THE EFFECT OF PRICE, ADVERTISING, AND INCOME ON CONSUMER DEMAND: AN ALMOST IDEAL DEMAND SYSTEM INVESTIGATION

by

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Dissertation submitted to the Faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of
Doctor of Philosophy
in
Marketing

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(Abstract)

Theoretically, an equiproportionate change in prices and income should not affect the sales of products. This is known as the homogeneity of demand property on which the economic consumer demand theory is built. Rejection of this assumption is indicative of a state of mind called 'money illusion'. Evidence from applied economics literature suggests that consumers respond asymmetrically to equal changes in prices and income. Such an asymmetry could be, among other things, due to the exclusion of marketing mix variables in their demand functions or inappropriate grouping of products.

The main focus of the dissertation is to provide a theoretically consistent approach to include marketing variables in a sales response function. Specifically, advertising is hypothesized to act as a moderator in eliminating the asymmetry.

A related issue investigated in this research is the existence and empirical testing of mental expenditure

accounts. Grouping of products into mental expenditure accounts is thought to improve the homogeneity of demand.

A system of equations is developed since the model involves prices and advertising of all products. The systems approach offers a consistent means to analyze sales when advertising programs interact; for example, orange juice advertising may affect the demand for milk and vice versa. The expenditure share system of equations is estimated using the Seemingly Unrelated Regression (SUR) estimation procedure to allow for dependence among error terms and cross-equation coefficients.

Theoretically, this research tests the validity of the well established consumer demand theory. It provides an approach, consistent with neoclassical economic theory, to include marketing mix variables in sales response modeling.

Managerially, this study helps in determining the level of advertising necessary to reduce the asymmetry in consumer response due to price and income changes. Substitution patterns obtained from the proposed analysis will aid managers to decide upon prices of closely related products within a category in the wake of income changes. The proposed model provides a methodology to explore and test market structure.

ACKNOWLEDGEMENT

I would like to thank Dr. George Franke, who guided me through the course of this dissertation and helped me develop a positive research orientation. I am grateful to him for providing me with the much needed support and encouragement throughout this research. I express my gratitude to him for his patience and perseverence. The value of his contribution is more than I can express in words.

I also wish to thank Dr. T. C. Srinivasan for his valuable insights which forced me to think through some of the very fundamental issues of this research, Dr. John T. Mentzer for lending me a helping hand whenever I needed one, Dr. Noreen Klein, for her detailed comments and suggestions, and Dr. Ray Myers for his statistical expertise. This dissertation has benefited greatly from their contribution.

I am indebted to my wife Jeegna for being so wonderfully understanding and supportive from start to finish and enduring the process with me. Finally, I would like to dedicate this dissertation in the loving memory of my late mother Mrs. Jasu Vashi who inspired me to pursue the highest level of academic achievement.

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Chapter 1: Introduction

Overview

Central to the field of marketing is the consumer and basic to the study of marketing phenomena is the analysis of consumer behavior. Consumers in today's world are faced with many alternative products and services to choose from. Marketing mix elements, such as price, advertising, and distribution, affect the choice of a particular product. This choice is usually subject to many constraints. For example, the consumer does not have unlimited funds or income for the acquisition of the desired products and services. Any changes in the income[1] (expenditure budget), prices, and/or other marketing mix variables could thus have an effect on consumer behavior.

Income changes over time; so do prices and other marketing mix variables. A standard exercise in the economic theory of consumer demand is to analyze how demand responds to changes in price and income. Economists have not paid much attention to other marketing mix variables such as advertising and promotion in studying consumer demand. On the other hand, marketers have investigated consumer demand by incorporating prices and other marketing mix variables in their analysis. However, marketers have largely ignored the issue of income

[1]The term income implies disposable income unless stated otherwise. It is used interchangeably with budget.

(or budget) constraints under which the consumer operates. The present study is an effort in integrating marketing and economic theory of consumer demand. Specifically, this study unifies the analysis of consumer demand by explicitly incorporating income (expenditure budget), prices, and other marketing mix variables.

Introduction

Two issues that have implications across a spectrum of marketing activities of a firm are the determination of the structure of the market in which its products compete, and the estimation of the market response function. The objective of a market structure analysis is to appropriately group products so that the competitive relationships between them can be identified and correctly measured, and its importance has motivated a distinct stream of research (e.g., Allenby 1989; Srivastava et al. 1984; Urban et al. 1984; Vilcassim 1989). The measurement of market response (i.e. the econometric measurement of demand) has a long history in marketing, and a number of studies has been reported in the literature addressing the various aspects pertaining to demand estimation (e.g., Lambin 1976; Naert and Leeflang 1978; Hanssens, Parsons and Shultz 1990).

Review of the literature (see Chapter 2 for a detailed discussion) on demand estimation in marketing reveals a disturbing deficiency in the specification of the estimating equation, and model building continues to be plagued by a lack of guiding theory and arbitrariness in specification. Hence, the generality of the results is cast in doubt. Further, the majority of studies dealing with demand estimation have dealt with single brands. Yet the concept of competition is one of the basic tenets of marketing, and given that all products in a market compete to varying degrees for the consumer's budgeted expenditure, the demand for each product should be modeled in the context of a system of competing products. The competitive structure of a product market can be viewed from a number of different perspectives. From a marketing standpoint, the most relevant approach is one that is consumer oriented. Specifically, how do consumers perceive the products in an overall market with regard to their attributes, and to what extent do they substitute between products in actual usage or purchase situations? Further, how do the marketing activities of the sellers influence the structure of the market, and thereby the nature and extent of competition between products? These are some of the broader questions that one attempts to answer in conducting an analysis of the structure of a product market.

Among the major weaknesses associated with previous efforts are: 1) the lack of a coherent theoretical basis for the methodology used, and 2) the inability to quantify the degree of competition at both the individual product[2] and the associated product category[3] level.

Against this background, the primary objective of this research is to provide a theoretically consistent approach to study the demand for products. In order to estimate the demand for products, certain theoretically derived properties of the demand functions must be satisfied. The properties of the demand functions are: 1) Adding up, 2) Homogeneity, 3) Symmetry, and 4) Negativity. While these properties of the demand functions are discussed in detail in Chapter 2, the first two properties deserve brief discussion at this stage.

The adding up property of the demand functions simply means that share of the budget spent on all products must sum to one. In other words, the percentage of disposable income spent on all products from the consumers' budgetary resources (assuming no debt or borrowing) should not exceed one hundred. As will be shown in the next chapter, this requirement is automatically satisfied when demand is modeled as system of equations.

The homogeneity property implies that when the consumer's income and wealth increases by, say, five percent accompanied

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[2]An individual product is defined as a tangible good that is offered to the customers for use or consumption.

[3]A product category is defined as several distinct products that make up an interrelated group of products.

by a five percent increase in all the prices, the quantity demanded should not change. When the demand is not homogeneous of degree zero[4] in income and prices, the individual's demand for commodities would be altered by an equiproportionate change in all prices and income. In this case, the consumer is said to suffer from money illusion (Branson and Klevorick 1969). Money illusion implies failure of the homogeneity property of the demand function.

A method is presented to simultaneously estimate the response functions and test the assumptions about the demand theory. The competitive structure of the market for frequently purchased products is analyzed via this method. The method is based on the microeconomic theory of consumer choice wherein a set of demand equations is estimated incorporating the effects of changes in budget, prices, and advertising. The method provides a test that shows which of a set of products remain unaffected by movements in prices, advertising, and consumers' income. Based on such a test the competition between products and product categories due to changes in prices, advertising, and income can be determined.

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[4]A function, say $z = \Phi(a, b)$, is said to be homogeneous of degree r when $a(\partial z/\partial a) + b(\partial z/\partial b) = (r)z$. Thus, when $a(\partial z/\partial a) + b(\partial z/\partial b) = 0$, the function $z = \Phi(a, b)$ is said to be homogeneous of degree zero. This is the same as saying that a function Φ is homogeneous of degree k if $\Phi(t\mathbf{x}) = t^k\Phi(\mathbf{x})$. In particular, Φ is homogeneous of degree zero if $\Phi(t\mathbf{x}) = \Phi(\mathbf{x})$.

The degree of competition at different levels (i.e. product and product category) is quantified and conclusions are drawn about the response of product/product category sales to changes in price, income, and promotional activities.

Approaches to Studying Demand

In recent years a considerable literature has developed in modeling consumer choice in the field of marketing. There is a large amount of progress in this area on these issues, as reflected in a special issue of Marketing Science in Fall 1986. Bayus and Rao (1989) remark that major concerns of recent efforts have been on the consumer choice of one alternative (for example, choice of one brand from a set of alternative brands). Further, as noted by Srinivasan and Winer (1990), most demand models are single-equation models which relate a set of independent variables to brand demand. Bayus and Rao (1989) also conclude that the broader topic of consumer choices from a subset of alternatives has been neglected.

Since the consumer operates under certain budgetary constraints, the allocation of limited resources in the best possible manner to obtain maximum utility becomes a complex task. The consumer has to choose from a variety of products available in the marketplace without going over the budgetary constraint. Various products, thus, compete to be included in the bundle of products that the consumer consumes. Under such circumstances, it is imperative that demand for products (not just brands) be modeled in a way that reveals the demand interrelatedness and interdependencies among the products competing in the marketplace. A system-wide approach to demand estimation enables us to model such interdependencies and interrelatedness among products. Such a system-wide approach has been used only recently to study marketing phenomena (e.g., Clements and Selvanathan 1988; Vilcassim 1989).

Moreover, as discussed in detail in the next chapter, the practice of demand estimation based on single-equation models is largely inadequate from a theoretical standpoint. This inadequacy has resulted in continuing lack of guiding theory and arbitrariness in functional form specification in model building. Hence, the generality of the results is cast in doubt.

Demand studies reported in the economics literature, on the other hand, are generally based on strong theoretical foundations, and are estimated in a system-wide context. The well established utility maximizing approach acts as the underlying guiding theory to demand estimation in economics. However, the formulation of the utility function is usually restrictive and includes mainly the price and income variables. From a marketing standpoint these studies are subject to a number of limitations. Among the limitations are the broad aggregation of products studied by economists (such as "food", "clothing", etc.), and the exclusion of important marketing mix variables from the estimating equations. These studies have attempted to explain the changes in demand for products in terms of income and price only. Clearly, when dealing with narrowly defined products, other important factors such as advertising, distribution, and other promotional activity should be included in the estimating equations. There have been few theoretical studies that show how these variables can be formally incorporated within the context of a demand system (e.g., Theil 1980; Vilcassim 1986).

As noted by Deaton (1983) in his excellent summary article on demand analysis, considerable evidence has been accumulated against the homogeneity property of demand function. As noted by him, although there is some variation in results through different data sets, different approximating functions, and different product aggregations, there is substantial and strong accumulated evidence rejecting this property of the demand function. One possible reason for the rejection of the homogeneity property could be the lack of attention given to the marketing mix elements, especially advertising, in the theoretical development of demand functions (cf. Scitovsky 1978; Young 1980). Thus, another objective of this research is to provide a theoretical basis and specific means of incorporating other marketing mix variables into the estimating equations of a demand system. Specifically, it is postulated that apparent money illusion will be reduced, if not eliminated, by incorporating advertising in the demand function.

Research Questions

The basic goal of this research is to test the fundamental assumption of homogeneity of demand in consumer demand theory. In other words, the primary thrust of this research is on testing the effect of proportional changes in both price and income on consumer demand of routinely purchased grocery store products. An important issue in this context is determining how the marketing mix of one product affects the demand for other related products.

In the early to mid-1980s, in an attempt to better explicate the then existing normative economic theory of wealth and consumption, Thaler introduced the concept of mental accounts. He suggested that households have a system of mental accounts (such as a current income account, an asset account, and a future income account) and their consumption is related to these accounts. Relating to the field of marketing, Thaler (1985) suggests that when regulating their day-to-day expenditures, consumers are constrained by their current (monthly) income. In addition, the expenditures tend to be grouped into various mental consumption accounts. In other words, it is postulated that an individual's consumption is sensitive to income and that individuals categorize their expenditures on the basis of the mental consumption accounts. The quantity of each product bought depends on not only (i) the price of that product and (ii) the price of all other products, but also (iii) the income of the buyer. Our knowledge in marketing, thus far, seems to be deficient in understanding and explaining the impact of consumers' income levels on their consumption behavior.

To better understand the effects of price and income changes, a detailed economic explanation of such changes is provided next.

(a) <u>Changes in price</u>

When the price of a product changes while the individual's money income remains fixed, there are two factors which affect the quantity demanded of that product: (1) the rate at which the product can be exchanged for another product changes, and (2) the individual's total purchasing power is altered.

To better understand these two effects consider two competing products A and B. Let the price of A be increased while the money income remains fixed. Then under normal circumstances we would expect the quantity demanded of A to decrease. This decrease could be due to two reasons. First, some consumers would switch their purchases from A to B. This crossover is called the <u>substitution effect</u>. Second, when money income is fixed, in real terms the consumer is a bit poorer. Being forced to buy a product at a higher price is just like having a decrease in real income or purchasing power. If the price of product A is increased it means that the consumer's money income will buy less of product A. Thus the purchasing power of the consumer's money has gone down, even though the number of dollars the consumer has is the same. Since it would cost more to purchase A, some consumers will buy less of A under their budgetary constraints. This reduction in consumption of product A due to the price increase of product A is called the income effect. Thus, income effect is defined as the increase or decrease in a consumer's real income (purchasing power) as a result of the change in the price of a product or services (Monroe 1990).

(b) Changes in Prices and Income

Standard economic theory assumes demand to be homogeneous of degree zero. In other words, when income and prices are increased by the same proportion, the quantity demanded remains unchanged. Demand being homogeneous of degree zero is another way of saying that only changes in relative prices, not absolute prices, affect behavior (Silberberg 1978). But Branson and Klevorick (1969) suggest that when prices, money income, and money wealth all increase proportionately, consumers notice the income and wealth increases more than they do the price levels, and increase their real consumption.

They suggest that consumers exhibit money illusion. Support for the money illusion hypothesis was found by Rutherford et al. (1985) in explaining the demand for milk. They found an asymmetric response by consumers to real price rises and real price falls. The real price increase and real price decline arose from different sources. The real price increase was brought about by increasing the money price of the product (while other prices stayed constant) and the real price decline was due to inflation while the money price was held constant. Demand asymmetry arising due to money illusion would imply that consumer reaction to real price increases would be greater than their reaction to real price decreases, as found by Rutherford et al.

Under such circumstances it would be interesting to study the income effects and substitution effects of products within and across accounts. When the price alone of a product within an account (such as food, clothing etc.) changes while income and other marketing mix elements remains unchanged, consumers are likely to exhibit substitution and/or income effects. In other words, if the price of a product A (within one account) goes up, then (i) that product is likely to be substituted by another product, say B, or (ii) product A is consumed in lesser quantity, or both (i) and (ii). The specific questions to be answered under the conditions of price change alone while everything else (including nominal income and other marketing mix elements) remains unchanged are: How much of product A is substituted by another product, say B, from the same account to which product A belongs? Or, how much of product A is substituted by another product from a different account? Similarly, another set of questions to be investigated is: Does the increase in price of product A (within one account) induce consumers to consume less of product A, or does it induce reduced consumption of another product from the same or a different account?

Potential Contributions of the Study

The research questions proposed above are a step in the direction of bringing a theoretical perspective to the impact of income on consumption in the area of marketing. These research questions are a blend of economics and marketing in an attempt to further the knowledge of researchers in the area of consumption behavior. The answers to the proposed questions would enable researchers to better understand the substitution and income effects within and across categories of products. Additionally, the role of price combined with income in the consumption behavior of consumers will be better understood.

The research questions proposed above have both theoretical and managerial importance. The theoretical implications of investigating the impact of income will enable us to shed more light on consumers' judgment, choice and decision processes. The existing behavioral/psychological explanations of how prices enter the consumer choice process (grounded in a combination of adaptation level theory, assimilation-contrast theory, and prospect theory) appear to be inadequate due to the absence of income effects. Answers to the proposed questions will extend our understanding of how consumers behave under budget constraints.

Managerially, the study will be relevant to both manufacturers and retailers. At the retail level this study will help show how consumers substitute one product with another product based on changes in income, prices, and promotional activity. The study will also aid in determining how demand for one product is affected by the prices and promotional activity of other products that are included in the consumers' monthly expenditure budget. At the manufacturer level, this study will aid in managing different but related products (e.g., soft drinks, fruit juices) that can be grouped into one broad product category (e.g., beverages).

To either audience, this study will aid in designing pricing and promotional strategies. Specifically, the results from the study can be used in decisions pertaining to product line composition. Patterns of product substitution, based on prices and promotional activity, can also be determined from this research. This is important in that it will contribute to better forecasting of demand. Additionally, the study will identify those products in one set that are unaffected by price changes of other products.

Organization of Chapters

The rest of this study is organized as follows. In chapter 2, properties of the demand functions are first discussed along with a discussion of separability and conditional demand functions. The literature dealing with demand estimation in both marketing and economics is then reviewed, and their major shortcomings are critically evaluated. In chapter 3, a general technique of incorporating marketing mix variables into the utility function is presented. A theoretically consistent system of demand equations is developed, with particular emphasis on the advertising variable. A methodology to simultaneously estimate the response functions and test the hypotheses about the homogeneity of demand is also presented. Chapter 4 begins with a description of the data used to analyze the proposed questions followed by the results. Chapter 5 provides the conclusions that can be drawn from this research, theoretical and managerial implications of this research effort, limitations of the present study, and directions for future research.

Chapter 2: Literature Review

The field of marketing has tended to model individual choice by applying theoretical frameworks primarily from two basic disciplines -- psychology and economics. In the context of choice modeling, theory generation can be defined as the general identification of the preference function and the translation of this preference structure into a model of choice (Corstjens and Gautschi 1983).

Thus consumer behavior is frequently presented in terms of preferences. The specification of which choices are actually available is given secondary place. However, it is important to study the limits to choices as well as the choices themselves. Individuals do not operate in an ideal world where they have unlimited sums of money (income) from which they can buy whatever they prefer. Rather, they operate under a specific budget which acts as constraint to choice. The choices made by an individual are constrained by prices in such a way that the total expenditure on the products chosen should not exceed some predetermined amount (usually the individual's disposable income).

The simplest and the most common type of constraint is the linear budget constraint. A linear budget constraint implies that the sum of all the products purchased (q_i) times their respective prices (p_i) does not exceed a predetermined budget M. The constraint can then be written as:

$$\sum_{i=1}^{n} p_i q_i = M \qquad 1$$

where p_i is the price of product i, i = 1, 2, ..., n, q_i is the quantity purchased of each of product i, and M is the budget.

In this chapter the previous work relating to demand estimation is briefly reviewed. The discussion draws from published studies in both marketing and economics. The objective of the review is to identify the major shortcomings in both streams of research, to examine their consequences on demand estimation from a marketing standpoint, and to outline in general terms a methodology to overcome these limitations. The details of the methodology will be given in the next chapter.

The discussion begins with a review of the economic theory of demand which includes the properties of the demand function, the concept of separability, and the relationship between separability and the conditional demand function. This material is followed by a review of the approaches to estimate demand.

2.1 Utility maximization and demand system

The economic theory of consumer demand is derived from the utility maximization approach. The basic axiom of the utility maximization approach is that a rational consumer will always choose a most preferred bundle of products from the set of feasible alternatives. This set of feasible alternatives is just the set of all bundles of products that the consumer can afford (Varian 1984). Operating under a specific budget constraint, the consumer tries to maximize the utility derived from consuming the most preferred bundle of products. The utility function measures the level of satisfaction an individual experiences as a result of consuming a particular set of products. The utility function is denoted by

$$U = U(q) \qquad 2.1.2$$

where $q = (q_1, q_2, \ldots, q_n)$ is a vector of n products demanded by the individual. The utility function (equation 2.1.2) is maximized subject to the budget constraint given by equation 1 above. Mathematically, maximization of the utility function (equation 2.1.2) subject to the budget constraint (equation 1) is carried out by the Lagrangian method. According to this procedure, form the equation

$$L(q, \lambda) = U(q) - \lambda(p'q - M) \qquad 2.1.3$$

where p is the vector of prices for all n products, M is the total budget, and λ is the Lagrangian multiplier interpreted as the marginal utility of income (Johnson et al. 1984). Differentiating the Lagrangian (equation 2.1.3) with respect to q_i and λ respectively, results in the first order conditions

$$U_q - \lambda p = 0, \quad \text{and} \quad p'q - M = 0 \qquad 2.1.4$$

where U_q is the vector of derivatives of the utility function with respect to the quantities q_i, $i = 1, \ldots, n$. The system of equations obtained from the first order conditions (equation 2.1.4) provides n + 1 equations in 2n + 2 variables: the n prices, the n quantities, the income M, and the Lagrangian multiplier λ. The system in equation 2.1.4 can be solved uniquely for $q_1, \ldots, q_n$, and λ in terms of prices and income. The resulting expressions are:

$$q_i = q_i(p_1, \ldots, p_n, M) \qquad i = 1, \ldots, n \qquad 2.1.5$$

$$\lambda = \lambda(p_1, \ldots, p_n, M)$$

Equation 2.1.5 is a system of demand equations.

2.1.1 Properties of the demand function

Adding-up and Homogeneity

Given that the demand function exists, the consumer, by some means or other, has rules for deciding how much of each product to purchase when faced with given prices and total budget. The quantities demanded under these circumstances are given by the functions:

$$q_i = g_i(M, p) \qquad i = 1, \ldots, n \qquad 2.1.1.1$$

where g_i is a function which relates the quantity demanded for each product to the prices of all n products and the total budget. The demand equation as given in equation 2.1.1.1 implies that the quantity demanded is a function of prices of all the products and the total budget. Such representation of demand is also known as the Marshallian demand function. Substituting equation 2.1.1.1 in equation 1 yields:

$$\sum_{i=1}^{n} p_i g_i(M,p) = M \qquad 2.1.1.2$$

The equation 2.1.1.2 is referred to as the adding up restriction, which implies that the sum of all the quantities purchased and their given prices must add up to the total budget. But there are other implications of the budget constraint given in equation 2.1.1.2. Notice that the constraint given in equation 2.1.1.2 contains a function g_i. The fact that the demand functions satisfy the budget constraint in equation 1 immediately places a constraint on the functions g_i. The budget constraint in equation 2.1.1.2 cannot be satisfied by any arbitrary selection of functions g. Thus, in order to satisfy the budget constraint given by equation 2.1.1.2 the function g_i needs to carefully selected.

Every demand equation (such as equation 2.1.1.1) must be homogeneous of degree zero in income and prices. In other words, if all prices and income are changed by an equal proportion, the quantity demanded must remain unchanged. Formally, for any positive number θ and for all i from 1 to n,

$$g_i(\theta M, \theta p) = g_i(M, p) \qquad 2.1.1.3$$

This restriction implies that the demand functions are homogeneous of degree zero, so that equation 2.1.1.3 is known as the homogeneity restriction. To illustrate the homogeneity restriction, let the demand for an product, say A, be dependent on its own price and prices of products B and C as well as the budget M, i.e., the demand function for product A takes the form $q_A = g_A(p_A, p_B, p_C, M)$. The homogeneity restriction requires that

$$p_A \cdot \frac{\partial q_A}{\partial p_A} + p_B \cdot \frac{\partial q_A}{\partial p_B} + p_C \cdot \frac{\partial q_A}{\partial p_C} + M . \frac{\partial q_A}{\partial M} = 0$$

It is also known as "absence of money illusion" since the units in which prices and budget are expressed have no effect on purchases.

Equations 2.1.1.2 and 2.1.1.3 are important features of demand analysis. It is sometimes useful to express them as restrictions on the derivatives of the demand functions, rather on the functions themselves. The adding up restriction implies that for k, i = 1, ..., n,

$$\sum_k p_k \frac{\partial g_k}{\partial M} = 1; \quad \sum_k p_k \frac{\partial g_k}{\partial p_i} + q_i = 0 \qquad 2.1.1.4$$

so that changes in M and in p cause rearrangements in purchases that do not violate the budget constraint. The two parts of equation 2.1.1.4 are sometimes referred to as Engel and Cournot aggregation, respectively.

The homogeneity restriction implies that for k, i = 1, ..., n,

$$\sum_k p_k \frac{\partial g_i}{\partial p_k} + M \frac{\partial g_i}{\partial M} = 0 \qquad 2.1.1.5$$

The above expression says that a proportionate change in p and M will leave purchases of product i unchanged.

These formulas can be expressed somewhat more neatly using a different notation. Let the budget shares w_i be

$$w_i = \frac{(p_i q_i)}{M} \qquad 2.1.1.6$$

Thus the budget shares are the fractions of the total budget allocated to each product.

