)		(-6.2504)					
QEP/N [2]	0.1900	4.0029	0.0714	-1.2914	-0.5534	-	-3454.6400	0.81	1.57	1.6693	0.5520	0.2436
		(7.2188)	(0.2168)	(-3.7532)	(-1.8725)		(-6.4433)					
QDO/N [2]	0.3100	4.2292	-0.0558	-0.3391	-0.6453	-	-3163.8500	0.57	1.28	1.5288	0.5055	0.2231
		(5.7829)	(-0.1124)	(-1.8715)	(-1.6283)		(-5.0024)					

[2] $\text{Ln } Q_{it}/N_t = \text{Ln a} + b1 \text{ Ln } PT_t/PNF_t + b2 \text{ Ln } PEP_t/PNF_t + b3 \text{ Ln } PDO_t/PNF_t - c2 \; 1/YNR_t + U_t$

Endogenous variables : Q_{it}/N_t - per capita consumption of tomatoes, eggplants, or dry onions, kg

Explanatory variables: PT_t/PNF_t - real retail tomatoes price, SR/kg; PEP_t/PNF_t - real retail eggplants price, SR/kg; PDO_t/PNF_t - real retail dry onions price, SR/kg; $1/YNR_t$ - inverse per capita real private consumption expenditure (income), SR; U_t - disturbance term

[a,b,c] Minimum, mean, and maximum per capita real income (y), SR 2,069.5, SR 6,258.4, and SR 14,183.2, respectively

[d] Elasticities are computed by dividing c2 values by income levels in a,b, and c, respectively

[e] Numbers in parentheses are t-statistics

CONSUMPTION DEMAND FOR SELECTED FOOD COMMODITIES IN SAUDI ARABIA WITH PROJECTIONS FOR 1993

by

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The recent economic growth and a population growth of some four percent annually have dramatically increased Saudi Arabia's demand for food. Between 1973 and 1982 when the incomes were accelerating, imports of cereals, vegetables and fruits more than tripled, while that of meat increased even more. The present study investigates the consumption income relation, i.e., the Engle curve relationship, for thirteen food commodities in Saudi Arabia, taking into consideration the price effect.

To get around the multicollinearity problem, the thirteen food commodities were separated into four groups, viz., staple foods, meat group, fresh fruits, and fresh vegetables based on the texture characteristics, marketing periods, and taste of the products. And to further simplify the estimation problem, the author considered only within group substitution. Estimations under constant and declining income elasticity models were made on each commodity within the group. The homogeneity and Slutsky restrictions were imposed. The results showed that food consumption was significantly affected by income level and that the effect of income on consumption demand varied among individual food commodities. In each food category, the income elasticity was below zero, confirming the Engel's law abundantly. The results also indicated that an increase in real income was likely to increase the consumption of meat, fresh fruits, and vegetables at the expense of staple foods.

The results fell into three groups with respect to income response: the results which R^2 clearly suggest declining income elasticity model; the results which R^2 neither clearly confirm nor refute declining or constant income elasticity response; and the results which R^2 clearly suggest constant income elasticity relationship. Since projected real income grows very moderately for the next seven-year-period and is overshadowed by population growth, no shifting in demand composition has occurred. However, when the real income was allowed to grow more rapidly, about 3 percent annually, the consumption of wheat, rice, mutton and lamb, beef and veal, and grapes increased by the same amount, while that of potatoes, chicken, bananas, eggplants, and dry onions, approached the saturation level. The consumption of oranges, apples, and tomatoes fell under undecided category.