The logarithmic derivatives of (Marshallian) demands are the total expenditure elasticities (e_i) and price elasticities (e_{ik});

$$e_i = \frac{\partial \log g_i(M,p)}{\partial \log M}$$

$$e_{ik} = \frac{\partial \log g_i(M,p)}{\partial \log p_k}$$

The diagonal elements e_{ii} are the own-price elasticities, while the off-diagonal e_{ik} terms are cross-price elasticities.

Thus in terms of the budget shares and the elasticities, the adding up restriction in equation 2.1.1.4 is equivalent to

$$\sum_k w_k e_k = 1; \qquad \sum w_k e_{ki} + w_i = 0 \qquad 2.1.1.7$$

and the homogeneity restriction in equation 2.1.1.5 is equivalent to

$$\sum_k e_{ik} + e_i = 0 \qquad 2.1.1.8$$

Equation 2.1.1.8 implies that the sum of all own- and cross-price elasticities of any product k has to be equal to the negative of its income elasticity. This condition has to be exactly fulfilled if we want to maintain that our computations produce estimates of derivatives or elasticities of demand functions (Phlips 1974).

In the case of single equation demand estimation, the equation

$$\log q_i = \alpha_i + e_i \log M + \sum_k e_{ik} \log p_k + u_i \qquad 2.1.1.9$$

has frequently been estimated on time series data of expenditures, budget and prices. Estimates of e_i and e_{ik} can be obtained by ordinary least squares regression applied to equation 2.1.1.9 <u>one product at a time</u>. The homogeneity restriction can then be checked by seeing whether the estimates satisfy equation 2.1.1.8 or, equivalently, by imposing the restrictions a priori and using standard statistical tests to test its validity. By contrast, the adding-up restriction cannot be accommodated within the double logarithmic specification. To see this, write equation 2.1.1.6 as

$$\log w_i = \log q_i + \log p_i - \log M \qquad 2.1.1.10$$

so that under the double logarithmic model

$$\log w_i = \alpha_i + (e_i - 1)\log M + (e_{ii} + 1)\log p_i + \sum_{k \neq i} e_{ik} \log p_k$$

2.1.1.11

The adding-up restrictions, equation 2.1.1.7, tells us that the sum of e_i's weighted by w_i's is unity so that (because the w_i's sum to one) (i) either all e_i's must be equal to one <u>or</u> (ii) at least one of them must be larger than unity and the others must be less than unity. If (i) is true, the model is not very interesting because it implies identical expenditure patterns at all levels of total expenditures. In reality the expenditure patterns are different at different levels of total expenditures.

In case (ii), there exists at least one "luxury" product for which $e_i > 1$ and at least one "necessity" product for which $e_i < 1$. We can then lump all luxuries together and write E_1 for total expenditures on them, while E_2 is defined as budget less total expenditure on luxuries. Equation 2.1.1.9 can then be used to examine the behavior of E_1 and E_2 as M increases. Deaton and Muellbauer (1980b) have argued that total expenditures add up to less than the budget in some regions of the income space and in some other regions of the income space the total expenditures exceed the budget constraints. Wold and Jureen (1953, pp. 105-107) have shown examples of price elasticity other than unity (taking the elasticity values as 1/2 and 2) for which the double-log form is theoretically inconsistent. Hence, the double logarithmic model will only satisfy adding up generally if we reverse our original supposition and take $e_i = 1$ for all products.

In spite of this implicit rejection of adding up, it is sometimes argued that for the analysis of a single product, the use of equation 2.1.1.9 does not commit us to logarithmic forms for the equations that remain unspecified. This argument is satisfactory if the double logarithmic form is used only for restricted ranges of total budget. Deaton and Muellbauer (1980b) see little virtue in the use of this model, particularly since there exist models that are equally simple but otherwise more satisfactory.

Demand analysis is concerned not only with the analysis of time-series data but also with the explanations of behavioral differences between households in cross-section studies. In such studies, it is usually assumed that all households face identical prices so that explanations of behavioral differences are sought in differences in total expenditures and in household characteristics, particularly those concerned with family composition. The homogeneity of demand functions can play no part in such an analysis since no price variation is observed. But adding up, which restricts total expenditure elasticities, is still important. Even so, the tradition in studies of family budgets has been to choose functional forms relating purchases to total expenditure on the basis of goodness of fit without paying much attention to this requirement.

Unfortunately, complete demand systems can be estimated only for a limited number of products since the available time-series (or statistical or published data) cover at most thirty or forty years. These products must therefore be large aggregates. One often wants to set up a demand equation for a much more disaggregated product (for example, for 'beer' rather than 'food', and for 'refrigerator' rather than 'durables', etc.). However, it would be practically impossible to estimate the demand at such disaggregate product levels in the framework of a complete system. The time-series data that is currently available is far less than the large number of parameters that will have to be estimated for a complete demand system at a more disaggregate product level.

One way out is to suppose separability (discussed in the next sub-section) and multistage-maximization, and to construct a sub-system (for 'food', say) derived by maximization of a branch utility function. But even this may be asking too much, given that one may wish to enter into the subtleties of the demand for a particular product. Some particular features of the demand function of a given product may not be shared by other demand equations in the subsystem: the demand for product i may be a function of a number of variables that do not appear in the other demand equations.

It is preferable then to try to estimate a complete system (or sub-system), as all equations in a system have the same characteristics (same functional form, same independent variables).

In the analysis of the demand for a particular product taken in isolation, an ad hoc specification of the demand function has to be found. Furthermore, this specification has to be such that conditions 2.1.1.5 or 2.1.1.7 are again satisfied. (Otherwise, it would be impossible to pretend that the estimated elasticities refer to a demand function.)

Symmetry (The Slutsky equation)

The basic idea of symmetry is that the price derivatives of a demand equation can be decomposed. Slutsky (1915) was the first to show that the reaction of the quantity demanded of a product to a change in its price (or to a change in the price of any other product) can be decomposed into an income effect and a substitution effect. The first effect designates the variation (in the quantity demanded) due to the fact that a price change implies a change in the real income of the consumer: if a price increases, for example, the purchasing power of consumers is reduced. They will therefore adjust their demand. Generally (but not necessarily) the reduction in purchasing power will lead to a reduction of demand.

The substitution effect is that part of the variation in quantity demanded that is due to the fact that if the prices of one product changes, its relative price also changes, with the result that less will be consumed of the product whose relative price increases (and more of the products which are substitutes of it), if one ignores the income effect.

Both effects are the result of one and the same price change. Their sum is equal to the observed variation in the quantity demanded. It is worth noting that the income effect is a <u>quantity</u> change, which results from a change in <u>price</u> (not nominal income).

The cross-price derivatives of the Hicksian demands are symmetric, that is, for all $i \neq j$

$$\frac{\partial h_i(u,p)}{\partial p_j} = \frac{\partial h_j(u,p)}{\partial p_i} \qquad 2.1.1.12$$

Since

$$h_i(u,p) = \frac{\partial c(u,p)}{\partial p_i} \qquad 2.1.1.13$$

$$\frac{\partial h_i}{\partial p_j} = \frac{\partial^2 c}{\partial p_j \partial p_i}$$

Similarly, since

$$h_j(u,p) = \frac{\partial c(u,p)}{\partial p_j} \qquad 2.1.1.14$$

$$\frac{\partial h_j}{\partial p_i} = \frac{\partial^2 c}{\partial p_i \partial p_j}$$

so that the only difference between the two lies in the order of the double differentiation. Young's theorem asserts that, given that continuous derivatives exist, the order of double differentiation does not matter and hence the two derivatives are identical.

Negativity

The n-by-n matrix formed by the elements $\partial h_i/\partial p_j$ is negative semidefinite; that is, for any n vector ξ, the quadratic form

$$\frac{\sum_i \sum_j \xi_i \xi_j \partial h_i}{\partial p_j} \leq 0 \qquad 2.1.1.15$$

For convenience, we denote $\partial h_i/\partial p_j = s_{ij}$ and denote the array of s_{ij}'s as S. This is the Substitution Matrix or Slutsky matrix of compensated price response; by equation 2.1.1.14 and 2.1.1.15 it is symmetric and negative semidefinite. The negativity property places a whole series of inequality restrictions on the elements of S; most importantly, the diagonal elements must be nonpositive: for all i,

$$s_{ii} \leq 0. \qquad 2.1.1.16$$

Thus an increase in price with utility held constant must cause demand for that product to fall or at least remain unchanged. As for the wider restrictions embodied in equation 2.1.1.15, imagine that some "compounds" C are sold that contain other products in fixed proportions and that these compounds are priced according to the prices of the ingredients. These C too must then have nonpositive own-price substitution effects in terms of their own (compensated) prices. Equation 2.1.1.16 is, of course, the "law of demand" that compensated demand functions can never slope upwards. The difference here is that equation 2.1.1.16 comes only from the concavity of the cost function which, as already emphasized, holds true whether preferences are convex or not. Negativity has thus nothing to do with the curvature of the indifference curve.

If symmetry and negativity are to be made testable, it must be possible to observe the substitution matrix S, and this means defining it in terms of the Marshallian demands. This is done through the Slutsky equation.

$$s_{ij} = \frac{\partial h_i}{\partial p_j} = \frac{\partial g_i}{\partial M} q_j + \frac{\partial g_i}{\partial p_j} \tag{2.1.1.17}$$

The last term in equation 2.1.1.17, $\partial g_i/\partial p_j$, is the uncompensated price derivative of q_i with respect to p_j. To "compensate" this, an amount q_j (the derivative of minimum cost with respect to p_j) times $\partial g_i/\partial M$ (the total expenditure derivative of q_i) must be added on. Everything on the right-hand side of equation 2.1.1.17 relates to the magnitudes that can, in principle, be directly observed by varying M and p. Hence S can be calculated experimentally and symmetry and negativity are empirically testable. Note finally that S is unaffected by transformations of the utility function since such transformations do not affect the right-hand side of equation 2.1.1.17.

Equation 2.1.1.17 is usually written as

$$\frac{\partial g_i}{\partial p_j} = s_{ij} - \frac{\partial g_i}{\partial M} q_j \qquad 2.1.1.18$$

so that the uncompensated price response is decomposed into a substitution effect of the price change (s_{ij}) and an income effect of the price change ($-q_j \partial g_i / \partial M$).

2.1.2 Separability

The concept of separability evolved from Strotz's (1957) "utility tree" concept which suggests that the relationship among all products stems almost entirely from the competition for fixed budget amounts.

The basic idea of this concept is that the elements belonging to the product bundle may be partitioned into different groups. Budget allocation then is a step-wise procedure whereby the consumer first allocates his/her total budget among groups and then allocates the group budgets among individual products within a group.

Strotz - Utility Tree

The two stage allocation process assumes that the utility function possesses certain properties. Let the utility function be expressed as:

$$U = U(q_1, q_2, \ldots, q_n) \qquad 2.1.2.1$$

and assume that it may be separated into s branches such that:

$$U = F\,[U^1(q^1) + U^2(q^2) + \ldots + U^s(q^s)]$$

where: $U^i(q^i) = U^i(q_1^{\,i}, q_2^{\,i}, \ldots, q_{ni}^{\,i})$

n_i = the number of products in the i^{th} group such that: $n_1 + n_2 + \ldots + n_s = n$.

That is, we assume the utility function is additive among groups. Now if 2.1.2.1 is maximized subject to

$$\Sigma\, p_i q_i = M,$$

Strotz arrives at a demand function which when expressed in linear form is:

$$q_j^i = \alpha_j^i + \sum_{i \in I} \beta_{ji}^i . p_i + \sum_{k \notin I} \beta_{jk}^i . p_k + \gamma_j^i . M$$

where: $q_j^{\,i}$ = j^{th} product belonging to the i^{th} product group

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

$i = 1, 2, \ldots, s$

p_i = the vector of n_i prices in the i^{th} group

p_k = the vector of $n - n_i$ prices in all other groups

$\alpha_j^{\,i}$'s are constant terms

$\beta_{ji}^{\,i}$ and $\beta_{jk}^{\,i}$'s are price slopes

$\gamma_j^{\,i}$'s are income slopes.

To illustrate, suppose we have a simplified six product world consisting of the following:

i = 1	i = 2	i = 3
Hamburger (H)	Volvos (V)	Movies (M)
Steak (S)	Fords (F)	Television (T)

We might logically divide these into three independent groups:

Foods	Automobiles	Entertainment.

Intuitively we would expect strong relationships between the products within each group but weak or no relationships between products in different groups. Taking group one, Strotz would express the demand functions as follows:

Hamburger:

$$q_H^1 = \alpha_H^1 + \beta_{HH}^1 \cdot p_H + \beta_{HS}^1 \cdot p_S + \beta_{HV}^1 \cdot p_V + \beta_{HF}^1 \cdot p_F + \beta_{HM}^1 \cdot p_M + \beta_{HT}^1 \cdot p_T + \gamma_H^1 \cdot M$$

Steak:

$$q_S^1 = \alpha_S^1 + \beta_{SS}^1 \cdot p_S + \beta_{SH}^1 \cdot p_H + \beta_{SV}^1 \cdot p_V + \beta_{SF}^1 \cdot p_F + \beta_{SM}^1 \cdot p_M + \beta_{ST}^1 \cdot p_T + \gamma_H^1 \cdot M$$

Strotz further shows that for the above relationships:

$$\frac{\beta_{HV}^1}{\beta_{SV}^1} = \frac{\beta_{HF}^1}{\beta_{SF}^1} = \frac{\beta_{HM}^1}{\beta_{SM}^1} = \frac{\beta_{HT}^1}{\beta_{ST}^1} = \frac{\gamma_H^1}{\gamma_S^1}$$

i.e., the coefficients $\beta_{j1k}{}^i$ and $\beta_{j2k}{}^i$ will be in fixed proportion for product k not in branch i and the fixed proportion is such that the ratio of the price slopes is equal to the ratio of the income slopes.

Using this result, it is easy to see that all cross-price relationships between product groups can be calculated with only a knowledge of the income coefficients and at least one intergroup coefficient.

Separability of products within a utility function in general assumes that the ratio of marginal utilities of a pair of products i and j is unaffected by the level of consumption of a third product k. That is, it is assumed that for all $k \neq i, j$

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

holds for at least some products.

Various types of separability assume that only the marginal utilities are changed equally because of a change in the consumption of the k^{th} product.

Based on different assumptions, there are three types of separability defined in the economics literature.

1) <u>Weak Separability</u> - If two products belong to the same group the ratio of their marginal utilities is independent of the quantity consumed of any product outside that group.

Another way of stating weak separability is that it implies that the utility function may be divided into subgroups such that the marginal rate of substitution (MRS) between two products i and j from the same group (say G) is independent of the quantities of products not belonging to group G.

Thus it is assumed that for all i, j $\in$ G and k $\notin$ G.

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

Goldman and Uzawa (1964) show that this implies a utility function of the non-additive form:

$$U\ (q_i,\ .\ .\ .,\ q_n) = F[U^1\ (q^1),\ U^2\ (q^2),\ .\ .\ .,\ U^s\ (q^s)]$$

where: $U^i\ (q^i) = U^i\ (q_1{}^i,\ q_2{}^i,\ .\ .\ .,\ q_{ni}{}^i)$

$i = 1, 2, . . ., s$ = number of groups

$\sum_{i=1}^{s} n_i = N$ = Total number of products

Weak separability is the least restrictive form of separability and leads to the following observable relationship:

$$\lambda \frac{\partial q_i}{\partial p_j} = X^{RS} \cdot q_{mi} \cdot q_{mj} \qquad 2.1.2.2$$

for i $\in$ R and j $\in$ S and R $\neq$ S where

$$q_{mi} = \frac{\partial q_i}{\partial M}, \quad q_{mj} = \frac{\partial q_j}{\partial M}, \quad X^{RS} = \text{constant}$$

$\lambda \frac{\partial q_i}{\partial p_j}$ is the compensated cross-price slope; i.e., the cross-price slope compensated for income changes.

The compensated cross-price derivatives between two products (i and j) belonging to two different groups (R and S) are proportional to the product of their income derivatives (q_{mi} and q_{mj}). The constant of proportionality (X^{RS}) is the constant between any given pair of groups but varies between group pairs.

Thus, with weak separability:

a) Substitution between products within a group is unrestricted as is substitution between groups as a whole.

b) Relationships between specific products in different groups are restricted to conform to the group interaction.

c) $e_{ik} = e_{jk}$ for all i, j $\in$ G and k $\notin$ G.

Equation (2.1.2.2) above of course suggests a substantial number of parameter restrictions and limits the number of parameters to be estimated.

2) Strong Separability

Assume that if two products, i and j, belong to different groups, R and S, each of their marginal utilities is independent of the quantities consumed of the other. That is, for i and j, where i $\in$ R, j $\in$ S, R $\notin$ S:

$$\frac{\partial U_j}{\partial q_i} = 0$$

Strong separability implies that the utility function can be partitioned into subgroups such that the marginal rate of substitution between two products i and j from two different groups (R and S) does not depend upon the quantities of products not belonging to the same subsets as i and j. That is, for all k $\in$ group G, i $\in$ group R, j $\in$ group S, R $\notin$ S $\notin$ G:

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

These conditions imply a utility function which is additive among product groups:

$$U(q_1, q_2, \ldots, q_n) = F[U^1 (q^1) + U^2 (q^2) + \ldots + U^s (q^s)]$$

which is consistent with the utility function needed for Strotz's utility tree. If <u>only one product appears in each of the s groups, we have want-independence</u>. (Only one product in each group = pointwise separability.)

The assumption of strong separability leads to

$$\lambda \frac{\partial q_i}{\partial p_j} = X.(q_{mi} \cdot q_{mj}) \qquad i \in R,\ j \in S,\ R \neq S$$

where

$$q_{m,i} = \frac{\partial q_i}{\partial M}, \quad q_{m,j} = \frac{\partial q_j}{\partial M}$$

X = constant between all groups and

$\lambda \frac{\partial q_i}{\partial p_j}$ is the compensated cross-price slope; i.e., the cross-price slope compensated for income changes.

Strong separability implies the following number of parameters to be estimated:

a) n income elasticities

b) 1 intergroup price elasticity

c) $1/2 \sum_{G=1}^{N} n_G (n_G + 1)$ intragroup price elasticities.

3) Implicit (Quasi) Separability

Conceptualized by Gorman (1970), preferences are said to be quasi-separable if and only if the cost function can be written as

$$c(u, p) = C[c_1(u, p_1), \ldots, c_r(u, p_r)] \qquad 2.1.2.3$$

where the functions C(.) and $g_r(.)$ have the general properties of cost functions. Products are partitioned into r groups with price subvectors $p_1, \ldots, p_r$. Deaton and Muellbauer (1980b, p. 134) discuss separability of this type (which may be termed implicit separability) and show that the group budget shares ($W_r = M_r/M$) may be derived from

$$W_r = \partial \ln C / \partial \ln c_r. \qquad 2.1.2.4$$

Intragroup budget shares ($W_{ri} = q_i p_i / M_r$) may be derived from

$$W_{ri} = \partial \ln c_r(u, p_r) / \partial \ln p_{ri}, \quad i \in \text{group } r \qquad 2.1.2.5$$

where $c_r(u, p_r)$ can be considered as group price indices that depend on the level of overall utility u. Each vector p_r is composed of the prices of the individual i products within the group r.

From Sheppard's lemma, the share of i within M (total group expenditures), or $W_{Ci} = q_i p_i / M$, may be derived from

$$W_{Ci} = \frac{\partial \ln C}{\partial \ln c_r} \cdot \frac{\partial \ln c_r}{\partial \ln p_{ri}} = W_r W_{ri} \qquad 2.1.2.6$$

2.1.3 Conditional Demand Functions and the Implications of Separable Utility

The following discussion on conditional demand functions and its linkage to separability is based on Pollak (1971) and Bryant (1983).

Consider an individual whose preferences can be represented by a utility function, $U(q_1, q_2, \ldots, q_n)$, where q_i denotes his/her consumption of the i^{th} product. The individual is supposed to regard the prices of all products $(p_1, p_2, \ldots, p_n)$ as given, and to behave as if s/he were maximizing $U(q_1, q_2, \ldots, q_n)$ subject to the budget constraint $\sum p_i q_i = M$, where M denotes the total budget.

In every price-income situation there is a unique collection of products which yields greater utility than any other combination satisfying the budget constraint. The quantities of the various products in this utility maximizing combination depend on all prices and income; that is

$$q_i = h^i(p_1, p_2, \ldots, p_n, M) = h^i(P, M) \qquad 2.1.3.1$$

where P denotes the vector of all prices. The functions $(h^1, h^2, \ldots, h^n)$ are the "ordinary demand functions".

If the individual's consumption of one product has been determined before s/he enters the market, then that product is said to have been "preallocated". For example, if we consider a college student who lives in an apartment off-campus, the monthly rent that is paid for occupying the space is viewed as "preallocated". It is assumed that the individual is not allowed to sell any of his/her allotment of a preallocated product, and that s/he cannot buy more of it. For definiteness, suppose that the n-th product (in this case the apartment) is preallocated. The student is then free to choose any bundle of products that will maximize his/her utility from the money remaining after paying the rent. Thus, we assume that the first n - 1 products are available on the market at prices $(p_1, p_2, . . ., p_{n-1})$ over which the individual has no control, and that his/her total expenditure on these products, A, is also predetermined. The individual is supposed to choose quantities of the first n - 1 products so as to maximize $U(q_1, q_2, . . ., q_n)$ subject to the "budget constraint"

$$\sum p_i q_i = A \qquad 2.1.3.2$$

and the additional constraint

$$q_n = q_n^* \qquad 2.1.3.3$$

where q_n^* denotes his/her allotment of the n-th product. Hence, the consumers' demand for the products available on the market depends on the prices of these products, total expenditures on them, and their allotment of the n-th product. That is,

$$q_i = g^{i \cdot n}(p_1, p_2, . . ., p_{n-1}, A, q_n) \quad i \neq n. \qquad 2.1.3.4$$

We call the function $g^{i \cdot n}$ the "conditional demand function" for the i-th product. The second superscript, n, indicates that the n-th product is preallocated.

Conditional demand functions can also be defined when more than one product is preallocated. In general, a conditional demand function expresses the demand for a product available on the market, as a function of

(1) the prices of all products available on the market,

(2) total expenditure on these products, and

(3) the quantities of the preallocated products.

Formally, we can partition the set of all products into two subsets, θ and θ^*. We assume that the products in θ are available on the market while those in θ^* are preallocated; thus, if $k \in \theta$, then q_k is available on the market, while if $k \in \theta^*$, then q_k is preallocated. We denote total expenditure on the products available on the market by A^θ. The individual is supposed to maximize $U(q_1, \ldots, q_n)$ subject to the "budget constraint" $\sum p_i q_i = A^\theta$ and the additional constraints

$$q_k = q_k^* \qquad k \in \theta^* \qquad 2.1.3.5$$

Since the demand for a product available on the market depends on the prices of the products available on the market, total expenditure on them, and the quantities of the preallocated products, equation 2.1.3.4 can be expressed as

$$q_i = g^{i.\theta^*}(P_\theta, A^\theta, Q_{\theta^*}) \qquad i \in \theta \qquad 2.1.3.6$$

where P_θ denotes the vector of prices of the products available on the market and Q_{θ^*} denotes the vector of preallocated products. The function $g^{i.\theta^*}$ is the conditional demand function for the i-th product; the second superscript, θ^*, indicates that the products in θ^* are preallocated.

Conditional demand functions are useful in a number of areas of the theory of consumer behavior. Pollak (1971) uses them to analyze the implications of separability. In addition, they can be used as the basis of a useful decomposition of the cross price derivatives of the demand functions.

The notion of separability is connected with conditional demand functions and can be explained and its uses investigated in terms of them (i.e. conditional demand).

The general implication of separability is that if a product is 'separable' from a set of other products, then its unconditional demand can be written as function of its own price, the prices of the products from which it is <u>not</u> separable and the total expenditures on these products. Neither the prices of the products from which it is separable nor total income needs to be included in the list of independent variables. Thus if a product is 'separable' from a large number of other products, then the data set necessary to estimate its demand or expenditure function is much smaller than if the product is not separable.

An example will make this point clear. Suppose that there are four products, that the product under investigation is product 1, and that it is separable from products 3 and 4.

Then, the demand for product 1 can be written either in its conventional unconditional form,

$$q_1 = h^1(p_1, p_2, p_3, p_4, M),$$

or, equivalently, as

$$q_1 = g^{1.3,4}(p_1, p_2, M_d),$$

where

$$M_d = p_1q_1 + p_2q_2 = M - p_3q_3 - p_4q_4.$$

It is this theorem which we implicitly appeal to when we estimate a demand function for clothing, say, and do not include the future prices of clothing and other products or when we exclude the wage rates of employed family members. In the former case we are implicitly assuming that the current demand for clothing is separable from the demands for future clothing and other products. In the latter case, we are assuming that the demand for clothing is separable from the demands for leisure of the family members.

Placed in this light, introducing the concept of separability raises the question of whether such common empirical practices as these are justified. It also raises the question of whether other less common simplifications are possible.

Separability allows us to use a simplified form of the conditional demand function to estimate the unconditional demand. In so doing, the number of independent variables that must be included in the equation is reduced and income is redefined in its discretionary form.

If two groups of products are separable, then the consumer's preferences with respect to the products in one group can be described independently of the quantities of the products consumed in the other group. For example, if food is a group, the consumer can rank different bundles in a way which is independent of his consumption of automobiles, entertainment, clothing, and everything else that lies outside the food group.

One must note what separability does not imply. It does not imply that a change in the consumption of product 3 has no effect on the demand for product 1 at all. After all, a rise in q_3 raises expenditures on product 3, p_3q_3, thereby lowering discretionary income M_d. And one would expect changes in discretionary income to affect the demand for product 1 even if preferences remained constant. This is so because changes in income simply alter the extent to which preferences can be satisfied without altering the preferences themselves.

In summary, then, separability can significantly reduce the number of independent variables needed to explain the demand, expenditure, or consumption of any particular product by allowing a simplified conditional demand function to be estimated. This can reduce the data needed for an analysis and increase the degrees of freedom at the disposal of the researcher, two benefits which have high payoffs.

2.2 A Select Review of the Econometric Approaches to Demand Estimation.

The econometric estimation of demand has a long history in marketing. A large number of studies has been reported in the literature, and any attempt to comprehensively review the literature would extend well beyond the scope of this chapter. Excellent reviews and discussions of demand estimation and the measurement of the response to marketing mix effects can be found in Clarke (1976), Hanssens, Parsons and Shultz (1990), Lambin (1976), and Naert and Leeflang (1978). The objective of this review is to evaluate critically certain aspects of demand estimation and identify the main shortcomings and examine procedures to rectify them.

Econometric demand modeling is approached differently by marketing researchers and economists. These two approaches can be classified as:

1) Aggregate models that are not explicitly based on postulated behavior of micro-units (household or individual consumers). Such an approach is widely observed in the marketing literature.

2) Models based explicitly on postulated behavior of micro-units and subsequently aggregated over micro-units. Economists tend to use such an approach on a regular basis.

Each of these will be discussed in turn.

2.2.1 Direct Aggregate Models

Most econometric approaches to modeling demand, as seen in the marketing literature, start from a direct specification of an aggregate model, i.e., the final specification is not derived from any underlying individual choice process. Several substantive issues arise when such an approach is used. Among the more important issues are:

a) Identifying the level at which demand is being estimated -- brand or product category level.

b) Specification of the functional form to be used in the estimation, and also how the dependent variable is to be measured (e.g., sales in dollars or units).

c) Identifying the explanatory variables to be included in the estimating equations. This should also incorporate a consideration of competitive effects.

d) Specification of the structure of the disturbance term.

e) An examination of the different estimation techniques, and the reasons behind the choice of a particular method.

f) A discussion of the appropriateness of the data used in the analysis, including any limitations or potential sources of error in measurement.

These issues are not independent of each other and in fact, there is substantial interdependence among them. The critique that follows will reflect this. Further, some issues relating to demand estimation must be addressed jointly (e.g., the specification of the functional form and the explanatory variables that should be included), but for ease of exposition these are discussed separately.

Level of Demand Modeled and the Nature of the Product

The level at which demand is estimated, i.e. at the brand or product category level, directly influences a number of other aspects of any econometric model. For example, the explanatory variables and the competitive effects that have to be included would clearly be different in the two situations. The estimation of demand may be carried out using a two-stage procedure. A product class model is first developed. Then given the demand for the product class, the demand for a particular brand can be estimated (Lambin 1976). The functional form and the explanatory variables used at each stage should be appropriately chosen, and a coherent link established between the two models.

Nature of the Product or Service

The nature of the product or service for which demand is being modeled has implications across a number of decisions, including the choice of an appropriate functional form, specification of the exogenous variables, and the incorporation of dynamic and carry-over effects. For example, in modeling the demand for a durable product, macroeconomic variables such as disposable income, expectation about future income and price levels, and the existing stock of the product will be important determinants. These variables will be less important in the case of non-durable products.

Most, if not all, published studies do clearly state the level at which demand is modeled, and also describe the nature of the product/service under study. But, consistency with the other aspects of modeling is lacking. To see this, the following aspects are examined.

Functional Forms

The specification of an appropriate functional form is one of the most critical aspects of modeling the response to the marketing mix variables. A variety of functional forms have been employed with the final specification often being *ad hoc* and heavily dependent on the data, as exemplified by the use of fit criteria such as R^2 and Mean Square Error. The generality of the results obtained are therefore cast in doubt.

The focus of most studies has been the estimation of the response parameters, and consequently a number of functional forms are tried and the "best" among them is then selected. The two most commonly used functional forms in marketing are the additive and multiplicative models (Tellis 1988). Evidence from Assmus et al. (1984) indicate that 44% of all studies analyzed in their meta-analysis used the additive functional form and 56% used the multiplicative functional form.

i) Additive Form (Linear Model)

The linear form is expressed as:

$$y = \alpha + \beta P + \sum_{j=1}^{J} \gamma_j X_j + u$$

where y is the dependent variable (usually sales or market share), P is the price variable, β is the parameter associated with price, X_j, j = 1, 2, . . ., J are other explanatory variables, $\gamma(j)$, j = 1, 2, . . ., J, are the parameters associated with other parameters and u is a disturbance term.

The advantages of such a specification are:

a) ease of estimation as the model is linear in parameters.

The disadvantages of the linear model are:

a) lack of theoretical basis for the specification.
b) fit (R^2) of such models could be artificially increased by including additional variables without a sound theoretical reasoning.
c) does not allow for interaction terms to be modeled explicitly. The interaction terms, though, could be added to the linear formulation at the expense of increasing the number of parameters to be estimated.
d) the additive form assumes a linear response to price changes.
e) imposes an elasticity structure whereby the elasticity equals $\beta(P/y)$, resulting in the undesirable property of

having lower elasticities for deeply discounted prices (Mulhern and Leone 1991).

ii) Multiplicative Form (Log-Linear or Double-Log Model)

The multiplicative form is expressed as:

$$y = e^{u}\prod_{j=1}^{J} X_j^{\beta(j)}$$

where y is the dependent variable (usually sales or market share) and X_j, j = 1, 2, . . ., J are the explanatory variables, $\beta(j)$, j = 1, 2, . . ., J, are the associated parameters and u is a disturbance term. Logarithmic transformation of both sides results in the double-log form.

$$\log y = \sum_{j=1}^{J} \beta_j \log X_j + u$$

The model has a number of advantages including:

a) ease of estimation as the model is linear in the parameters.

b) allows for limited interaction effects between the marketing mix variables.

c) the coefficients have the direct economic interpretation of being the respective elasticities.

d) empirical results obtained often have descriptive validity - more so than the linear form.

The disadvantages of the log-linear form are:

a) the lack of theoretical basis for the specification.

b) the constancy of the parameters and hence of the elasticity of demand, is not tenable in most situations. For example, if price is one explanatory variable, then for most downward sloping demand curves the price elasticity of demand is not a constant and is a function of the price level. A ten percent change in price is unlikely to affect demand by the same percentage at widely different prices.

c) if demand is estimated simultaneously for a set of competing brands with market share as the dependent variable, then the double-log form is not logically consistent (i.e. the predicted market shares may not lie between 0 and 1, and may not add up to 1). Naert and Bultez (1973) show that for this specification no restrictions (other than highly trivial ones) will make the model logically consistent. Based on theoretical reasoning, it can be argued that logical consistency is a desirable property. However, from an empirical standpoint, how critical is logical consistency? Clearly, if the estimation is for a single brand, then logical consistency is not critical. Brodie and deKluyver (1984), citing empirical evidence from a study of three markets, claim that log-linear models perform as well as models that are logically consistent. If demand is being estimated for a set of brands with market share as the dependent variable, then as the market shares must sum to one in any period, the error terms across the equations must sum to zero, i.e. they are linearly dependent or correlated. If this correlation among the error terms is high, then estimating the parameters in a joint generalized least square framework will lead to more efficient estimates than if estimated equation by equation. In both cases, however, the estimates will be consistent (Zellner 1962).

d) even if the model has descriptive validity, the fact that it has no underlying theoretical basis leaves the generality of the specification in doubt. Further, Godfrey and Wickins (1981), using a more powerful Lagrange Multiplier Test, demonstrate that even if the model has descriptive validity, it could still be misspecified. Hence descriptive validity per se is not sufficient, particularly if an understanding of the underlying phenomenon is as important as predictive validity.

e) the specification per se does not resolve the issue of which variables should or should not be included.

Out of the above two models, which functional form best fits the data is an empirical issue and ad hoc specifications are often used in the absence of an underlying guiding theory.

iii) Other Functional Forms

The primary justifications for the linear form are ease of estimation and descriptive validity of the results obtained. However, such a specification has some severe drawbacks. A major problem is the assumption of linearity of the responses to the marketing mix variables, particularly price and advertising. The specification is also not logically consistent. Further, as shown by Godfrey and Wickens (1981), using descriptive validity as a justification can be misleading because the model could still be misspecified.

Models that are inherently non-linear have been used very infrequently. Without strong a priori justification it is not clear what particular advantages are introduced by such specifications, given the increase in the complexity of estimation.

Specification of the Explanatory Variables

Simultaneous to the issue of specification of the functional form is the decision as to which explanatory variables should be incorporated into the model. In the absence of a guiding theory or strong a priori reasoning, the decision is usually driven by the availability of data and/or some measure of the goodness of fit. Even if the model specification is guided by a strong theory, a certain element of arbitrariness is present as no theory will completely and perfectly describe all relevant variables that should be included. The objective should therefore be to minimize the arbitrariness associated with model specification.

Two marketing mix variables of particular importance are advertising and price. In measuring the effect of price on demand it may be desirable to separate the effects of the regular price (or shelf price) from that due to special promotional activities, such as coupons and deals (temporary price cuts). The interaction between price and advertising is also of importance (Moriarty 1985; Wilkinson et al. 1982). Other marketing mix variables whose effects on demand are of interest in general are retail shelf space, market penetration as measured by (say) number of distribution outlets, and product quality.

Specification of Competitive Effects

A product's own marketing mix variables (price, advertising, quality, etc.) have an impact on its demand. The demand for that particular product is also affected by the marketing mix of the competing products. Most demand studies in marketing have dealt with markets characterized by fairly intense competitive activity. However, the incorporation of competition has been limited. The most frequently encountered method of including competition has been only implicitly via the use of relative effects, such as relative prices or advertising of the product (brand) under consideration. This is clearly limited and conveys no meaningful information on the asymmetric effects of competitive activity, such as cross-price and cross-advertising elasticities. Further, the use of relative effects presumes that the correct structure (i.e., the set of closely competing brands) is known. Frequently, this reduces to considering some arbitrarily selected set of brands as composing the relevant set. This is clearly very unsatisfactory as the estimates obtained will be inconsistent if an incorrect structure is assumed. Further, recent empirical findings from studies of market structure (e.g., Urban et al. 1984) demonstrate that it may be incorrect to assume that the entire product category consists of brands directly competing with each other.

It would be desirable to consider a set of related products in the context of a system, and estimate response parameters by incorporating dependencies and asymmetric effects across products.

To summarize, aggregate demand models have generally produced results with product descriptive validity (i.e. significant parameter estimates, significant overall measures of goodness of fit, and signs of coefficients being consistent with a priori expectations). The models are also easily estimable. Among the major drawbacks are that the model building continues to be plagued by lack of guiding theory and arbitrariness in specification. As discussed previously, descriptive validity per se is not a sufficient criterion for determining adequacy of model specification. Hence, the generalizability of the results remain in doubt.

2.2.2. Models Based Explicitly on Postulated Behavior of Microunits.

Whereas economists regularly model demand with microeconomic theory of consumer demand as its foundation, very few studies in marketing have utilized functional forms that start from an explicit model of postulated behavior of micro-units to obtain an aggregate response model. Two such studies, those by Blattberg and Jeuland (1981) and Bass and Pilon (1980), are exceptions to the general practice in marketing. These studies are reviewed first, followed by a review of the recent developments in modeling demand in the economics literature.

Blattberg and Jeuland (1981) focus on advertising effects on the micro-units and postulate two basic processes - reach and decay. They then explicitly aggregate over micro-units and time to obtain an aggregate sales response model that resembles but is different from widely used models. The authors provide some insights into the errors that can result when a typical macro distributed lag model is used. The effects of price and competitive variables are ignored. More importantly, although the model attempts to describe individual behavior, the model is not one of optimizing behavior.

Bass and Pilon (1980) also developed a model which has individual consumers as the unit of analysis. The basic framework is drawn from stochastic modeling of brand choice. Further, the form and nature of the decision variables is determined from the data using multiple time series analysis. Given these two basic constructs underlying the individual behavior, an aggregate model is derived. While this approach is an improvement over the types of aggregate models previously studied, the model suffers from the limitations of stochastic brand choice models - such models are at best only stochastically descriptive of consumer behavior.[5]

Therefore, it is seen that specification of demand models based on plausible behavior of micro-units is really lacking in marketing. This appears to be somewhat surprising, as economists have been developing such models, particularly for frequently purchased products, with increasing theoretical sophistication (Deaton and Muellbauer 1980a, 1980b; Phlips 1983; Pudney 1989; Theil 1975, 1976). It can be reasonably argued that such models are not directly applicable and require modification and adaptations to meet the specific requirements of marketing problems. But, that in itself is not proper justification for not attempting to use them.

Developing a model at the micro level helps overcome some

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[5]The study by Krishnamurthi and Raj (1985) involves some limited estimation at the individual level, but does not explicitly contain any behavioral description of micro-units. Winer (1980) describes an individual level model, but presents no empirical evidence. (An important drawback of this model is that estimation in the specified form is not feasible.)

of the problems previously identified with aggregate models. For example, when modeling is done at the individual level, problems relating to simultaneity and competitive reaction can be ignored, because in the modeling of the choices of an individual consumer, price, advertising, promotion, etc., can be treated as exogenous or parametric to the individual's decision problems.

2.2.2.1 Select Review of Demand Modeling in Economics Literature

Demand system specifications in contemporary economic literature are developed using a utility maximization framework. Each of the specifications results in a reduction of the number of coefficients in the complete system of demand functions, making joint estimation of the parameters more feasible. The resulting demand systems are attractive because they satisfy basic properties of the demand function reviewed in section 2.1.1. (Johnson et al. 1984), and they can be estimated from available time series data.

Three of the utility function approaches to estimate demand are discussed below[6]: 1) the linear expenditure system,

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[6]An alternative stream of research in demand estimation, which does not rely on the utility maximization approach, is developed by Theil (1965, 1976). This has resulted in a demand system known as the Rotterdam model. A major criticism of Theil's Rotterdam model is the assumption of constant elasticity of a good's marginal utility. The Rotterdam model has been applied by Clements and Selvanathan (1988) and Vilcassim (1989) to study marketing problems.

2) the indirect translog model, and 3) the Almost Ideal Demand System. The first approach falls under the category of static demand systems since it originates from assuming the utility function to take a particular functional form. The latter two approaches are known as "flexible functional forms" approaches since they do not require the utility function to take on a particular functional form.

Linear Expenditure System

The linear expenditure system (LES) is derived from a utility function suggested by Klein and Rubin (1947-1948):

$$U = \boldsymbol{\beta}' \log(q - \boldsymbol{\gamma}) \qquad 2.2.2.1$$

where $\boldsymbol{\beta} = [\beta_i]'$ is the n-component vector of marginal budget shares and $\boldsymbol{\gamma} = [\gamma_i]'$ is the n-component vector of quantities interpreted as minimum consumption levels. This interpretation holds only when γ_i is assumed positive. The parameter vectors $\boldsymbol{\beta}$ and $\boldsymbol{\gamma}$ are estimated subject to the restrictions $0 < \beta_i < 1$ ($i = 1, 2, \ldots, n$), $1'\boldsymbol{\beta} = 1$, and $(q - \boldsymbol{\gamma}) > 0$. Maximizing the utility function expressed in equation 2.2.2.1 subject to the budget constraint $p'q = M$ yields as first order conditions

$$(\mathbf{Q} - \boldsymbol{\Gamma})^{-1}\boldsymbol{\beta} - \lambda p = 0 \qquad 2.2.2.2$$

$$p'q - M = 0 \qquad 2.2.2.3$$

where $\mathbf{Q}$ and $\boldsymbol{\Gamma}$ are n x n diagonal matrices with nonzero elements given by the vector q and $\boldsymbol{\gamma}$. Upon solving equations 2.2.2.2 and 2.2.2.3 for the vector $\boldsymbol{\beta}$, and some rearrangement of terms, we get a system of demand equations given by

$$q = \gamma + (M - p'\gamma)P^{-1}\beta \qquad 2.2.2.4$$

The system of expenditure equations corresponding to the demand system in equation 2.2.2.4 can be written as

$$p_i q_i = p_i \gamma_i + \beta_i (M - \sum_j p_j \gamma_j) \qquad i,j = 1,...,n \qquad 2.2.2.5$$

and the individual expenditure functions contained in the system in equation 2.2.2.5 are expressed as

$$p_i q_i = p_i \gamma_i + \beta_i (M - \sum_j p_j \gamma_j) \qquad i,j = 1,...,n \qquad 2.2.2.6$$

The most appealing feature of the linear expenditure system is that it has only 2n parameters. However, this system is overly restrictive since inferior products are excluded from being modeled (Johnson et al. 1984). Moreover, the linear expenditure system is derived from individual utility functions and the issue of deriving an aggregate version of the linear expenditure system has been largely ignored (Phlips 1974). Recent developments in consumer demand theory have resulted in a demand system, known as the Almost Ideal Demand System (Deaton and Muellbauer 1980a) which aggregates perfectly over individuals. The Almost Ideal Demand System (AIDS) is discussed in the next section.

Flexible Functional Forms

The basic method to derive flexible functional forms is to approximate the direct utility function, the indirect utility function, or the cost function by some specific functional form that has enough parameters to be regarded as a reasonable approximation to whatever the true unknown function may be.

i) Indirect Translog Model

This model is due to Christensen, Jorgenson, and Lau (1975). They approximate the indirect utility function by a quadratic form in the logarithms of the price to expenditure ratios, that is

$$u = \psi(M,p) = \alpha_0 + \sum_i \alpha_i \log(\frac{p_i}{M}) + \frac{1}{2}\sum_i \sum_j \gamma_{i,j} \log(\frac{p_i}{M}) \log(\frac{p_j}{M})$$

2.2.2.7

where α_0, α_i's, and $\beta_{i,j}$'s are parameters.

The equation 2.2.2.7 can be regarded as a second-order Taylor approximation to any arbitrary utility function. The authors argue that if the data do not correspond to the demand functions derived from equation 2.2.2.7, then the demand theory must be false. However, there is no reason to suppose that utility functions are exactly translogarithmic for individual consumers or in aggregate so that equation 2.2.2.7 will be an approximation and like all approximations, will be more or less accurate.

Application of Roy's identity to equation 2.2.2.7 yields the system of demand equations

$$w_i = \frac{p_i \cdot q_i}{M} = \frac{\alpha_i + \sum_j \beta_{ij} \log(\frac{p_j}{M})}{\sum_j \alpha_j + \sum_j \sum_i \beta_{ij} \log(\frac{p_j}{M})} \qquad 2.2.2.8$$

where i, j = 1, . . ., n products.

A major limitation of this approach for estimating demand systems is the number of structural parameters required. Reference to equation 2.2.2.8 shows that the number of unrestricted and unknown structural parameters is (n - 1)(2n + 1). Often the limited data series of usual length and more refined product groupings involve serious estimation problems.

ii) <u>Almost Ideal Demand System</u>

Recent developments in economics have provided models that allow exact aggregation. The Almost Ideal Demand System (AIDS) is one such approach to demand estimation that has gained widespread acceptance in the economics literature due to its exact aggregation property.

It will be useful for the sake of completeness to indicate, briefly, the origin of AIDS. It lies in the definition of consistent aggregation given in Muellbauer (1976) which requires a 'representative' level of total expenditure, say M_o, to exist such that aggregate budget shares w_i^* of product i can be written as

$$w_i^* = \frac{\sum_h M_h w_{ih}(M_h, p)}{\sum_h M_h} = w_i[M_o(M_1, \ldots, M_H, p), p] \qquad 2.2.2.9$$

where M_h is total household expenditure, p is price vector, h denotes household and H is the total number of households involved in the aggregation. Extending an earlier result due to Gorman (1953), Muellbauer (1976) shows that for 2.2.2.9 to hold, budget shares, w_{ih}, of household h must have the generalized linear (GL) form

$$w_{ih}(M_h, p) = \upsilon_h(M_h, p)A_i(p) + B_i(p) + C_{ih}(p) \qquad 2.2.2.10$$

where υ_h, A_i, B_i, and C_{ih} are functions satisfying

$$\sum_i A_i = \sum_i C_{ih} = \sum_h C_{ih} = 0, \qquad \sum_i B_i = 1$$

Of particular interest is the case where M_o is independent of prices, depending only on the individual Ms (Ms are the individual incomes/expenditures). This occurs if, and only if, the υ_h function in 2.2.2.10 restricts to

$$\upsilon_h(x_h, p) = \{1-(x_h/k_h)^{-\alpha}\}\alpha^{-1}$$

where α is a constant and k_h, although not a function of M_h, and p are free to vary from household to household. In this case, the budget shares are said to have the 'price independent generalized linear' form (PIGL).

A subset of this PIGL class constrains the υ_h function to be independent of prices. The cost function, $c(u_h, p)$, corresponding to the PIGL form, is derived and shown to take the following form (called PIGLOG) as limiting case:

$$\log\{c(u_h,p)\} = (1-u_h)\log\{a(p)\} + u_h\log\{b(p)\}$$

where u_h is the utility indicator of household, h, and $a(p)$, $b(p)$ are linear, homogeneous, concave functions of price vector p. Choosing the following functional forms:

$$\log\{a(p)\} = \alpha_o + \sum_i \alpha_i \log p_i + 1/2\sum_i\sum_j \gamma^*_{ij}\log p_i \log p_j,$$
$$\log\{b(p)\} = \log\{a(p)\} + \prod_i p_j^{\beta_i}$$

and differentiating the log-cost function with respect to log-price, one obtains value shares which involve u. The latter is substituted by the use of the cost function to obtain AIDS,

$$w_i = \alpha_i + \sum_j \gamma_{ij}\log p_j + \beta_i \log[M/P] \qquad 2.2.2.11$$

where α_o, α_i, β_i, γ_{ij} $[=(\gamma_{ij}^* + \gamma_{ji}^*)/2]$ are parameters of the system, P is a price index defined by

$$\log P = \alpha_o + \sum_i \alpha_i \log p_i + 1/2\sum_i\sum_j \gamma_{ij}\log p_i \log p_j,$$

and the budget constraint implies

$$\sum_i \alpha_i = 1, \qquad \sum_i \beta_i = \sum_i \gamma_{ij} = 0.$$

The AIDS is not devoid of its limitations from the marketing researcher's point of view. From the marketers' perspective, original AIDS, as developed by Deaton and Muellbauer (1980a, 1980b), does not include any marketing mix variables other than price. Also, AIDS has been mainly used to estimate demand of broad categories such as 'food', 'clothing', 'housing', etc.

The testing of the homogeneity assumption is the primary focus of this dissertation. An explanation for the rejection of the homogeneity assumption is sought in this study. The issue of extending the AIDS model to include marketing mix variables in general, and to include advertising in particular, which is postulated to help understand apparent money illusion is the main focus of next chapter. Discussed in the next chapter is a specific means of including advertising in the original AIDS in a theoretically consistent manner and testing the homogeneity assumption with the extended model specification.

The second issue of determining consumers' mental accounts is also discussed in the next chapter.

Chapter 3: Proposed Model

Demand analysis focusing on the effects of household composition and changes in tastes and product quality suggests specific ways in which advertising might affect consumer behavior. Barten (1964) has proposed a household utility model with equivalent adult scales used to deflate the quantities in the utility function to amounts per equivalent adults. Fisher and Shell (1967) have proposed a similar model to analyze taste and quality changes. Muellbauer (1975) and Deaton and Muellbauer (1980b) provide further analysis of both models.

The basic feature of these models is that the quantities in the utility function are scaled - either multiplied or divided by parameters reflecting exogenous factors. In terms of the indirect utility function or cost function, scaling leads to a form of interactions between prices and the exogenously determined variables. In this dissertation, the marketing mix variables associated with a product are considered as the exogeneous factors. It is postulated that incorporating the marketing mix variables transforms the individual's underlying utility function. Such a transformation implies that the exogenous factors (marketing mix variables) act as preference changing parameters in the underlying utility functions. Changes in the scaling parameter are expected to have an impact on consumers' choice in addition to the impact due to the existing determinants of the utility function. The scaling approach is intuitively appealing.[7] The next section describes the general formulation of the scaling approach. An extension of the AIDS model, which includes advertising, is then derived which is consistent with the neoclassical economic theory.

Scaling

Following Muellbauer's (1975) formulation of modeling quality changes in the consumer's utility function (which is also regarded as the scaling approach), the consumer choice problem allowing for the impact of advertising can be written as

$$\text{maximize} \quad u = u(q^*) \qquad 3.1$$

$$\text{subject to} \quad p^{*\prime}q^* = M$$

where

$$q^* = (q_1^*, \ldots, q_n^*)$$

$$q_i^* = b_i q_i \qquad 3.2$$

$$p^* = (p_1^*, \ldots, p_n^*)$$

$$p_i^* = p_i/b_i$$

$$b_i = b_i(a)$$

In equation 3.2, b_i is the scaling parameter and depends on the marketing mix variables; q_i^* is an adjusted quantity, the product of the scaling parameter b_i and q_i; and p_i^* is an

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[7]An alternative approach based on a specification suggested by Gorman (1976) and analyzed by Pollak and Wales (1981) introduces other variables, such as demographic variables or advertising (Chang and Green 1992), through overhead costs. Pollak and Wales call such an approach "translating".

adjusted (or perceived) price, the market price p_i divided by the scaling parameter b_i.

The demand equations for the choice problem 3.1 have the form

$$q_i^* = q_i^*(p^*, M) \text{ or}$$

$$q_i = (1/b_i) q_i^*(p^*, M)$$

and the indirect utility function and cost function for the problem have the forms

$$u = \Phi(p^*, M) \quad \text{and}$$

$$M = c(p^*, u)$$

respectively.

Thus, substituting the price variable p in the previously identified AIDS model by p^* ($= p/b_i$), we can develop a new model called Scaled Almost Ideal Demand System (SAIDS). The cost function of SAIDS is given by

$$\log c = \alpha_0 + \sum_i \alpha_i \log\left(\frac{p_i}{b_i}\right) + \frac{1}{2}\sum_i \sum_j \gamma_{ij} \log\left(\frac{p_i}{b_i}\right) \log\left(\frac{p_j}{b_j}\right) + u\beta_0 \prod_i \left(\frac{p_i}{b_i}\right)^{\beta_i} \tag{3.3}$$

where the α's, β's, and γ's are parameters. Applying Sheppard's lemma ($w_i = \partial \log c / \log p_i$), the Hicksian demand equations for equation 3.3 have the form

$$w_i = \alpha_i + \sum_j \gamma_{ij} \log\left(\frac{p_j}{b_j}\right) + \beta_i u \beta_0 \prod_i \left(\frac{p_i}{b_i}\right)^{\beta_i} \tag{3.4}$$

[Since $\partial \log c / \partial \log p_i$ is equivalent to $\partial \log c / \partial \log (p_i/b_i)$].

Solving equation 3.3 for u and substituting into equation 3.4, the corresponding Marshallian demand equations have the form

$$w_i = \alpha_i + \sum_j \gamma_{ij}\log(\frac{p_j}{b_j}) + \beta_i \log(\frac{M}{P}) \qquad 3.5$$

where

$$P = \alpha_0 + \sum_i \alpha_i \log(\frac{p_i}{b_i}) + \frac{1}{2}\sum_i\sum_j \gamma_{ij}\log(\frac{p_i}{b_i})\log(\frac{p_j}{b_j})$$

and b_i, the scaling parameter, is a function of the exogenous factors (marketing mix variables).

Although there are a host of marketing mix variables that can alter the consumers' utility function, advertising is believed to have the most impact on their purchase behavior. Marketers can have an impact on the choice of a product by conveying the positive features of the product in its advertisement. The decision to purchase a particular product from a group of competing products can be influenced by emphasizing the desirable attributes of a product.

Because the focus of this dissertation is on the advertising variable, the scaling parameter b_i might be limited to a function of a_i, the advertising for product i, or a_i plus advertising for products closely related to product i, depending on the extent that advertising between products is either complementary or competitive.

The function b_i, in equation 3.5, could be defined in general as

$$b_{it} = d_{i0} + \sum_{k=0}^{K} l_{ik} a_{i,t-k}$$

The subscript t stands for time and allows for the introduction of past advertising effects, and the d's and l's are parameters. For the sake of simplicity, the function b_i is restricted to include only the current period own advertising, that is, $b_i = a_i$. Such a formulation of b_i not only keeps the number of parameters to be estimated low but also reduces the complexity involved with increased nonlinearity induced due to lagged parameters. Moreover, since the advertising data is available only at the quarterly level, it can be argued that the effect of previous periods' advertising is not carried over to the present period.

For empirical purposes, an error term is added to the above specification of SAIDS. Thus the system of demand equations is expressed as

$$w_i = \alpha_i + \sum_j \gamma_{ij} \log\left(\frac{p_j}{a_j}\right) + \beta_i \log\left(\frac{M}{P}\right) + \epsilon_i \qquad 3.6$$

The error terms for any given commodity are assumed to be identically, independently, and normally distributed. That is, they are assumed to be uncorrelated over time and have the same variances. The error terms, however, are assumed to be contemporaneously correlated across equations since the error terms for different demand equations in a system at a given point in time are likely to reflect some common factors (Chang and Green 1992).

Hypotheses

In general, to test for demand being homogeneous of degree zero we can impose the restriction $\sum_j \gamma_{ij} = 0$ on the unrestricted model and perform a likelihood ratio test.

Thus for the two models, (i) the AIDS model specified by Deaton and Muellbauer (equation 2.2.2.11), and (ii) the AIDS model incorporating advertising, SAIDS (equation 3.6), developed here, we can impose the same restriction (as shown in the previous paragraph) and perform the likelihood ratio test to determine whether incorporating advertising has helped explain the nonhomogeneity of demand. Specifically, for both AIDS and SAIDS, $H_0: \sum_j \gamma_{ij} = 0$

The next hypothesis is an analysis of the existence of various mental accounts that consumers might have developed. In order to determine whether consumers have developed mental accounts for certain products, we will make use of the quasi-separability concepts explained in Chapter 2. Specifically, equation 2.1.2.6 suggests that the share of a product i (W_{Ci}) can be derived by multiplying the share of the group to which product i belongs (W_r) with the share of product i within its group (W_{ri}). This is expressed as

$$W_{Ci} = W_r W_{ri} \tag{3.7}$$

Differentiating 3.7 with respect to the price of j in group S (P_{sj}) and holding u constant, the form of the between-Slutsky term can be derived as follows:

$$\gamma_{r_i s_j} = \frac{\partial W_{C_i}}{\partial P_{s_j}} = \frac{\partial^2 \ln C}{\partial \ln c_r . \partial \ln c_s} \cdot \frac{\partial \ln c_r}{\partial \ln p_{r_i}} \cdot \frac{\partial \ln c_s}{\partial \ln p_{s_j}} \tag{3.8}$$

Taking each variable on the right hand side of 3.8 in turn, we get

$$\text{(i)} \quad \frac{\partial \ln C}{\partial \ln c_r} = W_r, \qquad \text{(ii)} \quad \frac{\partial \ln W_r}{\partial \ln c_s} = \gamma_{rs},$$
$$\text{(iii)} \quad \frac{\partial \ln c_r}{\partial \ln p_{r_i}} = W_{r_i}, \qquad \text{(iv)} \quad \frac{\partial \ln c_s}{\partial \ln P_{s_j}} = W_{s_j}, \tag{3.9}$$

where γ_{rs} is the estimated cross price parameter between groups r and s, estimated from an aggregate AIDS as well as SAIDS model that has shares W_r and W_s as dependent variables. This result (ii) is derived by specifying an equation for share r and taking the derivative with respect to the group price index holding the level of utility (or M/P) constant. Hence the restriction that is implied by quasi-separability of the cost function may be written in terms of known shares and estimated parameters as

$$\gamma_{r_i s_j} = W_{r_i} W_{r_j} \gamma_{rs} \tag{3.10}$$

In other words, two groups, r and s, may be considered separable if the compensated cross price effects between the share of product i in group r and the price of product j in group s (s ≠ r) satisfy restriction 3.10. W_{ri}, W_{sj}, and γ_{rs}, may be respectively considered to be the expenditure share of each product in group r, the expenditure shares for each product within the group s, and the cross price parameter between the groups r and s in a more aggregate system of demand equations.

The procedure for implementing this restriction is straightforward. For example, an estimate of γ_{rs} can be obtained by using a two-product demand system to explain the shares of group r and group s. A second model is then estimated in which individual products' shares in group r and group s are dependent variables. The shares of the individual products in group r (W_{ri}) and group s (W_{sj}) are multiplied by γ_{rs} to obtain a set of parametric restrictions that are then placed on the cross price terms between each product's price in group r and in group s. A likelihood ratio test is then performed to determine if the restrictions are accepted by the data.

Testing

Given that the errors are correlated across equations, Zellner's (1962) Seemingly Unrelated Regression (SUR) estimation procedure is used to test the hypotheses. The SYSLIN procedure of SAS/ETS® (1988) is used to perform the estimation of the system of SURs.

Statistical Issues relating to Estimation and Hypotheses Testing

The AIDS as well as the SAIDS for a particular product i can be represented by

$$y_i = x_i\beta_i + \epsilon_i \tag{3.11}$$

where y_i is a n x 1 vector of observations on the dependent variable i

x_i is a n x k_i matrix of observations on the explanatory variables for the product i

β_i is a k_i x 1 vector of parameters associated with product i

ϵ_i ia a n x 1 vector of residuals for product i.

The t^{th} observation of equation (3.7) is

$$y_{it} = x_{it}^T\beta_i + \epsilon_{it}$$

Estimation of a System of Equations

A system of equations for the (P + 1) products can be represented as:

$$\begin{bmatrix} y_1 \\ y_2 \\ \cdot \\ \cdot \\ \cdot \\ y_{P+1} \end{bmatrix} = \begin{bmatrix} x_1 & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & x_2 & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & x_{P+1} \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta_2 \\ \cdot \\ \cdot \\ \cdot \\ \beta_{P+1} \end{bmatrix} + \begin{bmatrix} \epsilon_1 \\ \epsilon_2 \\ \cdot \\ \cdot \\ \cdot \\ \epsilon_{P+1} \end{bmatrix}$$

i.e.,

$$Y = \mathbf{X}\boldsymbol{\beta} + \boldsymbol{\epsilon}$$

where Y is a (T*(P + 1)) x 1 vector of observations on the dependent variables

X is a (T*(P + 1)) x (P + 1) block-diagonal matrix of observations on the predictor variables

$\boldsymbol{\beta}$ is a (T*(P + 1)) x 1 vector of parameters

$\boldsymbol{\epsilon}$ is a (T*(P + 1)) x 1 vector of disturbance terms.

The adding-up property implies that the error terms are linearly dependent. Thus, the variance-covariance matrix of the disturbance terms is singular. In order to obtain a non-singular matrix the linear dependency among the error terms must be removed. The variance-covariance matrix of the error terms is made non-singular by deleting one equation from the above system of equations. The resulting estimation of the coefficients of the system is invariant to which equation is deleted.

Ordinary Least Squares (OLS) is typically utilized for a single sales equation, whereas Zellner's (1962) method of Seemingly Unrelated Regressions (SUR) is often the most appropriate estimation procedure for a system of "related" sales equations. The equation are related insofar as the sales of one item is likely to be obtained at the expense of another, the error in an equation describing one brand's sales may provide some insights about the error in an equation describing another brand's sales.

When the equations are correctly specified, OLS should produce unbiased and consistent estimates. However, SUR should yield more efficient estimates of the sales response function parameters, i.e., the SUR estimator will have a smaller variance. Hence, from a practical standpoint, the primary benefit of more efficient estimators is that the researcher will obtain smaller confidence intervals for sales response function parameters (Bolton 1989).

Moreover, the demand systems approach offers a consistent means to analyze advertising, particularly when advertising programs interact; for example, beef advertising may affect the demand for other meats and vice versa.

F-Test

The F-test is based on the values of the sum of squares of the restricted model and the sum of squares of the unrestricted model, each divided by their respective degrees of freedom. Let the hypothesis be represented in matrix notation as

$$\mathbf{L}\boldsymbol{\beta} = \mathbf{c}.$$

Then the numerator of the F-test is given by

$$\mathbf{N} = (\mathbf{L}\mathbf{b} - \mathbf{c})'(\mathbf{L}(\mathbf{X}'\mathbf{X})\mathbf{L}')^{-1}(\mathbf{L}\mathbf{b} - \mathbf{c})$$

divided by degrees of freedom, where b is the estimate of $\boldsymbol{\beta}$. The denominator, say D, is the model mean square error. The degrees of freedom for the numerator is obtained on the basis of the number of restrictions placed on the system of equations. The degrees of freedom for the denominator is obtained from the number of data points in the system of equations. If $MS_R(.)$ is the values of the mean squares of the restricted model under the null hypothesis (H_0) and MSE is the value of the mean square error of the model, then asymptotically H_0 is rejected at the α-level of significance if

$$F_{(test)} > F_{(\alpha,\ df1,\ df2)}$$

Chapter 4: Estimation and Results

4.1 Overview

This chapter describes the analysis procedures and results of this study. The next section describes the preparation of the data for analysis. This section is divided into two subsections. The first subsection describes the data for the product group comprising expenditures on alcohol and cigarettes. The second subsection describes the data for the product group comprising expenditures on fruit products.

Next the statistical model is selected for each of the product groups under consideration. In order to test the hypotheses pertaining to homogeneity of demand for multiple products, the issue of separability among these products should be resolved first. When there are two or more groups of products it is necessary that they are separable from each other before homogeneity for demand among those product can be tested. The third section provides a detailed explanation for testing separability using the alcoholic beverages and cigarettes as a broad product grouping. The same argument is used for testing separability among the various fruit product categories.

The fourth section, divided into two subsections, presents the results of statistical tests to determine which product (or product groups) are separable from which other products (or product groups) for the broad product groups.

The first subsection discusses results from analyzing the broad product group alcoholic beverages and cigarettes. The results of the homogeneity tests for the alcoholic beverages and cigarettes are presented based upon the separability analysis. The second subsection discusses results from analyzing the broad product group comprised of fruit products. The results of the homogeneity tests for the fruit products are presented based upon separability analysis. The data used in the analysis of fruit products as well in the analysis of alcohol and cigarettes are provided in the appendix.

4.2 Data Preparation

The level of aggregation to test the hypotheses is at the product and the product category level. As discussed in chapter 3, the model is presented in terms of budget shares of various products as the dependent variable. The independent variables are prices and advertising of the products under consideration, and expenditures on those products. The dependent variable, budget shares (w_i), for each product is obtained from the yearly survey called Continuing Consumer Expenditure Survey (CCES) conducted by the Bureau of Labor Statistics. The consumers' responses to this survey are in the public domain and are available on data tapes compiled on a yearly basis by the Economic Research wing of the Bureau of Labor Statistics. The CCES is available from the year 1982 through 1990. This survey includes data on individual consumers' expenditures on various products as well as their incomes and other demographic characteristics. The advertising data on the various products is obtained from a publication titled Class/Brand $ published by Leading National Advertisers. The Class/Brand $ publication offers data for the advertising expenditures on each product in several different media. This data set is compiled quarterly and a year-end issue is published with the annual data on dollar amounts spent on each product. The data on the price variable is obtained from the Consumer Price Index (CPI) statistics compiled by the Bureau of Labor Statistics. For the purposes of testing the hypotheses developed in Chapter 3, two different product groups were selected. They are (i) Alcoholic Beverages and Cigarettes, and (ii) Fruit Products. These two data sets were selected because they both offered a natural grouping of products needed to test the hypotheses discussed in Chapter 3. An additional benifit of studying the Alcoholic Beverages and Cigarettes category is its public policy implications. Lastly, the selection of these two data sets was governed by their easy of availability. A detailed description of data for these two groups is described in the next two subsections.

4.2.1 Alcoholic beverages and cigarettes data

One product group included consumers' expenditures on cigarettes and home consumption of alcoholic beverages. The expenditures on alcoholic beverages were segregated into expenditures on beer, liquor, and wine. Such a break-up of expenditures on individual alcoholic beverages facilitates tests of separability between alcoholic beverages and cigarettes.

4.2.2 Fruit products data

The other product group selected for the analysis was the fruit products group. The expenditure on fruit products is divided into four broad categories: fresh fruits, canned and dried fruits, fresh fruit juice, and frozen fruits and juices. The expenditure on fresh fruits is further divided into four specific fruits (based on data availability): apples, bananas, oranges, and other fruits. For some analyses, the canned fruit and fruit juice categories are combined to form one category named processed fruits. Please refer to Figure 1 for a pictorial representation of the grouping of fruit products. The price indices that are available are consistent with the above categorizations of fruit products. That is, there are separate price indices for apples, bananas, oranges, other fruits, fresh fruits, canned fruits, fruit juice, processed fruit, and frozen fruit. The availability of data in the above format facilitates tests of separability among various different combinations of fruit products.

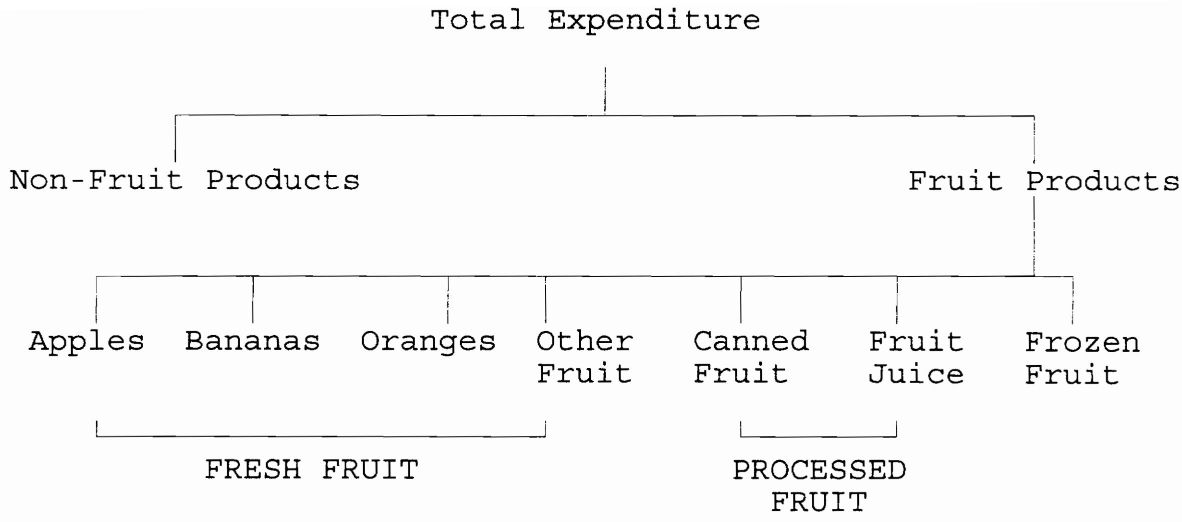

Figure 1:
Pictorial representation of the grouping of fruit products.

4.3 Procedure to Establish Separability

To perform tests of separability between different groups of products, the argument presented in chapter 3 is restated. Two groups, r and s, are considered separable if the cross-price effects between the share of product i in group r and the price of good j in group s ($s \neq r$) satisfy

$$\gamma_{r_i s_j} = W_{r_i} W_{s_j} \gamma_{rs} \tag{4.1}$$

where W_{ri} is the expenditure share of each product within the group r, W_{sj} is the expenditure share of each product within the group s, and γ_{rs} is the cross price parameter between the groups r and s in a more aggregate system of demand equations. For example, for the broad product group consisting of cigarettes and alcoholic beverages, the separability test was performed to determine if cigarettes were separable from alcoholic beverages. For this broad group, W_{ri} is the share of each specific type of alcoholic beverage expenditure, W_{sj} is equal to 1 since aggregated cigarettes group is used, and γ_{rs} is the cross-price parameter between the alcoholic beverages and cigarette expenditures in a more aggregate AIDS model. Thus the restriction in equation 4.1 is reduced to

$$\gamma_{r_i s} = W_{r_i} \gamma_{rs} \tag{4.2}$$

The procedure for performing this test is as follows. An estimate of γ_{rs} was obtained by using a two-group AIDS model to explain the shares of cigarettes and alcoholic beverages.

A second model was then estimated in which individual alcoholic beverages shares and cigarette shares were dependent variables. The average shares of the individual types of alcoholic beverages were multiplied by γ_{rs} to obtain a set of parametric restrictions that were then placed on the cross-price terms between each alcoholic beverage type price and cigarette price. An F-test was then performed to determine if the restrictions were accepted by the data.

An iterative seemingly unrelated regression procedure was used for estimating the coefficients of the system of demand equations. SAS's PROC SYSLIN performs an F test for joint hypotheses to test separability between groups of products. The test is performed by specifying the relevant products to be tested in the STEST statement in the PROC SYSLIN procedure. The null hypothesis is equation 4.1 above. Acceptance of the null hypothesis implies that the products/product groups being tested are separable from each other. Rejection of the null hypothesis implies that the products/product groups under consideration cannot be regarded as separable from each other. The above procedure is also used to test the fruit products.

4.4 Results

In the next two subsections, results of the tests for separability between various products/product groups on the two data sets is presented. For the two data sets, Alcoholic beverages/cigarettes and fruit products, both AIDS and SAIDS models were used to fit the data. The specific models developed to test the homogeneity of demand for products included in both the data sets are provided in the appendix. The results from the alcohol beverages/cigarettes data are presented first followed by the results from the fruit products data.

4.4.1 Alcoholic Beverages and Cigarettes

As a first step in testing homogeneity of demand for the individual alcoholic beverages products, it is assumed that the alcoholic beverages product group is separable from all other products. The expenditures on the alcoholic beverages product group is assumed to be unaffected by changes in the price of all other products in the consumers' budgeted expenditures. This amounts to including only the three types of alcoholic beverages in the demand system. The homogeneity results and the coefficients for this analysis are presented next.

For both AIDS and SAIDS,

$$H_0: \gamma_{beer,beer} + \gamma_{beer,liqr} + \gamma_{beer,wine} = 0$$

$$H_0: \gamma_{liqr,beer} + \gamma_{liqr,liqr} + \gamma_{liqr,wine} = 0$$

$$H_0: \gamma_{wine,beer} + \gamma_{wine,liqr} + \gamma_{wine,wine} = 0$$

		AIDS		SAIDS	
Product/ Product group	d.f.	F value	p value	F value	p value
BEER	1,62	2.348	0.130	0.015	0.902
LIQUOR	1,62	0.009	0.921	2.393	0.127
WINE	1,62	5.919	0.017	3.859	0.054

Result

Under AIDS, only demand for wine was found to be not homogeneous. However, at a strict $\alpha = 0.05$ level, the demand for all three was found to be homogeneous under SAIDS.

Table AP1:
TABLE OF PARAMETER ESTIMATES FOR BEER, LIQUOR, AND WINE

	AIDS		SAIDS	
Product/ Product group	Param. Est.	p value	Param. Est.	p value
BEER				
Intercept	2.0215	0.0638	0.4476	0.0001
Beer	0.7217	0.0455	-0.0815	0.0564
Liquor	-0.3920	0.3167	0.0922	0.0055
Wine	-0.6856	0.1087	-0.0052	0.7695
Expenditure	-0.1575	0.0058	-0.0306	0.4611
LIQUOR				
Intercept	0.3668	0.6214	0.3191	0.0001
Beer	-0.7703	0.0033	0.0846	0.0167
Liquor	0.2643	0.3341	-0.0237	0.3522
Wine	0.4898	0.1015	-0.0054	0.7052
Expenditure	0.0583	0.1269	0.0571	0.0981
WINE				
Intercept	-1.3883	0.0538	0.2332	0.0001
Beer	0.0485	0.8328	-0.0031	0.9156
Liquor	0.1277	0.6181	-0.0685	0.0036
Wine	0.1957	0.4793	0.0106	0.3954
Expenditure	0.0993	0.0079	-0.0264	0.3691

From the above table it can be seen that under AIDS the signs for the own-price coefficients of all three products is contrary to expectations, whereas under SAIDS the sign of the own-price coefficients of BEER and LIQUOR is as expected (negative). Further, the own-price coefficient is significant for BEER under both AIDS and SAIDS, whereas those of LIQUOR and WINE are nonsignificant.

The analysis so far was performed under the condition of separability of alcoholic beverages from all other products. However, it is interesting to check for homogeneity of demand for alcoholic beverages by relaxing the assumption of its separability from all other products. To accomplish this goal, cigarettes, a different but closely related product was included in the system of demand equations developed to test homogeneity of demand. The inclusion of cigarettes, however, warrants testing the assumption of separability (or lack thereof) between alcoholic beverages and cigarettes before proceeding with the homogeneity tests.

For the alcohol beverages and cigarette data, tests were performed to determine if alcoholic beverages were separable from cigarettes at the group level. That is, a total of three restrictions was imposed on the system of equations. The system included three equations. The dependent variable for each of the three equations is expenditure share for beer, expenditure for liquor, and expenditure for wine. The explanatory variables for each equation are price of beer, price of liquor, price of wine, price of cigarettes, and real group expenditure on alcoholic beverages and cigarettes. In practice, restrictions were placed on the coefficient for cigarettes price in all three equations. Thus, separability between cigarettes and alcoholic beverages was tested at the group level. In addition to testing the separability at the group level, separability was tested between cigarettes and each type of alcoholic beverage. The results are as follows.

SEPARABILITY BETWEEN ALCOHOLIC BEVERAGES AS A GROUP
AND
CIGARETTES

H_0: Alcoholic beverages as a group is separable from cigarettes.

		AIDS		SAIDS	
Product/ Product group	d.f.	F value	p value	F value	p value
ALCOHOLIC BEVERAGES VS. CIGARETTES	3,122	3.114	0.028	4.670	0.004

Result

Alcoholic beverages as a group is not separable from cigarettes under both AIDS and SAIDS.[8]

[8]All three types of alcoholic beverages were found to be not separable from cigarettes under AIDS. However, under SAIDS, only liquor was found to be not separable from cigarettes. Beer and wine were found to be separable from cigarettes when individual separability tests were run under SAIDS.

The above results indicate the number of products (equations) to be included in the system for performing homogeneity tests. Since separability between cigarettes and alcoholic beverages is not established at the group level, two sets of homogeneity tests are performed: (1) homogeneity is tested between alcoholic beverages as a group and cigarettes, and (2) homogeneity is tested for individual products that are included in the overall group of alcoholic beverages and cigarettes.

The system of equations for testing homogeneity between cigarettes and alcoholic beverages includes two equations. The dependent variables of these two equations are the expenditure shares of cigarettes and alcoholic beverages as a group respectively. The explanatory variables are price of cigarettes, price of alcoholic beverages a group, and total expenditure on cigarettes and alcoholic beverages.

The system of equations for testing homogeneity between all products that comprise cigarettes and alcoholic beverages includes four equations. The dependent variables of these four equations are the expenditure shares of beer, liquor, wine, and cigarettes respectively. The explanatory variables are price of beer, price of liquor, price of wine, price of cigarettes, and total expenditure on cigarettes and alcoholic beverages.

The results of (1) the test of homogeneity of demand among cigarette and alcoholic beverages as group, and (2) the test of homogeneity of demand among individual products that comprise the broad category, are presented next. Each set of homogeneity tests is followed by a table of estimates of parameters of the respective preceding models.

For both AIDS and SAIDS,

$H_0: \gamma_{alc,alc} + \gamma_{alc,cig} = 0$

		AIDS		SAIDS	
Product/ Product group	d.f.	F value	p value	F value	p value
ALCOHOLIC BEVERAGES and CIGARETTES	1,32	7.292	0.011	1.235	0.275

Result

Homogeneity was rejected at group level under AIDS but was accepted at group level under SAIDS.

Table AP2:
TABLE OF PARAMETER ESTIMATES FOR ALCOHOLIC BEVERAGES AS A GROUP AND CIGARETTES

	AIDS		SAIDS	
Product/ Product group	Param. Est.	p value	Param. Est.	p value
ALCOHOLIC BEVERAGES				
Intercept	-3.4523	0.0264	0.3896	0.1079
Alc. bev.	1.2095	0.0115	-0.0266	0.2384
Cigarettes	-0.3375	0.0183	-0.0173	0.5534
Expenditure	0.3086	0.0001	0.1991	0.0010
CIGARETTES				
Intercept	4.4523	0.0052	0.6103	0.0143
Alc. bev.	-1.2095	0.0115	0.0266	0.2384
Cigarettes	0.3375	0.0183	0.0173	0.5534
Expenditure	-0.3086	0.0001	-0.1991	0.0010

From the above table it is seen that under AIDS the sign for the own-price coefficients for the ALCOHOLIC BEVERAGES group is contrary to expectations, whereas under SAIDS the sign of the own-price coefficients of ALCOHOLIC BEVERAGES is as expected (negative). Furthermore, under SAIDS, the EXPENDITURE variable has a significant impact on the consumption of ALCOHOLIC BEVERAGES and CIGARETTES. Specifically, as the expenditure on ALCOHOLIC BEVERAGES and CIGARETTES as a group increases, a larger proportion is spent on consuming ALCOHOLIC BEVERAGES.

For both AIDS and SAIDS,

$$H_0: \gamma_{beer,beer} + \gamma_{beer,liqr} + \gamma_{beer,wine} + \gamma_{beer,cigs} = 0$$

$$H_0: \gamma_{liqr,beer} + \gamma_{liqr,liqr} + \gamma_{liqr,wine} + \gamma_{liqr,cigs} = 0$$

$$H_0: \gamma_{wine,beer} + \gamma_{wine,liqr} + \gamma_{wine,wine} + \gamma_{wine,cigs} = 0$$

$$H_0: \gamma_{cigs,beer} + \gamma_{cigs,liqr} + \gamma_{cigs,wine} + \gamma_{cigs,cigs} = 0$$

		AIDS		SAIDS	
Product/ Product group	d.f.	F value	p value	F value	p value
BEER	1,90	11.952	0.001	0.229	0.632
LIQUOR	1,90	1.950	0.166	2.659	0.106
WINE	1,90	0.239	0.626	0.010	0.919
CIGARETTES	1,90	2.021	0.158	1.882	0.173

Result

When the demand system including beer, liquor, wine, and cigarettes was estimated, homogeneity for beer was rejected under AIDS. However, homogeneity of demand for beer was accepted under SAIDS. The demand for the other three products was homogeneous under both AIDS and SAIDS.

Table AP3:
TABLE OF PARAMETER ESTIMATES FOR BEER, LIQUOR, WINE, AND CIGARETTES

	AIDS		SAIDS	
Product/ Product group	Param. Est.	p value	Param. Est.	p value
BEER				
Intercept	-5.2753	0.0026	0.2431	0.2105
Beer	1.7613	0.0003	-0.0470	0.0491
Liquor	0.0294	0.8616	0.0292	0.0482
Wine	0.0557	0.7672	0.0024	0.7904
Cigarettes	-0.6421	0.0004	-0.0026	0.9127
Expenditure	0.0601	0.1223	0.1098	0.0189
LIQUOR				
Intercept	2.0026	0.1424	-0.2237	0.1580
Beer	-1.0959	0.0046	0.0165	0.3816
Liquor	0.2153	0.1305	-0.0254	0.0352
Wine	0.2286	0.1500	0.0054	0.4708
Cigarettes	0.2487	0.0693	-0.0462	0.0220
Expenditure	0.1091	0.0015	0.0032	0.9289
WINE				
Intercept	0.8389	0.5557	0.3622	0.0148
Beer	-0.5919	0.1284	0.0098	0.5635
Liquor	0.1776	0.2355	-0.0362	0.0016
Wine	0.0524	0.7511	0.0013	0.8479
Cigarettes	0.2123	0.1395	0.0278	0.1183
Expenditure	0.1444	0.0001	0.0722	0.0345
CIGARETTE				
Intercept	3.4337	0.1141	0.6183	0.0151
Beer	-0.0734	0.8978	0.0205	0.4820
Liquor	-0.4223	0.0643	0.0325	0.0791
Wine	-0.3368	0.1804	-0.0092	0.4322
Cigarettes	0.1810	0.3947	0.0209	0.4863
Expenditure	-0.3137	0.0001	-0.1854	0.0024

The above table suggests that inclusion of advertising variable in the demand system restores the signs of the coefficients in the expected direction two out of the four products included in the demand system. Specifically, under

SAIDS, BEER and LIQUOR consumption decreases as the price of these products increases, even though the price variable is adjusted to incorporate the effects of advertising. In other words, advertising these two products does not does eliminate the negative impact of price increases. Other substantive implications that may be derived from table AP3 are:

(a) As expenditure on the four products included in the demand system increases, less money is spent on cigarettes. The increase in the expenditure on the alcoholic beverages and cigarettes is shared by increased consumption of beer and wine.

(b) As the price of liquor increases, so does the consumption of cigarettes. Additionally, the increase in the price of liquor has a negative impact on the sales of liquor, but helps the sales of beer.

Table AH1:
SUMMARY OF HOMOGENEITY RESULTS (AT GROUP LEVEL)[9]

Product/ Product group	AIDS	SAIDS
ALCOHOLIC BEVERAGES and CIGARETTES	Rejected	Accepted

Table AH2:
SUMMARY OF HOMOGENEITY RESULTS (OF INDIVIDUAL PRODUCTS)

(i) <u>Three alcoholic beverages</u>

Products	AIDS	SAIDS
BEER	Accepted	Accepted
LIQUOR	Accepted	Accepted
WINE	Rejected	Accepted

(ii) <u>Three alcoholic beverages and cigarettes</u>

Products	AIDS	SAIDS
BEER	Rejected	Accepted
LIQUOR	Accepted	Accepted
WINE	Accepted	Accepted
CIGARETTES	Accepted	Accepted

[9] Homogeneity was tested only for groups that were found to be separable.

4.4.2 Fruit Products

The broad grouping of fruit products consists of several individual fruit products. They are apples, bananas, oranges, other fruit, canned fruit, fruit juice, and frozen fruit. Out of these seven individual fruit products, some of them can be combined to form natural categories. These natural categories are used to analyze separability between various fruit products. The natural categories, as shown in Figure 1, are formed as follows:

1) Fresh fruit includes apples, bananas, oranges, other fruit.
2) Processed fruit includes canned fruit and fruit juice.
3) Frozen fruit.

These natural categories are used to perform various tests to establish separability between them. The specific product groupings tested for separability are as follows.

1) Fresh fruits and canned fruit.
2) Fresh fruits and fruit juice.
3) Fresh fruits and frozen fruit.
4) Processed fruits and frozen fruit.
5) Fresh fruits (as one group) and processed fruits.
6) Fresh fruits and processed fruits.

The following pages furnish the results of the separability tests followed by the homogeneity of demand tests for each of the above six groupings. The products to be included in the system of demand equations are determined from the results of the separability results. (The overall results of the separability tests are pictorially represented in Chapter 5. AIDS results are summarized in Figure 2, and SAIDS results are Figure 3.)

SEPARABILITY BETWEEN FRESH FRUITS AND CANNED FRUIT

H_0: Fresh fruits as a group are separable from canned fruit.

		AIDS		SAIDS	
Product/ Product group	d.f.	F value	p value	F value	p value
FRESH FRUIT vs. CANNED FRUIT	4,148	1.306	0.270	1.719	0.148

Result

Fresh fruits as a group is separable from canned fruit under both AIDS and SAIDS[10].

[10]Each individual fresh fruit product is also separable from canned fruit.

HOMOGENEITY BETWEEN FRESH FRUITS ONLY
(Since fresh fruit is separable from canned fruit)

Thus, for both AIDS and SAIDS,

$H_0: \gamma_{appl,appl} + \gamma_{appl,bana} + \gamma_{appl,orng} + \gamma_{appl,othr} = 0$

$H_0: \gamma_{bana,appl} + \gamma_{bana,bana} + \gamma_{bana,orng} + \gamma_{bana,othr} = 0$

$H_0: \gamma_{orng,appl} + \gamma_{orng,bana} + \gamma_{orng,orng} + \gamma_{orng,othr} = 0$

$H_0: \gamma_{othr,appl} + \gamma_{othr,bana} + \gamma_{othr,orng} + \gamma_{othr,othr} = 0$

		AIDS		SAIDS	
Product/ Product group	d.f.	F value	p value	F value	p value
APPLES	1,90	41.142	0.001	0.291	0.590
BANANAS	1,90	7.706	0.006	0.001	0.988
ORANGES	1,90	49.507	0.001	0.574	0.450
OTHER FRUIT	1,90	40.249	0.001	0.296	0.590
CANNED FRUIT		Not Applicable		Not Applicable	

Result

The demand for apples, bananas, oranges, and other fruit is not homogeneous under AIDS. By incorporating the advertising variable in the demand system, the homogeneity of demand is restored for all four fresh fruit products.

Table FP1:
TABLE OF PARAMETER ESTIMATES FOR INDIVIDUAL FRESH FRUITS

	AIDS		SAIDS	
Product/ Product group	Param. Est.	p value	Param. Est.	p value
APPLES				
Intercept	1.705	0.0001	0.198	0.0001
Apple	-0.201	0.0006	-0.008	0.0600
Banana	-0.266	0.0007	-0.000	0.9982
Orange	-0.103	0.0214	0.002	0.6738
Other	0.229	0.0111	-0.003	0.7689
Expenditure	-0.037	0.1589	0.011	0.5924
BANANA				
Intercept	0.616	0.0004	0.173	0.0001
Apple	-0.134	0.0007	-0.003	0.1334
Banana	-0.038	0.4290	0.000	0.7690
Orange	-0.044	0.1360	0.001	0.6201
Other	0.116	0.0522	0.001	0.8101
Expenditure	-0.015	0.4066	-0.005	0.6390
ORANGE				
Intercept	1.666	0.0001	0.129	0.0120
Apple	-0.232	0.0001	-0.009	0.0454
Banana	-0.172	0.0137	0.001	0.6364
Orange	-0.154	0.0006	-0.002	0.6737
Other	0.207	0.0141	-0.004	0.7474
Expenditure	-0.049	0.0544	0.019	0.4136
OTHER FRUIT				
Intercept	-2.987	0.0001	0.498	0.0001
Apple	0.567	0.0001	0.021	0.0496
Banana	0.476	0.0070	-0.002	0.7871
Orange	0.301	0.0052	-0.001	0.9192
Other	-0.553	0.0093	0.006	0.8379
Expenditure	0.101	0.1078	-0.025	0.6407

SEPARABILITY BETWEEN FRESH FRUITS AND FRUIT JUICE

H_0: Fresh fruits as a group are separable from fruit juice.

		AIDS		SAIDS	
Product/ Product group	d.f.	F value	p value	F value	p value
FRESH FRUIT vs. FRUIT JUICE	4,148	2.989	0.020	2.918	0.023

Result

Fresh fruits as a group is not separable from fruit juice under both AIDS and SAIDS[11].

[11] Each individual fresh fruit product is also not separable from fruit juice.

HOMOGENEITY BETWEEN FRESH FRUITS AND FRUIT JUICE
(AT GROUP LEVEL)

For both AIDS and SAIDS,

H_0: $\gamma_{\text{fresh fruit,fresh fruit}} + \gamma_{\text{fresh fruit,fruit juice}} = 0$

		AIDS		SAIDS	
Product/ Product group	d.f.	F value	p value	F value	p value
FRESH FRUIT and FRUIT JUICE	1,32	1.836	0.185	1.252	0.618

Result

The demand for Fresh Fruits (as a group) and Fruit juice is homogeneous under AIDS as well as under SAIDS.

Table FP2:
TABLE OF PARAMETER ESTIMATES FOR FRESH FRUITS AS A GROUP AND FRUIT JUICE

	AIDS		SAIDS	
Product/ Product group	Param. Est.	p value	Param. Est.	p value
FRESH FRUIT				
Intercept	1.1653	0.0001	0.8418	0.0001
Fresh Fruit	0.2522	0.0009	-0.0063	0.5182
Fruit Juice	-0.3204	0.0021	0.0113	0.0017
Expenditure	0.1175	0.0001	0.0923	0.0001
FRUIT JUICE				
Intercept	-0.1653	0.4649	0.1582	0.0001
Fresh Fruit	-0.2522	0.0009	0.0063	0.5182
Fruit Juice	0.3204	0.0021	-0.0113	0.0017
Expenditure	-0.1175	0.0001	-0.0923	0.0001

The above table indicates that under AIDS the signs of the own-price and cross-price coefficients are contrary to expectations. That is, the results from fitting the AIDS model suggest that as the price of Fresh Fruit and Fruit Juice goes up the expenditure on them goes up respectively. However, under SAIDS, we get more meaningful results. The signs of the own- and cross-price coefficients are as expected (though the Fresh Fruit coefficient is nonsignificant.)

HOMOGENEITY BETWEEN FRESH FRUITS AND FRUIT JUICE
(AT INDIVIDUAL LEVEL)

For both AIDS and SAIDS,

$$H_0: \gamma_{appl,appl} + \gamma_{appl,bana} + \gamma_{appl,orng} + \gamma_{appl,othr} + \gamma_{appl,fruit\ juice} = 0$$

$$H_0: \gamma_{bana,appl} + \gamma_{bana,bana} + \gamma_{bana,orng} + \gamma_{bana,othr} + \gamma_{bana,fruit\ juice} = 0$$

$$H_0: \gamma_{orng,appl} + \gamma_{orng,bana} + \gamma_{orng,orng} + \gamma_{orng,othr} + \gamma_{orng,fruit\ juice} = 0$$

$$H_0: \gamma_{othr,appl} + \gamma_{othr,bana} + \gamma_{orng,othr} + \gamma_{othr,othr} + \gamma_{othr,fruit\ juice} = 0$$

$$H_0: \gamma_{fruit\ juice,appl} + \gamma_{fruit\ juice,bana} + \gamma_{fruit\ juice,orng} + \gamma_{fruit\ juice,othr} + \gamma_{fruit\ juice,fruit\ juice} = 0$$

		AIDS		SAIDS	
Product/ Product group	d.f.	F value	p value	F value	p value
APPLES	1,116	8.781	0.003	3.404	0.067
BANANAS	1,116	0.006	0.935	1.383	0.242
ORANGES	1,116	9.013	0.003	4.806	0.030
OTHER FRUIT	1,116	4.447	0.037	5.679	0.018
FRUIT JUICE	1,116	0.016	0.898	4.492	0.036

Result

Incorporating the advertising variable in the system of demand equations for the four Fresh Fruits and Fruit Juice did not have much impact. The homogeneity of demand was restored only for APPLES at strict $\alpha = 0.05$ level. Additionally, adjusting the price of Fruit Juice resulted in the rejection of the homogeneity of demand for Fruit Juice.

Table FP3:
TABLE OF PARAMETER ESTIMATES FOR INDIVIDUAL FRESH FRUITS AND FRUIT JUICE

	AIDS		SAIDS	
Product/ Product group	Param. Est.	p value	Param. Est.	p value
APPLES				
Intercept	0.753	0.0014	0.111	0.0007
Apple	-0.112	0.0017	-0.003	0.2017
Banana	-0.183	0.0002	-0.001	0.5996
Orange	-0.088	0.0030	-0.002	0.4180
Other	0.056	0.3781	0.001	0.9178
Juice	0.188	0.0356	-0.013	0.0041
Expenditure	-0.022	0.2513	0.022	0.1330
BANANA				
Intercept	0.115	0.4073	0.119	0.0001
Apple	-0.066	0.0034	-0.001	0.3647
Banana	-0.024	0.3775	-0.001	0.8055
Orange	-0.042	0.0221	-0.001	0.5031
Other	0.003	0.9278	0.003	0.4128
Juice	0.132	0.0220	-0.006	0.0046
Expenditure	-0.000	0.9451	0.009	0.2048
ORANGE				
Intercept	0.637	0.0027	0.046	0.1550
Apple	-0.141	0.0001	-0.004	0.1633
Banana	-0.131	0.0021	0.001	0.9792
Orange	-0.132	0.0001	-0.006	0.0714
Other	0.033	0.5677	0.001	0.9345
Juice	0.243	0.0038	-0.015	0.0024
Expenditure	-0.037	0.0381	0.022	0.1668
OTHER FRUIT				
Intercept	-0.713	0.2355	0.603	0.0001
Apple	0.427	0.0001	0.006	0.3427
Banana	0.443	0.0008	0.001	0.7743
Orange	0.310	0.0003	0.015	0.1102
Other	-0.118	0.5000	-0.002	0.9262
Juice	-0.789	0.0022	0.050	0.0003
Expenditure	0.156	0.0055	0.031	0.4452

Table FP3 (continued):
TABLE OF PARAMETER ESTIMATES FOR INDIVIDUAL FRESH FRUITS AND FRUIT JUICE

	AIDS		SAIDS	
Product/ Product group	Param. Est.	p value	Param. Est.	p value
FRUIT JUICE				
Intercept	0.206	0.4456	0.118	0.0001
Apple	-0.107	0.0129	0.001	0.5208
Banana	-0.104	0.0610	-0.001	0.8362
Orange	-0.046	0.1863	-0.005	0.1166
Other	0.025	0.7514	-0.002	0.6956
Juice	0.225	0.0431	-0.014	0.0010
Expenditure	-0.095	0.0003	-0.086	0.0001

SEPARABILITY BETWEEN FRESH FRUITS & FROZEN FRUIT

H_0: Fresh fruits as a group are separable from frozen fruit.

		AIDS		SAIDS	
Product/ Product group	d.f.	F value	p value	F value	p value
FRESH FRUIT vs. FROZEN FRUIT	4,148	4.060	0.003	1.316	0.266

<u>Result</u>

While fresh fruits as a group is not separable from frozen fruit under AIDS,[12] they are separable under SAIDS[13].

[12]Except for apples, individual fresh fruits are not separable from frozen fruit under AIDS.

[13]Each individual fresh fruit product is also separable form frozen fruit under SAIDS.

HOMOGENEITY BETWEEN FRESH FRUITS AND FROZEN FRUIT
(AT GROUP LEVEL)

For both AIDS and SAIDS,

$H_0: \gamma_{\text{fresh fruit,fresh fruit}} + \gamma_{\text{fresh fruit,frozen fruit}} = 0$

		AIDS		SAIDS	
Product/ Product group	d.f.	F value	p value	F value	p value
FRESH FRUIT and FROZEN FRUIT	1,32	0.003	0.952	Not Applicable[14]	

Result

The demand for Fresh Fruits and Frozen Fruits is not homogeneous under AIDS.

[14]Homogeneity of demand among the fresh fruit group and frozen fruit is not tested because they are separable under SAIDS.

Table FP4:
TABLE OF PARAMETER ESTIMATES FOR FRESH FRUITS AS A GROUP AND FROZEN FRUIT

	AIDS		SAIDS	
Product/ Product group	Param. Est.	p value	Param. Est.	p value
FRESH FRUIT				
Intercept	0.9011	0.0001	Not Applicable[15]	
Fresh fruit	0.2615	0.0001		
Frozen fruit	-0.2593	0.0002		
Expenditure	0.0673	0.0003		
FROZEN FRUIT				
Intercept	0.0989	0.5305		
Fresh fruit	-0.2615	0.0001		
Frozen fruit	0.2593	0.0002		
Expenditure	-0.0673	0.0003		

[15]Coefficients for fresh fruit group and frozen fruit are not estimated because fresh fruit group and frozen fruit are separable under SAIDS.

HOMOGENEITY BETWEEN FRESH FRUITS AND FROZEN FRUIT
(AT INDIVIDUAL LEVEL)

For AIDS,

$H_0: \gamma_{appl,appl} + \gamma_{appl,bana} + \gamma_{appl,orng} + \gamma_{appl,othr} + \gamma_{appl,frozen\ fruit} = 0$

$H_0: \gamma_{bana,appl} + \gamma_{bana,bana} + \gamma_{bana,orng} + \gamma_{bana,othr} + \gamma_{bana,frozen\ fruit} = 0$

$H_0: \gamma_{orng,appl} + \gamma_{orng,bana} + \gamma_{orng,orng} + \gamma_{orng,othr} + \gamma_{orng,frozen\ fruit} = 0$

$H_0: \gamma_{othr,appl} + \gamma_{othr,bana} + \gamma_{othr,orng} + \gamma_{othr,othr} + \gamma_{othr,frozen\ fruit} = 0$

$H_0: \gamma_{frozen\ juice,appl} + \gamma_{frozen\ fruit,bana} + \gamma_{frozen\ fruit,orng} +$
$\gamma_{frozen\ fruit,othr} + \gamma_{frozen\ fruit,frozen\ fruit} = 0$

		AIDS		SAIDS	
Product/ Product group	d.f.	F value	p value	F value	p value
APPLES	1,116	21.855	0.001	Not Applicable[16]	
BANANAS	1,116	0.908	0.342		
ORANGES	1,116	27.709	0.001		
OTHER FRUIT	1,116	17.732	0.037		
FROZEN FRUIT	1,116	0.425	0.515		

[16]Homogeneity of demand is not tested between fresh fruits and frozen fruit because fresh fruits and frozen fruit were found to be separable under SAIDS

Table FP5:
TABLE OF PARAMETER ESTIMATES FOR INDIVIDUAL FRESH FRUITS AND FROZEN FRUIT

	AIDS		SAIDS	
Product/ Product group	Param. Est.	p value	Param. Est.	p value
APPLES				
Intercept	1.1001	0.0001	Not Applicable[17]	
Apple	-0.1405	0.0013		
Banana	-0.2126	0.0003		
Orange	-0.0963	0.0063		
Other	0.0924	0.2368		
Frozen	0.1395	0.0718		
Expenditure	-0.0452	0.0553		
BANANA				
Intercept	0.2501	0.0763		
Apple	-0.0866	0.0021		
Banana	-0.0242	0.4760		
Orange	-0.0431	0.0508		
Other	0.0122	0.8059		
Frozen	0.1129	0.0266		
Expenditure	-0.0226	0.1324		
ORANGE				
Intercept	0.9556	0.0001		
Apple	-0.1655	0.0001		
Banana	-0.1481	0.0017		
Orange	-0.1538	0.0001		
Other	0.0440	0.4927		
Frozen	0.2206	0.0013		
Expenditure	-0.0625	0.0023		
OTHER FRUIT				
Intercept	-1.5459	0.0052		
Apple	0.4553	0.0001		
Banana	0.4750	0.0007		
Orange	0.3752	0.0001		
Other	-0.1279	0.4976		
Frozen	-0.7007	0.0006		
Expenditure	0.1783	0.0030		

[17] Coefficients for individual fresh fruits and frozen fruit are not estimated because individual fresh fruits and frozen fruit are separable under SAIDS.

Table FP5 (continued):
TABLE OF PARAMETER ESTIMATES FOR INDIVIDUAL FRESH FRUITS AND FROZEN FRUIT

	AIDS		SAIDS	
Product/ Product group	Param. Est.	p value	Param. Est.	p value
FROZEN FRUIT			Not Applicable[18]	
Intercept	0.2398	0.2234		
Apple	-0.0627	0.0945		
Banana	-0.0900	0.0680		
Orange	-0.0819	0.0105		
Other	-0.0207	0.7689		
Frozen	0.2276	0.0024		
Expenditure	-0.0478	0.0283		

[18]Coefficients for individual fresh fruits and frozen fruit are not estimated because individual fresh fruits and frozen fruit are separable under SAIDS.

SEPARABILITY BETWEEN PROCESSED FRUITS AND FROZEN FRUIT

H_0: Processed fruits as a group is separable from frozen fruit.

		AIDS		SAIDS	
Product/ Product group	d.f.	F value	p value	F value	p value
PROCESSED vs. FROZEN FRUIT	2,94	4.647	0.012	0.297	0.743

Result

While processed fruits as a group is not separable from frozen fruit under AIDS[19], it is separable from frozen fruit under SAIDS[20].

19Each individual processed fruit is separable from frozen fruit.

20Each individual processed fruit is separable from frozen fruit.

HOMOGENEITY BETWEEN PROCESSED FRUITS AND FROZEN FRUIT
(AT GROUP LEVEL)

For both AIDS and SAIDS,

$H_0: \gamma_{\text{processed fruit,processed fruit}} + \gamma_{\text{processed fruit,frozen fruit}} = 0$

		AIDS		SAIDS	
Product/ Product group	d.f.	F value	p value	F value	p value
PROCESSED and FROZEN FRUIT	1,32	7.995	0.008	Not Applicable[21]	

Result

Demand for Processed Fruit and Frozen Fruit is not homogeneous under AIDS.

[21]Homogeneity of demand is not tested among processed fruit group and frozen fruit because processed fruit and frozen fruit were found to be separable under SAIDS.

Table FP6:
TABLE OF PARAMETER ESTIMATES PROCESSED FRUIT AS A GROUP AND FROZEN FRUIT

	AIDS		SAIDS	
Product/ Product group	Param. Est.	p value	Param. Est.	p value
PROCESSED FRUIT			Not Applicable[22]	
Intercept	-0.2695	0.3869		
Processed fruit	0.7517	0.0055		
Frozen fruit	-0.5300	0.0077		
Expenditure	0.0115	0.7570		
FROZEN FRUIT				
Intercept	1.2695	0.0002		
Processed fruit	-0.7517	0.0055		
Frozen fruit	0.5300	0.0077		
Expenditure	-0.0115	0.7570		

[22]Coefficients for processed fruit group and frozen fruit are not estimated because processed fruit group and frozen fruit are separable under SAIDS.

HOMOGENEITY BETWEEN PROCESSED FRUITS AND FROZEN FRUIT
(AT INDIVIDUAL LEVEL)

For AIDS,

H_0: $\gamma_{\text{canned fruit,canned fruit}} + \gamma_{\text{canned fruit,fruit juice}} + \gamma_{\text{canned fruit,frozen fruit}} = 0$

H_0: $\gamma_{\text{fruit juice,canned fruit}} + \gamma_{\text{fruit juice,fruit juice}} + \gamma_{\text{fruit juice,frozen fruit}} = 0$

H_0: $\gamma_{\text{frozen fruit,canned fruit}} + \gamma_{\text{frozen fruit,fruit juice}} + \gamma_{\text{frozen fruit,frozen fruit}} = 0$

		AIDS		SAIDS	
Product/ Product group	d.f.	F value	p value	F value	p value
CANNED FRUIT	1,62	0.370	0.545	Not Applicable[23]	
FRUIT JUICE	1,62	1.302	0.258		
FROZEN FRUIT	1,62	4.478	0.038		

[23]Homogeneity among the two types of processed fruit and frozen fruit is not tested because processed fruit as a group was found to be separable from frozen fruit under SAIDS.

Table FP7:
TABLE OF PARAMETER ESTIMATES FOR INDIVIDUAL PROCESSED FRUITS AND FROZEN FRUIT

	AIDS		SAIDS	
Product/ Product group	Param. Est.	p value	Param. Est.	p value
CANNED FRUIT			Not Applicable[24]	
Intercept	-0.1799	0.7843		
Canned fruit	0.0189	0.9518		
Fruit juice	0.4138	0.4291		
Frozen fruit	-0.3145	0.3462		
Expenditure	0.0069	0.8759		
FRUIT JUICE				
Intercept	-0.2996	0.6639		
Canned Fruit	0.2082	0.5280		
Fruit Juice	0.2592	0.6353		
Frozen fruit	-0.2881	0.4469		
Expenditure	0.0140	0.7632		
FROZEN FRUIT				
Intercept	1.4796	0.0122		
Canned fruit	-0.2272	0.3987		
Fruit juice	-0.6730	0.1365		
Frozen fruit	0.6297	0.0470		
Expenditure	-0.0209	0.5806		

[24]Coefficients for individual processed fruits and frozen fruit are not estimated because individual processed fruits and frozen fruit are separable under SAIDS.

SEPARABILITY BETWEEN FRESH FRUIT (as a group)
AND
PROCESSED FRUITS

H_0: Processed fruits as a group is separable from fresh fruit.

		AIDS		SAIDS	
Product/ Product group	d.f.	F value	p value	F value	p value
FRESH FRUIT vs. PROCESSED FRUIT	2,94	7.458	0.001	0.977	0.380

<u>Result</u>

While processed fruits as a group is not separable from fresh fruit under AIDS[25], it is separable from fresh fruit under SAIDS[26].

---

[25]Each individual processed fruit is separable from fresh fruit.

[26]Each individual processed fruit is separable from fresh fruit.

HOMOGENEITY BETWEEN FRESH FRUIT AND PROCESSED FRUIT
(AT GROUP LEVEL)

For AIDS,

$H_0: \gamma_{\text{processed fruit,processed fruit}} + \gamma_{\text{processed fruit,fresh fruit}} = 0$

		AIDS		SAIDS	
Product/ Product group	d.f.	F value	p value	F value	p value
FRESH FRUIT and PROCESSED FRUIT	1,32	4.514	0.041	Not[27] Applicable	

Result

The demand for Fresh Fruit (as a group) and Processed Fruit is not homogeneous under AIDS

[27]Homogeneity among the processed fruit group and fresh fruit is not tested because the processed fruit group was found to separable from fresh fruit under SAIDS.

Table FP8:
TABLE OF PARAMETER ESTIMATES FOR PROCESSED FRUITS AS A GROUP AND FRESH FRUIT

	AIDS		SAIDS	
Product/ Product group	Param. Est.	p value	Param. Est.	p value
PROCESSED FRUIT			Not Applicable[28]	
Intercept	-0.5535	0.1233		
Processed fruit	0.5560	0.0006		
Fresh fruit	-0.3905	0.0002		
Expenditure	-0.1535	0.0001		
FRESH FRUIT				
Intercept	1.5535	0.0001		
Processed fruit	-0.5560	0.0006		
Fresh fruit	0.3905	0.0002		
Expenditure	0.1535	0.0001		

[28]Coefficients for processed fruits group and fresh fruit are not estimated because processed fruits group and fresh fruit are separable under SAIDS.

HOMOGENEITY BETWEEN THE GROUP OF FRESH FRUITS AND PROCESSED FRUIT (AT INDIVIDUAL LEVEL)

For both AIDS and SAIDS,

H_0: $\gamma_{\text{fresh fruit,canned fruit}} + \gamma_{\text{fresh fruit,fruit juice}} + \gamma_{\text{fresh fruit,frozen fruit}} = 0$

H_0: $\gamma_{\text{canned fruit,canned fruit}} + \gamma_{\text{canned fruit,fruit juice}} + \gamma_{\text{canned fruit,frozen fruit}} = 0$

H_0: $\gamma_{\text{fruit juice,canned fruit}} + \gamma_{\text{fruit juice,fruit juice}} + \gamma_{\text{fruit juice,frozen fruit}} = 0$

		AIDS		SAIDS	
Product/ Product group	d.f.	F value	p value	F value	p value
FRESH FRUIT	1,62	0.975	0.327	Not[29] Applicable	
CANNED FRUIT	1,62	0.133	0.716		
FRUIT JUICE	1,62	1.443	0.234		

[29]Homogeneity among the two types of processed fruit and fresh fruit is not tested because the processed fruit group was found to be separable from fresh fruit under SAIDS.

Table FP9:
TABLE OF PARAMETER ESTIMATES FOR INDIVIDUAL PROCESSED FRUITS AND FRESH FRUIT

	AIDS		SAIDS	
Product/ Product group	Param. Est.	p value	Param. Est.	p value
FRESH FRUIT			Not Applicable[30]	
Intercept	1.6735	0.0639		
Fresh Fruit	0.3946	0.0003		
Canned fruit	-0.1606	0.6151		
Fruit juice	-0.4250	0.0124		
Expenditure	0.1551	0.0001		
CANNED FRUIT				
Intercept	-0.1617	0.7577		
Fresh fruit	-0.2104	0.0010		
Canned Fruit	0.0179	0.9249		
Fruit Juice	0.2346	0.0198		
Expenditure	-0.0804	0.0003		
FRUIT JUICE				
Intercept	-0.5117	0.3662		
Fresh fruit	-0.1842	0.0060		
Canned fruit	0.1427	0.4865		
Fruit juice	0.1903	0.0729		
Expenditure	-0.0746	0.0015		

[30]Coefficients for individual processed fruits and fresh fruit are not estimated because individual processed fruits and fresh fruit are separable under SAIDS.

SEPARABILITY FRESH FRUITS AND PROCESSED FRUITS

H_0: Processed fruits as a group is separable from fresh fruit as a group.

		AIDS		SAIDS	
Product/ Product group	d.f.	F value	p value	F value	p value
FRESH FRUIT vs. PROCESSED FRUIT	8,144	3.426	0.001	0.923	0.499
APPLES vs. PROCESSED FRUIT	2,144	2.092	0.127	1.806	0.167
BANANAS vs. PROCESSED FRUIT	2,144	3.183	0.044	2.219	0.112
ORANGES vs. PROCESSED FRUIT	2,144	8.887	0.000	2.192	0.115
OTHER FRUITS vs. PROCESSED FRUIT	2,144	4.568	0.011	2.813	0.063

Result

1) While fresh fruits as a group is not separable from processed fruit as a group under AIDS, it is separable from processed fruit as a group under SAIDS.

2) Apples is separable from processed fruit as a group under both AIDS and SAIDS.

3) While bananas and oranges are not separable from processed fruit as a group under AIDS, they are separable from processed fruit as a group under SAIDS.

4) While other fruit is not separable from processed fruit as a group under AIDS, it is separable from processed fruit as a group, at a strict $\alpha = 0.05$.

SEPARABILITY BETWEEN FRESH FRUITS AND PROCESSED FRUITS

		AIDS		SAIDS	
Product/ Product group	d.f.	F value	p value	F value	p value
APPLES vs. CANNED FRUIT	1,144	0.104	0.747	1.019	0.314
BANANAS vs. CANNED FRUIT	1,144	0.438	0.509	0.636	0.426
ORANGES vs. CANNED FRUIT	1,144	8.672	0.003	1.712	0.192
OTHER FRUITS vs. CANNED FRUIT	1,144	2.429	0.121	1.675	0.197

Result

1) Apples, bananas and other fruit are separable from canned fruit under both AIDS and SAIDS.

2) While oranges are not separable from canned fruit under AIDS, they are separable from canned fruit under SAIDS.

SEPARABILITY BETWEEN FRESH FRUITS AND PROCESSED FRUITS

		AIDS		SAIDS	
Product/ Product group	d.f.	F value	p value	F value	p value
APPLES vs. FRUIT JUICE	1,144	3.327	0.070	1.575	0.211
BANANAS vs. FRUIT JUICE	1,144	5.495	0.020	2.616	0.108
ORANGES vs. FRUIT JUICE	1,144	18.118	0.001	1.478	0.226
OTHER FRUITS vs. FRUIT JUICE	1,144	9.128	0.003	2.882	0.091

Result

While apples, bananas, oranges and other fruit are not separable from fruit juice under AIDS, they are separable from fruit juice under SAIDS.

HOMOGENEITY BETWEEN FRESH FRUITS AND PROCESSED FRUITS (AT GROUP LEVEL)

For AIDS,

$H_0: \gamma_{\text{fresh fruit,fresh fruit}} + \gamma_{\text{processed fruit,fresh fruit}} = 0$

		AIDS		SAIDS	
Product/ Product group	d.f.	F value	p value	F value	p value
FRESH FRUIT and PROCESSED FRUIT	1,32	4.514	0.041	Not Applicable[31]	

Result

The demand for Fresh Fruits (as a group) and Processed Fruits (as a group) is not homogeneous under AIDS.

[31] Homogeneity of demand among fresh fruit group and processed fruit group is not tested because the processed fruit group and fresh fruit group were found to be separable under SAIDS.

Table FP10:
TABLE OF PARAMETER ESTIMATES FOR FRESH FRUITS AS A GROUP AND PROCESSED FRUIT AS A GROUP

	AIDS		SAIDS	
Product/ Product group	Param. Est.	p value	Param. Est.	p value
PROCESSED FRUIT			Not Applicable[32]	
Intercept	-0.5535	0.1233		
Processed fruit	0.5560	0.0006		
Fresh fruit	-0.3905	0.0002		
Expenditure	-0.1535	0.0001		
FRESH FRUIT				
Intercept	1.5535	0.0001		
Processed fruit	-0.5560	0.0006		
Fresh fruit	0.3905	0.0002		
Expenditure	0.1535	0.0001		

The above table indicates that under AIDS, although the coefficients of the PROCESSED FRUIT and FRESH FRUIT variables are significant, they do not have the anticipated signs.

[32] Coefficients for fresh fruit as a group and processed fruit as a group are not estimated because they are separable under SAIDS.

HOMOGENEITY BETWEEN FRESH FRUITS AND PROCESSED FRUITS
(AT INDIVIDUAL LEVEL)

For AIDS,

H_0: $\gamma_{appl,appl} + \gamma_{appl,bana} + \gamma_{appl,orng} + \gamma_{appl,othr} + \gamma_{appl,canned\ fruit} + \gamma_{appl,fruit\ juice} = 0$

H_0: $\gamma_{bana,appl} + \gamma_{bana,bana} + \gamma_{bana,orng} + \gamma_{bana,othr} + \gamma_{bana,canned\ fruit} + \gamma_{bana,fruit\ juice} = 0$

H_0: $\gamma_{orng,appl} + \gamma_{orng,bana} + \gamma_{orng,orng} + \gamma_{orng,othr} + \gamma_{orng,canned\ fruit} + \gamma_{orng,fruit\ juice} = 0$

H_0: $\gamma_{othr,appl} + \gamma_{othr,bana} + \gamma_{othr,orng} + \gamma_{othr,othr} + \gamma_{othr,canned\ fruit} + \gamma_{othr,fruit\ juice} = 0$

H_0: $\gamma_{canned\ fruit,appl} + \gamma_{canned\ fruit,bana} + \gamma_{canned\ fruit,orng} + \gamma_{canned\ fruit,othr} + \gamma_{canned\ fruit,canned\ fruit} + \gamma_{canned\ fruit,fruit\ juice} = 0$

H_0: $\gamma_{fruit\ juice,appl} + \gamma_{fruit\ juice,bana} + \gamma_{fruit\ juice,orng} + \gamma_{fruit\ juice,othr} + \gamma_{fruit\ juice,canned\ fruit} + \gamma_{fruit\ juice,fruit\ juice} = 0$

		AIDS		SAIDS	
Product/ Product group	d.f.	F value	p value	F value	p value
APPLES	1,140	1.596	0.208	Not Applicable[33]	
BANANAS	1,140	0.379	0.538		
ORANGES	1.140	10.635	0.001		
OTHER FRUIT	1,140	1.157	0.283		
CANNED FRUIT	1,140	0.001	0.967		
FRUIT JUICE	1,140	0.852	0.363		

<u>Result</u>

Except for oranges, the demand for all the other products, included in the demand system models described on the previous page, is homogeneous.

[33]Homogeneity among the individual type of fresh fruit and individual type of processed fruit is not tested because processed fruit group and fresh fruit group were found to be separable under SAIDS

Table FP11:
TABLE OF PARAMETER ESTIMATES FOR INDIVIDUAL FRESH FRUITS AND INDIVIDUAL PROCESSED FRUITS

	AIDS		SAIDS	
Product/ Product group	Param. Est.	p value	Param. Est.	p value
APPLES			Not Applicable[34]	
Intercept	0.7027	0.1382		
Apple	-0.0847	0.0061		
Banana	-0.1494	0.0002		
Orange	-0.0748	0.0032		
Other	0.0550	0.3026		
Canned	-0.0276	0.8689		
Juice	0.1528	0.1052		
Expenditure	-0.0104	0.5957		
BANANA				
Intercept	0.3110	0.3285		
Apple	-0.0418	0.0397		
Banana	-0.0083	0.7319		
Orange	-0.0298	0.0687		
Other	-0.0010	0.9772		
Canned	-0.0911	0.4260		
Juice	0.1295	0.0397		
Expenditure	0.0011	0.9298		
ORANGE				
Intercept	1.3945	0.0020		
Apple	-0.1068	0.0002		
Banana	-0.1113	0.0015		
Orange	-0.1084	0.0001		
Other	0.0466	0.3268		
Canned	-0.3353	0.0313		
Juice	0.3191	0.0005		
Expenditure	-0.0472	0.0107		

[34]The parameters of the individual types of processed and fresh fruit were not estimated because the processed fruit group was found to be separable from the fresh fruit group under SAIDS.

Table FP11 (continued):
TABLE OF PARAMETER ESTIMATES FOR INDIVIDUAL FRESH FRUITS AND INDIVIDUAL PROCESSED FRUITS

	AIDS		SAIDS	
Product/ Product group	Param. Est.	p value	Param. Est.	p value
OTHER FRUIT			Not Applicable[35]	
Intercept	-1.0889	0.4590		
Apple	0.4215	0.0001		
Banana	0.4471	0.0004		
Orange	0.2999	0.0003		
Other	-0.1627	0.3326		
Canned	0.1639	0.7563		
Juice	-0.8243	0.0078		
Expenditure	0.1709	0.0091		
CANNED FRUIT				
Intercept	0.0385	0.9262		
Apple	-0.1125	0.0001		
Banana	-0.1125	0.0015		
Orange	-0.0515	0.0197		
Other	0.0581	0.2265		
Canned	0.1067	0.4795		
Juice	0.1154	0.1693		
Expenditure	-0.0551	0.0036		
FRUIT JUICE				
Intercept	-0.3580	0.5422		
Apple	-0.0756	0.0446		
Banana	-0.0653	0.1561		
Orange	-0.0352	0.2387		
Other	0.0039	0.9523		
Canned	0.1835	0.3880		
Juice	0.1073	0.3585		
Expenditure	-0.0593	0.0218		

[35]The parameters of the individual types of processed and fresh fruit were not estimated because the processed fruit group was found to be separable from the fresh fruit group under SAIDS.

In general, the results are more likely to indicate homogeneity when advertising is included in the system than when it is not.

For the fruit products, out of the six possible categories all but one combination were found to be inseparable for the AIDS model. Specifically, the six possible product groupings are (1) Fresh fruit and canned fruit, (2) Fresh fruit and fruit juice, (3) Fresh fruit and frozen fruit, (4) Fresh fruit and processed fruit, (5) Frozen fruit and processed fruit, and (6) Fresh (four) fruit and processed fruit. Out of these six grouping only the first grouping, Fresh fruit and canned fruit was found to be separable. The other five groupings were found to be inseparable.

However, this inseparability did not prevail when advertising was included in the AIDS model. That is, for the SAIDS model, all categories but one were found to be separable. Specifically, the second grouping of fresh fruit and fruit juice was found to be inseparable, while the other five groupings were found to be separable when advertising was incorporated in the AIDS model.

Table FS1:
SUMMARY OF SEPARABILITY RESULTS

Product/ Product group	AIDS	SAIDS
FRESH $FRUIT_1$[36] vs. CANNED FRUIT	Separable	Separable
FRESH $FRUIT_1$ vs. FRUIT JUICE	Not Separable	Not Separable
FRESH $FRUIT_1$ vs. FROZEN FRUIT	Not Separable	Separable
PROCESSED FRUIT[37] vs. FROZEN FRUIT	Not Separable	Separable
PROCESSED FRUIT vs. FRESH $FRUIT_2$[38]	Not Separable	Separable
PROCESSED FRUIT vs. FRESH $FRUIT_2$	Not Separable	Separable

[36]The fresh $fruit_1$ category consisted of apples, bananas, oranges, and other fruit.

[37]The processed fruit category consists of canned fruit and fruit juice.

[38]A fresh $fruit_2$ category used in this test was an aggregate of the four fresh fruits: apples, bananas, oranges, other fruit.

Table FH1:
SUMMARY OF HOMOGENEITY RESULTS (AT GROUP LEVEL)[39]

Product/ Product group	AIDS	SAIDS
FRESH FRUIT[40] and CANNED FRUIT	Rejected	Accepted
FRESH FRUIT and FRUIT JUICE	Accepted	Accepted
FRESH FRUIT and FROZEN FRUIT	Rejected	Not Applicable
PROCESSED FRUIT and FROZEN FRUIT	Rejected	Not Applicable
PROCESSED FRUIT and FRESH FRUIT	Rejected	Not Applicable
PROCESSED FRUIT and FRESH FRUIT	Rejected	Not Applicable

[39]Homogeneity was tested only for groups that were found to be separable.

[40]Since fresh fruit group was found to be separable from canned fruit, homogeneity was tested among the four types of fresh fruit.

Table FH2:
SUMMARY OF HOMOGENEITY RESULTS (OF INDIVIDUAL PRODUCTS INCLUDED IN THE TWO CATEGORIES)

Four Fresh Fruits and Canned Fruit

Product/ Product group	AIDS	SAIDS
APPLES	Rejected	Accepted
BANANAS	Rejected	Accepted
ORANGES	Rejected	Accepted
OTHER FRUIT	Rejected	Accepted
CANNED FRUIT	Not Applicable	Not Applicable

Four Fresh Fruits and Fruit Juice

Products	AIDS	SAIDS
APPLES	Rejected	Accepted
BANANAS	Accepted	Accepted
ORANGES	Rejected	Rejected
OTHER FRUIT	Rejected	Rejected
FRUIT JUICE	Accepted	Rejected

Table FH2 (continued):
SUMMARY OF HOMOGENEITY RESULTS (OF INDIVIDUAL PRODUCTS INCLUDED IN THE TWO CATEGORIES)

Four Fresh Fruits and Frozen Fruit

Products	AIDS	SAIDS
APPLES	Rejected	Not Applicable
BANANAS	Accepted	Not Applicable
ORANGES	Rejected	Not Applicable
OTHER FRUIT	Rejected	Not Applicable
FROZEN FRUIT	Accepted	Not Applicable

Two Processed Fruits and Frozen Fruit

Products	AIDS	SAIDS
CANNED FRUIT	Accepted	Not Applicable
FRUIT JUICE	Accepted	Not Applicable
FROZEN FRUIT	Rejected	Not Applicable

Table FH2 (continued):
SUMMARY OF HOMOGENEITY RESULTS (OF INDIVIDUAL PRODUCTS INCLUDED IN THE TWO CATEGORIES)

Two Processed Fruits and Fresh Fruit

Products	AIDS	SAIDS
FRESH FRUIT	Accepted	Not Applicable
CANNED FRUIT	Accepted	Not Applicable
FRUIT JUICE	Accepted	Not Applicable

Four Fresh Fruits and Two Processed Fruits

Products	AIDS	SAIDS
APPLES	Accepted	Not Applicable
BANANAS	Accepted	Not Applicable
ORANGES	Rejected	Not Applicable
OTHER FRUIT	Accepted	Not Applicable
CANNED FRUIT	Accepted	Not Applicable
FRUIT JUICE	Accepted	Not Applicable

Chapter 5: Conclusion

This chapter discusses conclusions that can be drawn from this study, points to the limitations of this study, and outlines directions for future research. First, the findings are reviewed and interpreted. Second, the implications of the present research for marketing researchers and marketing managers are presented. The section on implications is divided in to two subsections: Theoretical implications and Practical Implications. Third, the limitations of the present study are addressed. Finally, directions for future research are outlined, followed by concluding remarks.

Findings

The main objective of the research was to test for homogeneity of demand. However, in testing the homogeneity of demand, it was necessary first to test the separability between various products. Thus, a test for separability was developed. Two data sets were used to test the hypothesis that inclusion of advertising variable will reduce, if not eliminate, the rejection of the homogeneity of demand property under the AIDS model. The tests performed to check (a) the separability prerequisite, and (b) the main hypotheses of homogeneity of demand showed promising results under the SAIDS model.

The Table 1 below summarizes the gains in accepting homogeneity by fitting the SAIDS model. Modeling of consumer demand under the SAIDS model, fit at both individual and group level, results in a 100% (eight of eight tests) acceptance of the homogeneity of demand assumption for the Alcoholic Beverages and Cigarettes product category, up from 62% (five of eight tests) under the AIDS model. When the AIDS and SAIDS models are fit at the individual product level only, the acceptance of homogeneity of demand assumption increases from 72% (five of seven tests) under AIDS to 100% (seven of seven tests) under SAIDS.

For the Fruit Products category, the SAIDS model fit at both individual and group level increases the acceptance of homogeneity of demand assumption from 48% (fifteen of thirtyone tests) under the AIDS model to 67% (six of nine tests). When the AIDS and SAIDS models are fit at the individual product level only, the acceptance of homogeneity of demand assumption increases from 54% (fourteen of twentysix tests) under the AIDS model to 62% (five of eight tests) under the SAIDS model.

Table 1:
PROPORTION OF ACCEPTANCE OF HOMOGENEITY ASSUMPTION UNDER AIDS AND SAIDS

	AIDS	SAIDS
ALCOHOLIC BEVERAGES AND CIGARETTES		
% Homogeneity accepted (at individual products level)	72%	100%
% Homogeneity accepted (all individual and group level)	62%	100%
FRUIT PRODUCTS		
% Homogeneity accepted (at individual products level)	54%	62%
% Homogeneity accepted (all individual and group level)	48%	67%

The figures in the above table indicate that when the advertising variable was included in the AIDS model, the demand for the group of products that was previously non-homogeneous was often found to be homogeneous. Thus, including the advertising variable improves the homogeneity of demand as hypothesized.

Moreover, as the following table indicates, fitting the SAIDS model results in more signs, of the own-price coefficients, being as expected. When the demand for Alcoholic Beverages and Cigarettes is fit at both individual and group level, under the SAIDS model, 56% (five of nine coefficients) of the signs of the own-price coefficients are as expected 56%, up from 0% (none of nine coefficients) under the SAIDS model. When the AIDS and SAIDS models are fit at the individual product level only, proportion of the expected signs of own-price coefficients increases from 0% (none of seven coefficients) to 57% (four of seven coefficients)

For the Fruit Products category, the SAIDS model fit at both individual and group level improves the proportion of expected signs of own-price coefficients from 44% (sixteen of thirtysix coefficients) under the AIDS model to 82% (nine of eleven coefficients). When the AIDS and SAIDS models are fit at the individual product level only, the proportion of expected signs of own-price coefficient improves from 62% (sixteen of 26 coefficients) under the AIDS model to 78% (seven of nine coefficients) under the SAIDS model.

Table 2:
PROPORTION OF EXPECTED SIGNS OF OWN-PRICE COEFFICIENTS UNDER AIDS AND SAIDS

	AIDS	SAIDS
<u>ALCOHOLIC BEVERAGES AND CIGARETTES</u>		
% sign of own-price coefficient as expected (at individual products level)	0%	57%
% sign of own-price coefficient as expected (all individual and group level)	0%	56%
<u>FRUIT PRODUCTS</u>		
% sign of own-price coefficient as expected (at individual products level)	62%	78%
% sign of own-price coefficient as expected (all individual and group level)	44%	82%

The rejection of the fundamental assumption in consumer demand theory, the homogeneity of demand, appears to be attributable to misspecification of the model as used by economists. Economists have neglected the advertising variable while fitting an AIDS model. Also, they have been fitting the AIDS model on aggregate product categories. It was more realistic to test the model at the individual product level. Homogeneity of demand was found to be rejected at the individual product level under AIDS. When the advertising variable was introduced while fitting the AIDS model at the individual product level, the fundamental property of the homogeneity of demand was accepted. However, the impact of advertising in restoring the homogeneity of demand assumption should be examined with prudence. It is likely that the SAIDS model developed in this dissertation could itself be misspecified. Inclusion of any one or more of the other marketing mix variables (such as promotion, distribution or quality) could also result in the acceptance of the homogeneity of demand assumption.

Homogeneity of demand is rejected when the individual's demand for products is altered by an equiproportionate change in all prices and income. Rejection of the homogeneity of degree zero assumption is commonly viewed as the existence of money illusion. In other words, while testing for the homogeneity property in empirical fitting of the AIDS model, the proportion of unexplained variance is attributed to consumers suffering from money illusion. Such a conclusion, as discussed towards the end of the Theoretical Implications section, is improper.

The results from fitting the AIDS model with the two data sets in this research indicate that, in general, homogeneity of demand is rejected. Demand is not homogeneous when consumers tend to pay more attention to nominal price changes. Under such conditions consumers' behavior departs from being rational and they tend not to maximize the utility from the products they purchase. They tend to over-emphasize the effects of price changes and under-emphasize the impact of equiproportionate income changes.

One possible explanation of such behavior is the fact that consumers face price changes more frequently than they realize changes in their income. Income may change once every twelve months while prices may change more frequently than changes in income. Such a perceived asymmetry in price and income changes elicits less than rational behavior. However, as the results from this research have shown, such a departure from rational behavior can be avoided if marketers employ the tools, such as advertising, available at their disposal. The evidence for irrationality seems to disappear with the inclusion of marketing mix variables. Specifically, such irrationality can be accounted for by including the advertising variable in the consumers' utility function. Incorporating the advertising data while empirically fitting the AIDS model seems to reduce the impact of positive price changes. By emphasizing on the product benefits and attributes in its advertisement, marketers can justify the increase in price.

Because the premise of this research was to study consumers' behavior under a budget constraint, it became necessary to study whether consumers developed mental expenditure accounts to allocate their resources. During the course of this investigation, a methodology was developed to test the existence of expenditure accounts in the consumers' minds. Some products that were found to be not separable from each other under the AIDS specification were found to be separable under the SAIDS specification.

Specifically, for the fruit products data, Table FS1 (Chapter 4) indicates that 5 out of 6 tests for separability among groups of fruit products were rejected under AIDS while only 1 out of 6 tests for separability among groups of fruit products was rejected under SAIDS. Out of the 5 tests that rejected separability among the fruit products, demand for 4 products was found to be non-homogeneous (Table FH1 in Chapter 4).

In addition to validating the assumption of homogeneity of demand in the economic theory of demand, inclusion of the advertising variable resulted in more clearly establishing the separability among products. The advertising adjusted price levels altered the consumers' utility function. Incorporating advertising, consistent with the neoclassical economic theory, in the demand system helped determine which products should be grouped together when testing for homogeneity. The modeling approach developed in this dissertation is a significant contribution in empirical testing of the existence of mental accounts. The applications of such mental accounts are discussed in detail under the practical implications subsection later in this chapter.

Also, the issue of separability plays an important role in the acceptance of homogeneity assumption. When separability is established, and homogeneity tested within these separable groups, there is more acceptance of the homogeneity assumption. Advertising helps in establishing separability, which in turn helps in establishing homogeneity.

The separability results from Chapter 4 lead us to the conclusion that changes in the price and advertising variables of one group of products has no impact on the consumption of products contained in another group. The demand for one group of products is unaffected by the changes in the marketing mix elements of products falling under that group which is separable from the first.

The individual results from the analysis performed on two separate categories of products, namely Alcoholic Beverages (including Cigarettes) and Fruit Products, are summarized below.

ALCOHOLIC BEVERAGES and CIGARETTES

A total of four separate analyses were performed on the Alcoholic Beverages and Cigarettes category. The individual products that were included in these four analyses and the outcome of these four analyses is discussed in the subsections below.

(a_A) Separability between alcoholic beverages as a group and cigarettes.

Result: Under both AIDS and SAIDS, alcoholic beverages are not separable from cigarettes.

Since it was found that Alcoholic beverages were not separable from cigarettes, the tests of homogeneity were performed at both the group level and individual product level. The outcome of the tests of homogeneity of demand at the group level and the individual product level is discussed in sub-sections (b) and (c) below.

(b_A) Homogeneity of demand was tested at the group level between alcoholic beverages as group and cigarettes.

Result: Under AIDS, homogeneity of demand was rejected at the group level but was accepted at the group level under SAIDS.

(c_A) Homogeneity of demand was tested for the individual alcoholic beverages along with cigarettes.

Result: When the demand system including beer, liquor, wine, and cigarettes was estimated, homogeneity of demand for beer was rejected under AIDS. However, homogeneity of demand for beer was accepted under SAIDS. The demand for the other three products was homogeneous under both AIDS and SAIDS.

Further, tests of homogeneity of demand were performed under the assumption that alcoholic beverages were separable from cigarettes. In order to test the homogeneity of demand for the alcoholic beverages, a system of equations consisting of three alcoholic beverages was constructed. The system had three alcoholic beverages: beer, wine, and liquor as the independent variables. The outcome of the test of homogeneity of demand on the group that includes only the three types of alcoholic beverages: beer, liquor, and wine, is discussed in subsection (d) below.

(d_A) Homogeneity of demand among the three individual alcoholic beverages.

Result: Under AIDS, only demand for wine was found to be not homogeneous. However, at a strict $\alpha = 0.05$ level, the demand for all three was found to be homogeneous under SAIDS.

FRUIT PRODUCTS

Since the theory of demand applies to and the tests of homogeneity are done at the individual product level and since not all possible products are included in the demand system it is implicitly assumed during the homogeneity testing that all other products are separable from the overall fruit products category. Confined to the overall fruit category under this rather restrictive assumption, there are several individual fruit products included in the overall fruit category. Some of these individual fruit products are combined to form natural categories. Thus, while testing for homogeneity among the various fruit products, it becomes imperative that separability (or lack thereof) is first established among the natural fruit product categories before proceeding to the homogeneity tests. A total of 6 tests of separability were performed. The purpose of the separability tests was to empirically determine the existence of mental accounts. Such mental accounts were hypothesized to explain the rejection of homogeneity-of-demand assumption of the economic theory of consumer demand. The results of these six separability tests are presented in the subsections below. (Please refer to Figure 2 and Figure 3 at the end of this chapter for a tree representation of the mental accounts). Each separability result is followed by the tests of homogeneity of demand which include the appropriate group of products based on the separability results.

(a_F) Separability between the group of fresh fruits and canned fruit.

Result: Fresh fruit as a group is separable from canned fruit under AIDS as well as under SAIDS.

(a_{1F}) Since fresh fruits category was separable from canned fruit category, homogeneity of demand was tested among the individual products that comprise the fresh fruit category.

Result: Homogeneity was rejected for all four individual fresh fruits under AIDS. Homogeneity was accepted for all four individual fresh fruits under SAIDS.

(b_F) Separability between the group of fresh fruits and fruit juice.

Result: Fresh fruit as a group is not separable from fruit juice under AIDS as well as under SAIDS.

(b_{1F}) Homogeneity between the fresh fruit as a group and fruit juice

Result: Homogeneity was accepted under AIDS as well as under SAIDS.

(b_{2F}) Homogeneity between individual fresh fruits and fruit juice (since fresh fruit as a group was found to be not separable from fruit juice under AIDS as well as SAIDS).

Result:

Apples: Not homogeneous under AIDS and under SAIDS

Bananas: Homogeneous under AIDS and under SAIDS

Oranges: Not homogeneous under AIDS and under SAIDS

Other fruit: Not homogeneous under AIDS and under SAIDS

Fruit juice: Homogeneous under AIDS but NOT under SAIDS

(c_F) Separability between the group of fresh fruits and frozen fruit.

Result: Fresh fruit as a group is not separable from frozen fruit under AIDS but IS separable under SAIDS.

(c_{1F}) Homogeneity between the fresh fruit as a group and frozen fruit.

Result: Homogeneity was accepted under AIDS, but not tested under SAIDS because of the outcome of test performed in c_F above.

(c_{2F}) Homogeneity between individual fresh fruits and frozen fruit under AIDS only (since fresh fruit as a group is not separable from frozen fruit under AIDS but is separable under SAIDS).

Result:

Apples:	Not homogeneous under AIDS
Bananas:	Homogeneous under AIDS
Oranges:	Not homogeneous under AIDS
Other fruit:	Not homogeneous under AIDS
Frozen fruit:	Homogeneous under AIDS

(d_F) Separability between the group of processed fruit and frozen fruit.

Result: Processed fruit as a group is not separable from frozen fruit under AIDS but IS separable under SAIDS.

(d_{1F}) Homogeneity between the processed fruit as a group and frozen fruit.

Result: Homogeneity was rejected under AIDS, but not tested under SAIDS because of the outcome of the test performed in d_F.

(d_{2F}) Homogeneity between individual processed fruits and frozen fruit under AIDS only (since processed fruit as a group is not separable from frozen fruit under AIDS but is separable under SAIDS).

Result:

Canned fruit: Homogeneous under AIDS

Fruit juice: Homogeneous under AIDS

Frozen fruit: Not homogeneous under AIDS

(e_F) Separability between the group of processed fruit and group of fresh fruit, that is, the expenditure, the prices, and the advertising of the four individual fruit products is combined into one group of fresh fruits.

Result: Processed fruit as a group is NOT separable from fresh fruit under AIDS but IS separable under SAIDS.

(e_{1F}) Homogeneity between the processed fruit as a group and the group of fresh fruits.

Result: Homogeneity was rejected under AIDS, but not tested under SAIDS because of the outcome of the test performed in e_F.

(e_{2F}) Homogeneity between individual processed fruits and fresh fruit as one group under AIDS only (since processed fruit as a group is not separable from fresh fruit under AIDS but is separable under SAIDS).

Result:

Canned fruit: Homogeneous under AIDS

Fruit juice: Homogeneous under AIDS

Fresh fruit: Not homogeneous under AIDS

(f_F) Separability between the group of processed fruit and group of fresh fruit.

Result:

(1) Processed fruit as a group is NOT separable from fresh fruit under AIDS but IS separable under SAIDS

Furthermore,

(2) Apples are separable from processed fruit as a group under AIDS as well as under SAIDS

(3) bananas are NOT separable from processed fruit as a group under AIDS but IS separable under SAIDS

(4) oranges are NOT separable from processed fruit as a group under AIDS but is separable under SAIDS.

(5) Other fruits are NOT separable from processed fruit as a group under AIDS but IS separable under SAIDS.

Research Implications

The issues investigated in this dissertation have both theoretical and practical implications in advancing the field of marketing. The theoretical implications from the present study are presented next followed by the practical use of the model developed in this research.

Theoretical Implications

The present study was undertaken to validate one of the basic tenets of demand theory. The primary problem in this research was to investigate the homogeneity of demand. Homogeneity of demand is a fundamental concept in the theory of demand. It is the foundation of the economic theory of consumer demand. When this fundamental property does not hold true, the application of the theory to study demand is questionable. The results derived from the economic theory of consumer demand are doubtful. The failure of this fundamental property of the demand theory is evidence of consumers suffering from apparent money illusion.

Individuals whose demands for commodities would be altered by an equiproportionate change in all prices and money income are said to suffer from apparent money illusion. Money illusion implies that individuals process the nominal price and income information differently. When the lags that necessarily exist in processing price information in the real world are taken into account, the chances of price-level misperception by consumers are higher. Under such conditions, consumers tend to deviate from utility maximizing behavior and are believed to operate under money illusion. The condition of money illusion has far reaching implications on the way demand for products is studied. Although, it must be pointed out that money illusion should not be concluded without more substantial evidence than has been provided by traditional analyses.

Our present understanding of the way in which consumers behave is incomplete without addressing the issue of homogeneity of demand. Evidence from the previous research on the homogeneity of demand suggests that this property is not satisfied in most studies. Despite its importance in theory building as well as being the foundation of vast bodies of theoretical developments, researchers have continued to ignore the issue of homogeneity of demand. It is with this purpose in mind that a theoretically consistent approach to study consumer behavior was developed.

Here the search for explanations of the rejections of neoclassical theory is continued by developing and testing a model of consumer behavior that incorporates advertising effects. Clearly, firms advertise because they believe it can alter consumer behavior. If advertising does alter behavior, and the relative intensities of advertising for different products vary over time, rejections of neoclassical theory may reflect misspecification rather than a per se rejection of the theory.

Looking at the summary results in Tables 1 and 2 earlier in this chapter, it can be argued that SAIDS gives more reasonable results than AIDS. Including the advertising effects in the demand system not only help in restoring the homogeneity property but also yield more signs of the own-price coefficients in the expected direction.[41] An interesting implication of this result is that advertising can be interpreted as affecting utility in such a way that consumers avoid the appearance of money illusion (as measured in the model). They appear to behave rationally once advertising effects are included in the demand system.

The issue of separability investigated in this research has direct implication on analyzing market structures. Allenby (1989) advocated a theoretically consistent approach to studying market structure. He has pointed out previous research that has failed to deliver on certain criteria. These criteria are (1) Theoretical foundation, (2) Dynamic, (3) Data Availability, (4) Exploratory, (5) Hypothesis Testing, and (6) Overlapping Clusters. The SAIDS modeling approach developed in this research is a microeconomic consumer demand theory based approach to market structure. The data needed to test the model is freely available. The dynamic aspect of demand can be easily modeled in SAIDS. It is exploratory in nature, in the sense that market structures can be explored on the basis of mental accounts. At the same time, specific hypotheses can be tested about the nature of demand.

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[41]It needs to be pointed out that since SAIDS uses more information than AIDS the results are not strictly comparable. Furthermore, when homogeneity is rejected, comparison of reasonableness of coefficients is debatable.

Moreover, the SAIDS model is also useful in determining consumers' mental accounts. Consumers are said to develop mental accounts when they combine products to form a category. They then make budget (expenditure) allocation across accounts and for products within an account. Such mental accounts can aid theoreticians as well as practitioners in developing hierarchies of the market by studying which products are comprise an account and which products are separable from the rest. Thus, the methodology developed in this research not only meets the first five criteria set forth by Allenby (1989) but also assists in research on market structure.

However, the SAIDS model developed in this dissertation provides additional benefits compared to Allenby's approach. The SAIDS model is a substantial improvement over the AIDS model because of its ability to test the assumptions of the economic demand theory and explore the composition of products in a consumer's mental consumption account. It offers estimates of demand for products that are consistent with the neoclassical economic theory and extracts product groupings based on consumers' overt purchase behavior.

The rejection of homogeneity of demand property has lead economists to believe that consumers suffer from money illusion. Such a conclusion should be drawn with caution. There are complex set of causes for money illusion. To infer the appearance of money illusion based on the rejection of homogeneity property is premature. The present study is an attempt to sort out the possible causes of apparent money illusion.

The results from this study indicate that economists have hastily arrived at the conclusion that consumers suffer from money illusion. The evidence of apparent money illusion can be explained by appropriately specifying the utility function. By incorporating the relevant marketing mix elements in the consumers' utility function, the variance in fitting the demand system can be easily accounted for.

Moreover, by appropriately grouping the products and conducting the empirical analysis at the appropriate level, the evidence of apparent illusion disappears. Analyzing demand from the mental accounts perspective acts as a competing explanation for money illusion. The false appearance of money illusion is a function of the erroneous level of analysis.

Practical Implications

This dissertation has contributed to methodological as well as substantive issues. A methodology is developed to incorporate advertising variable in the demand equations. This dissertation sought an explanation and cure for spurious evidence of money illusion. This research has provided a solution to the problem of asymmetry in processing price and income information. The proposed model provided a rationale for the inclusion of advertising in the complete demand system. The model developed in this research incorporated the advertising variable in the consumers' utility function to reduce the impact of price changes. The advertising variable was used to adjust the price-levels, which in turn reduced money illusion.

The approach presented here allows for advertising effects while preserving the fundamental properties of behavior postulated by neoclassical economics theory. This is accomplished by assuming that preferences are defined over prices, income and advertising levels. As a consequence, sales functions depend on advertising levels in a way that permits the simultaneous estimation of a multiple sales functions in a complete demand system.

The approach presented in this research is very general in nature. It enables researchers to incorporate other variables in the consumers' utility function in a theoretically consistent manner. In the present study, only advertising was used to empirically test the assumption and study its impact in alleviating the problem. However, researchers may use the SAIDS model developed in this study to include any number of different variables that seem to have an impact on consumers' demand. Once it is established that inclusion of such variables restore the basic properties of the demand system, the empirical results obtained from the estimating the sales response functions have more meaning and practical use.

In addition to testing neoclassical restrictions, the inclusion of advertising terms enables one to provide evidence on the hypothesis that advertisers have the power to influence the patterns of demand across broad product groups.

If consumers do have money illusion they are paying more attention to the nominal price of the product than the real price. They pay more attention to any price increases due to the general economy and inflation but forget that their incomes have also gone up. Advertising variable helps in reducing the impact of the price increases. The SAIDS model suggests that managers should use the advertising variable when estimating demand of the product categories, especially when they are thinking of price increases (due to inflation or general price increase due to economic conditions.) When the features or attributes of the product are emphasized or brought out in the advertising the manager is better served in masking the price increase. The consumers will buy the products looking more at their attributes if these are emphasized in the advertising.

Moreover, the generality of the SAIDS model allows the managers to study the impact of other variables such as distribution, shelf space, couponing, product quality etc. Also the interrelatedness or dependencies (due to differences in distribution, product quality and its impact on prices and expenditures) within and among product groups can be studied with this approach. Thus a very general approach to studying demand among products is presented.

The present approach can be successfully applied to product line pricing. The results of the analysis enable the manager to set prices according to the shifts in the demand patterns based on the consumers' income and the prices, adjusted for the advertising levels. The present approach lets the managers determine the leverage that can be obtained from advertising, and simultaneously increase the price. The SAIDS model is an improvement on product line pricing approach proposed by Reibstein and Gatignon (1984). While their approach is purely statistical in nature, the SAIDS model is grounded in the utility maximization theory.

The approach developed in this dissertation is helpful in developing strategies suitable for category management. Managers can use the SAIDS model to monitor the sales within a product category comprising closely related products. For instance, the impact on the sales of closely related products within a product category due to changes in the marketing mix variables of a slow moving product within that category can be easily studied with the SAIDS model.

The SAIDS model allows managers to deduce the manner in which products are categorized in the consumers' mental expenditure accounts. The model helps category managers to concentrate on products within the account and not be overly concerned with products outside the account. Retailers can develop pricing and advertising strategies for groups of products within and outside the mental account. Based on the empirical results from the SAIDS model, retailers can change the marketing mix of products within a category. Such an approach will reduce the fears of cannibalization from those products falling outside the consumers' mental expenditure account. For example, the store manager at Kroger can profitably manage the sales of product categories such as processed food, produce, meats, and dairy products by applying the SAIDS model.

The flexibility of adding other variables in the SAIDS model also has government and public policy implications. The government can successfully apply the SAIDS model to estimate the demand for product or product groupings in the wake of regulatory variables. Public policy makers can monitor the demand for products/commodities based on the regulatory variables as predictors and study the impact of higher taxes, rationing or restricted distribution on sales. Also, the impact of ban on advertising of sin products in certain media can be studied. For certain commodity groups such as milk, eggs, the usefulness of advertising can be studied. Demographic variables can be easily incorporated in the SAIDS model to study their impact on the consumption of goods among the population. The SAIDS model offers a convenient tool to determine if the demand for products is affected by consumers being in certain age groups, or income groups etc. Changes in the demand patterns due to demographic variables can easily monitored.

The separability tests are helpful in tracking the inclusion and exclusion of products in an individual's mental expenditure account. For instance, the SAIDS model is useful in answering the following questions: Which age group will include a product in its mental account? At which income level do consumers change the composition of the products comprising their mental account? By answering these questions, marketers can effectively develop segments. The SAIDS model can aid managers in focusing their marketing efforts on a particular segment. Advertising messages or distributional efforts can be then be targeted towards these segments. The SAIDS model serves the dual purpose of determining target markets and market structure.

To recapitulate, this dissertation searched for explanations of the rejections of neoclassical theory by developing and testing a model of consumer behavior that incorporates advertising. In the process of testing the model, a methodology was also developed to devise a scheme for separating products that do not belong in the same group.

This separation has improved the acceptance of the neoclassical predictions. Two possible explanations for the rejection is offered in this study. One is the misspecification of the AIDS model, and the other is inappropriate grouping of products (mental accounts).

Limitations of the Research

This research has provided a methodology to incorporate marketing mix variable other than price in the AIDS model. However, there are several limitations to this study. They are discussed below.

(i) Advertising Data.

The present analysis was performed with advertising data that was obtained from Leading National Advertisers publications. The LNA data is compiled on a quarterly basis. It can be argued that for some products, especially frequently purchased packaged goods, the quarterly advertising data might mask the effect of advertising. Further, the model analyzed in this study is a restricted model. The restriction placed on the model during the data analysis stage was in terms of the inclusion of only the current period advertising. However, the proposed methodology developed in Chapter 3 is capable of including previous period advertising. Moreover, the advertising data used in this research is in terms of the total dollar amount spent on the overall advertising on the products included in the analysis. The total dollar amount spent on advertising a particular product is the sum of the dollars spent in advertising that product in various advertising media. Though not directly applicable to the products studied in this research, the drawback of using the aggregated advertising dollar amount is it costs more to advertise in some media such as television relative to advertising in some other media such as newspaper. Thus, using the aggregated dollar amount may not bring out the relevant impact of advertising a product in a particular media on its demand. Incorporating the advertising data in the form of aggregated dollar amount provides a possible explanation of why SAIDS still rejects homogeneity in a variety of fruit analyses. Furthermore, the present analysis ignores the effects on product demand due to the daily or weekly promotional activities such as couponing and cents-off.

(ii) Governmental Data Source/Panel Diary Data.

The data used in this research are mainly derived from a panel of consumers recruited by the Bureau of Labor Statistics. Individuals were given two diaries over a two week period and were asked to record all of their purchases of the everyday items. The diaries ware collected after each week of purchases were recorded by the consumers. The common problems of errors in exact recording of items and non-inclusion of items being purchased are to be acknowledged while interpreting the results of this analysis. The problems discussed above regarding the entries in the diary are further compounded with the possible errors in coding the data before it is made available for public use.

Suggestions for Future Research

As noted previously in the Findings and Research Implications sections, this study has established that the AIDS model needs to be respecified when studying homogeneity of demand. However, as pointed out in the Limitations section above, testing the model at the individual brand level would be more beneficial to brand managers. Also, including additional variable of promotional activities, such as couponing and cents-off, would make the proposed methodology more valuable to the brand managers who are interested in monitoring the daily movements in sales of their brands among a set of competing brands.

The model developed in this study is flexible enough to include the dynamic impact of advertising variable. The impact of past advertising on current consumption can be easily studied by applying the SAIDS model to the appropriate data. Further work on alternative dynamic advertising specifications may yield important insights into consumer behavior.

The study of demand has been approached from many different perspectives and theoretical foundations. Researchers have analyzed demand from a number of different approaches, such as neoclassical economic theory approach, random utility modeling approach, stochastic modeling approach, and ad hoc fitting of sales response models.

Although neoclassical economic theory provides a solid theoretical grounding for analyzing demand, it has fallen out of favor among researchers in the recent past. Neoclassical economic theory has often been criticized because of its lack of relevance and impractical results. A common complaint against neoclassical economic theory is it has too many assumption which are often regarded as unreasonable and unrealistic. Observed behavior is often shown to be different than the predictions from the neoclassical theory. Hence there is a tendency to reject the neoclassical economic theory as a foundation for demand analysis.

The failure of observed behavior coinciding with the predicted behavior could be a result of the inappropriate use of the theory. When the underlying requirements of the theory are not met, the likelihood of observed behavior being inconsistent from the predicted behavior is higher. Results from this dissertation has shown that before completely rejecting the neoclassical economics theory, the validity of the assumptions on which it rests must be verified. Future research must be undertaken to build upon the vast body of knowledge grounded in the neoclassical economic theory but with the appropriate modification to the theory.

The approach taken in this study to study demand is one of the many approaches found in the literature. An alternative approach to study systems of demand is the Rotterdam approach presented by Theil (1980). The Rotterdam approach attempts to estimate demand without relying on the assumptions of the neoclassical economic theory of demand. It is mainly statistical in nature and avoids the premise that individuals exhibit utility maximizing behavior. As a matter of interest, future research must be undertaken to reconcile the separability results from this study with that of the Rotterdam approach. Such convergence of separability results will further validate the concept of mental accounts. A methodology to incorporate advertising in the system of demand equations under the Rotterdam approach is explored by Clements and Selvanathan (1988) and Vilcassim (1989).

Another interesting direction for future research is to tackle the issue of money illusion at the segment level. The evidence of money illusion could be an artifact of aggregating different segments. The appearance of money illusion can be further explored among consumers belonging to different income and/or age groups. A related topic that warrants further investigation is the issue of existence of money illusion among or within mental accounts. Additional insights into consumers' purchase behavior and product substitution patterns can be gained by comparing the degree of money illusion between within and across accounts.

Conclusion

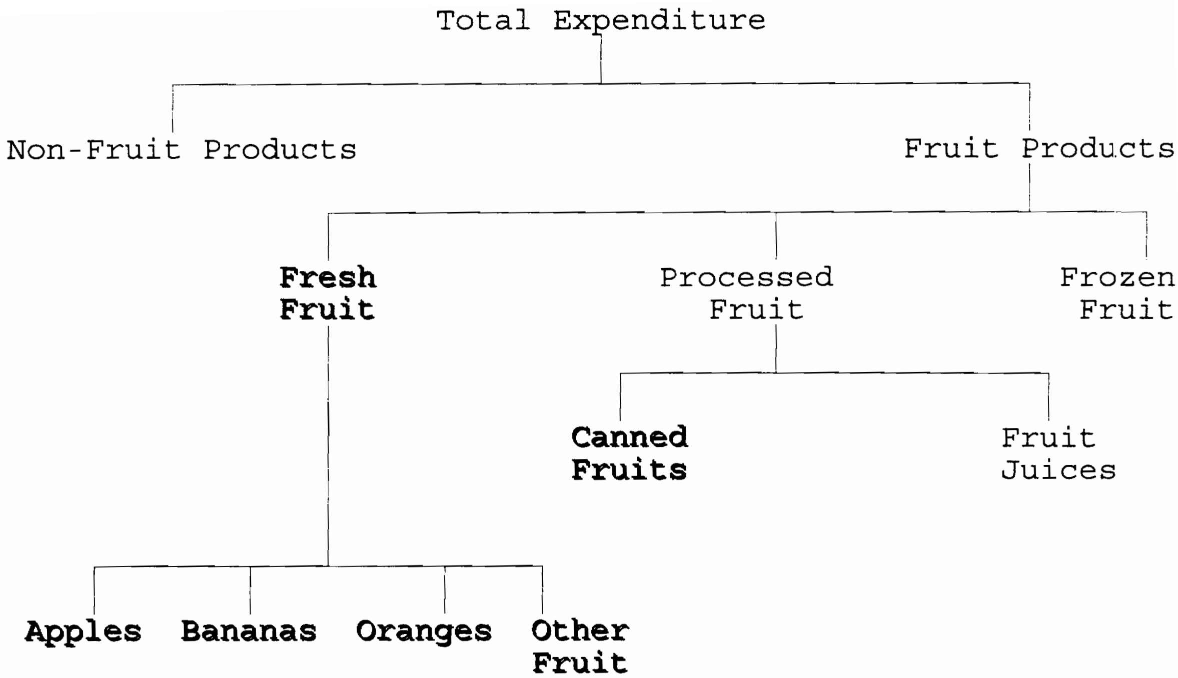
As explained in the Research Questions section in Chapter 1, the primary thrust of this proposal was to test the homogeneity-of-demand assumption of the economic consumer demand theory. An important issue in this context is determining how the consumers' income and the marketing mix of one product affects the demand for other related products. In other words, it was postulated that an individual's consumption is sensitive to income and that individuals categorize their expenditures on the basis of the mental consumption accounts.

The evidence from the applied economics literature suggested that the homogeneity-of-demand assumption is frequently rejected, indicating that consumers suffer from money illusion. One possible reason for the rejection of the homogeneity assumption is the ignoring of the marketing mix variables. The SAIDS model was developed by incorporating advertising variable in the demand system in a way which is consistent with the neoclassical economic theory. The apparent money illusion (rejection of homogeneity-of-demand assumption) was expected to be reduced, if not eliminated, by incorporating advertising in the demand function.

Additionally, the SAIDS model developed in chapter 3 provided a convenient way to determine consumers' mental accounts. Specifically, a test was provided to empirically segregate a group of products. The impact of changes in price and advertising of products which form this group was felt within this group only. The demand for products within the group remained unaffected by changes in price and advertising of products not contained in that group. To illustrate this point, the food products account was divided into two accounts, the fruit products account and other food products account, as shown in Figure 1 in chapter 4. The results from the data analysis show that consumers' demand for products is consistent within the empirically derived mental accounts within the fruit products category. The consumers exhibited three mental accounts within the fruit products category. They are: fresh fruits, processed fruits, and frozen fruits. The demand for products comprising these mental accounts is consistent with the economic theory of consumer demand. For instance, when the price of any product in the fresh fruits category changes, the demand for other fruit products remains unaffected except for the demand for fruit juices. In other words, any changes in the marketing mix variables for the fresh fruit products and fruit juices results in the substitution of other products within that category. The analysis is not restricted to the fruit products category and the various fruit products accounts as described in Figure 1. It is conceivable that consumers have a different schema of mental accounting as far as the fruit products are concerned. The determination of a different representation of competitive structure of products is limited only by the data availability. Moreover, the proposed methodology can be applied to test the existence of mental accounts within and between non-competing or non-comparable alternatives.

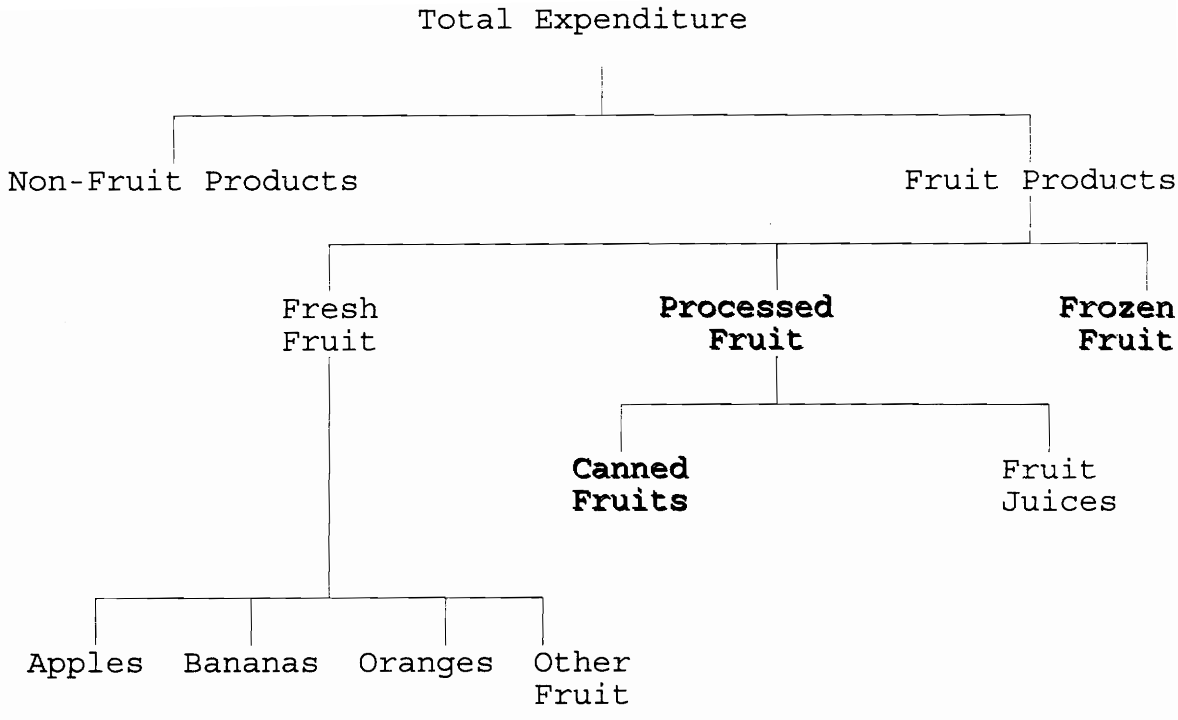
Homogeneity is rejected due to the inclusion of products that are not supposed to be grouped together. When such products are grouped together, obviously the distribution of expenditure (budgeted) dollars is not going to be equiproportionate. Thus before testing homogeneity, products should be carefully grouped to form a system of demand equations which includes only those products which are not separable from each other. Only nonseparable products ought to be included in the system which tests homogeneity. The rejection of homogeneity is as much a function of model specification as of inappropriate grouping of products. Lack of inclusion of pertinent variables in the demand system is one cause of the rejection of homogeneity of demand. Also, the products to be included in the system should be carefully selected. If we do not know of any natural groupings based on prior research or experience, we can identify the groupings by employing the test provided in this research.

In summary, this research provided a possible explanation for the rejection of the homogeneity-of-demand assumption and developed a framework to test this explanation. Additionally, this research provided a test to investigate the existence of mental accounts. These mental accounts provide a competing explanation for the rejection of homogeneity of demand property of neoclassical economic theory. The false appearance of money illusion is a result of analysis at the wrong level. Substantively, this research provided a tool to explore the competitive structure of the fruit products by relying on the theory of mental accounts. Thus, this dissertation has made useful theoretical and empirical contributions to the study of consumer behavior.



The above tree is a pictorial representation of the separability results shown in Table FS1 in Chapter 4. Under the AIDS model, only the shadowed products shown above are **separable** from each other. Specifically, only Fresh Fruit (individually and as a group) are separable from Canned Fruits. The pairwise tests of separability among all other categories of fruit products indicate that Fresh Fruit, Fruit Juices, Frozen Fruit and Processed Fruit are not separable from each other. Thus, under the AIDS model, changes in the price of Fresh Fruit has no impact on the demand for Canned Fruits. The Processed Fruit, Frozen Fruit and Fruit Juices act as potential substitutes when the price of Fresh Fruit goes up. The consumers appear to exhibit two accounts in which they allocate their expenditure on fruit products. One account is for expenditure on Canned Fruits and the other account is for expenditure on all other fruit products.

Figure 2:
Tree Representation of Mental Accounts among FRUIT PRODUCTS under AIDS.



The above tree is a pictorial representation of the separability results shown in Table FS1 in Chapter 4. Under the SAIDS model, the shadowed products shown above are **separable** from each other. Only Fresh Fruit (individually and as a group) are not separable from Fruit Juices. The pairwise tests of separability among all other categories of fruit products indicate that Fresh Fruit, Canned Fruit, Frozen Fruit and Processed Fruit are separable from each other. Thus, under the SAIDS model, changes in the price of Fresh Fruit has no impact on the demand for Processed Fruit, Frozen Fruit or Canned Fruits. Only Fruit Juices act as potential substitutes when the price of Fresh Fruit goes up. The consumers appear to exhibit four accounts in which they allocate their expenditure on fruit products. One account is for combined expenditure on Fresh Fruit and Fruit Juices, and one account each for Processed Fruit, Frozen Fruit, and Canned Fruits.

Figure 3:
Tree Representation of Mental Accounts among FRUIT PRODUCTS under SAIDS.

ALCOHOLIC BEVERAGES AND CIGARETTE EXPENDITURE DATA

YEAR	BEER	LIQUOR	WINE	CIGARETTES
Y82Q1	17.9348	8.4773	8.8231	34.6749
Y82Q2	25.8570	9.8930	8.7828	38.1407
Y82Q3	19.4870	11.8482	7.7207	32.3089
Y82Q4	18.1402	14.5119	12.9129	40.2597
Y83Q1	16.1889	9.6902	7.4412	41.5311
Y83Q2	20.8299	12.0016	11.1943	38.4384
Y83Q3	28.3075	11.8950	11.7624	44.4210
Y83Q4	21.1328	9.9281	12.8609	41.2204
Y84Q1	18.2169	7.1071	7.6453	42.0732
Y84Q2	21.4903	6.3752	7.0018	42.2045
Y84Q3	21.0288	7.6960	6.7587	42.5503
Y84Q4	23.8394	10.4741	11.3386	40.3039
Y85Q1	20.5179	7.3983	7.2878	46.2787
Y85Q2	26.0182	7.7337	10.1738	51.1979
Y85Q3	24.8040	7.8663	13.0455	42.6764
Y85Q4	21.9518	10.0217	10.2869	42.3787
Y86Q1	16.4905	5.1649	5.5107	38.5164
Y86Q2	19.0125	5.3378	6.9667	40.9500
Y86Q3	16.1330	5.6927	5.8474	41.8405
Y86Q4	18.2572	7.1734	8.6918	37.5076
Y87Q1	16.3501	5.1493	6.1165	39.8866
Y87Q2	20.1890	5.9215	6.5559	38.7101
Y87Q3	18.7629	6.2569	6.1087	45.4259
Y87Q4	19.6248	6.3479	11.6155	41.6819
Y88Q1	13.4238	5.3547	5.8370	40.1167
Y88Q2	17.7099	3.6062	6.0450	42.9611
Y88Q3	19.2101	4.2432	5.7980	42.4645
Y88Q4	16.1460	7.5556	8.4552	44.3495
Y89Q1	15.7417	6.3349	7.5127	41.6650
Y89Q2	19.2647	5.4028	6.5442	44.6784
Y89Q3	18.9124	4.0690	9.6109	44.3092
Y89Q4	14.5756	6.8679	8.8673	49.7978
Y90Q1	17.0014	5.8331	7.0148	48.0519
Y90Q2	16.3592	4.0456	7.3736	47.1679
Y90Q3	18.3898	5.2611	5.9826	45.6625
Y90Q4	20.9820	10.3324	11.9418	46.8897

ALCOHOLIC BEVERAGES AND CIGARETTES PRICE DATA

YEAR	BEER	WINE	LIQUOR	ALL ALCOHOLIC BEVERAGES	CIGARETTES
Y82Q1	93.700	99.533	96.900	95.700	81.967
Y82Q2	95.167	100.500	97.833	96.900	84.100
Y82Q3	95.667	101.133	98.800	97.633	86.000
Y82Q4	96.133	100.433	99.233	97.867	93.967
Y83Q1	98.033	100.633	99.733	99.033	100.233
Y83Q2	100.867	100.900	100.200	100.600	101.400
Y83Q3	101.667	100.367	100.767	101.133	105.467
Y83Q4	102.100	99.867	100.800	101.267	106.400
Y84Q1	102.767	99.167	101.233	101.667	108.400
Y84Q2	104.233	99.133	101.233	102.400	108.967
Y84Q3	104.633	99.067	101.500	102.633	111.467
Y84Q4	105.033	99.267	101.800	103.033	111.800
Y85Q1	106.000	99.567	102.200	103.633	114.600
Y85Q2	106.600	100.233	102.767	104.267	115.200
Y85Q3	107.133	100.267	103.167	104.700	117.733
Y85Q4	107.333	100.633	112.933	108.200	119.200
Y86Q1	108.000	102.133	113.233	108.833	122.333
Y86Q2	108.967	102.567	113.367	109.433	123.167
Y86Q3	108.900	102.800	113.267	109.400	126.400
Y86Q4	109.100	102.200	113.433	109.467	126.933
Y87Q1	110.200	104.267	114.067	110.700	130.567
Y87Q2	110.700	105.467	114.267	111.333	131.933
Y87Q3	110.900	106.700	114.633	111.767	135.400
Y87Q4	111.600	106.567	114.933	112.200	136.600
Y88Q1	113.067	106.300	115.233	112.933	141.933
Y88Q2	114.600	107.667	115.733	114.200	143.233
Y88Q3	114.833	108.600	116.500	114.733	148.333
Y88Q4	114.900	108.467	116.900	114.833	149.633
Y89Q1	115.967	109.667	117.467	115.800	158.233
Y89Q2	118.133	110.400	119.067	117.533	161.600
Y89Q3	119.000	111.700	120.933	118.733	168.167
Y89Q4	119.700	111.967	122.067	119.467	169.767
Y90Q1	121.600	113.067	123.133	121.000	174.733
Y90Q2	123.767	114.467	124.567	122.800	177.733
Y90Q3	124.467	114.900	127.000	123.867	185.767
Y90Q4	124.500	115.100	127.933	124.200	187.867

ALCOHOLIC BEVERAGES AND CIGARETTES ADVERTISING DATA

YEAR	BEER	LIQUOR	WINE	CIGARETTES
Y82Q1	72.091	64.545	30.956	186943.38
Y82Q2	102.686	78.885	36.165	208745.05
Y82Q3	112.871	56.472	21.266	214050.02
Y82Q4	118.736	109.095	72.091	243649.92
Y83Q1	96.262	54.253	28.114	221181.29
Y83Q2	114.698	70.359	24.543	235396.37
Y83Q3	128.776	52.122	17.398	193193.20
Y83Q4	154.785	105.734	57.928	195293.87
Y84Q1	97.365	50.405	17.720	183824.47
Y84Q2	130.788	69.572	39.611	216116.42
Y84Q3	184.521	52.391	22.036	206431.95
Y84Q4	162.239	99.389	69.024	226363.20
Y85Q1	119.329	48.899	19.441	182298.21
Y85Q2	149.181	65.390	48.943	174816.33
Y85Q3	161.490	47.819	38.137	197309.52
Y85Q4	172.429	88.583	77.144	222493.56
Y86Q1	128.749	43.224	29.917	164741.27
Y86Q2	173.592	60.099	70.653	169089.96
Y86Q3	195.202	42.057	68.785	144545.65
Y86Q4	190.610	80.443	66.503	146732.89
Y87Q1	135.832	33.211	22.437	134104.84
Y87Q2	182.953	53.638	69.806	144549.92
Y87Q3	192.525	47.109	50.320	148058.42
Y87Q4	173.093	90.097	69.024	141222.34
Y88Q1	149.004	34.920	24.298	136944.70
Y88Q2	190.338	60.914	49.044	159165.20
Y88Q3	225.364	50.269	31.892	158467.60
Y88Q4	185.425	81.902	31.687	181043.00
Y89Q1	118.140	43.569	13.649	174732.10
Y89Q2	182.014	65.065	24.204	178706.90
Y89Q3	192.927	52.204	11.915	144740.30
Y89Q4	184.120	111.343	41.084	152929.00
Y90Q1	128.433	48.857	13.733	125583.50
Y90Q2	165.654	81.009	33.349	139143.70
Y90Q3	198.226	53.783	17.330	127309.50
Y90Q4	160.853	107.200	32.777	171662.00

FRUIT EXPENDITURE DATA

YEAR	APPLES	BANANAS	ORANGES	OTHER FRUIT	CANNED FRUIT	FRUIT JUICE	FROZEN FRUIT
Y82Q1	4.254	4.167	4.067	6.667	3.477	8.451	4.716
Y82Q2	4.720	4.876	2.986	14.983	4.165	10.214	4.976
Y82Q3	3.571	4.245	1.198	18.830	3.192	8.567	5.565
Y82Q4	5.219	3.958	3.191	9.935	4.643	8.352	4.767
Y83Q1	4.635	4.343	3.811	6.762	3.526	8.518	4.478
Y83Q2	4.366	4.169	3.182	13.893	4.469	10.714	4.526
Y83Q3	3.671	3.442	1.370	19.063	3.714	8.642	4.859
Y83Q4	4.706	3.812	3.205	7.564	4.387	8.468	4.581
Y84Q1	5.414	4.426	3.842	7.581	5.222	9.569	5.769
Y84Q2	4.088	4.496	2.368	13.568	3.755	7.945	4.477
Y84Q3	3.611	3.779	1.327	18.396	3.633	9.646	4.232
Y84Q4	5.007	3.853	3.034	8.242	5.284	9.106	5.330
Y85Q1	4.807	4.440	3.718	7.974	4.544	10.158	5.627
Y85Q2	4.670	4.954	3.365	14.289	4.351	10.257	5.415
Y85Q3	3.779	4.299	1.233	18.141	3.920	9.685	4.707
Y85Q4	5.469	4.024	3.290	8.343	5.224	10.289	5.306
Y86Q1	2.333	1.947	1.944	4.930	3.016	6.528	3.667
Y86Q2	1.908	2.236	1.088	8.177	2.899	5.670	3.005
Y86Q3	2.710	2.306	0.894	10.076	2.731	6.078	2.694
Y86Q4	2.715	2.169	1.664	5.526	3.350	6.099	2.514
Y87Q1	2.839	2.284	1.904	5.844	3.472	6.368	2.684
Y87Q2	2.515	2.251	1.389	9.201	2.616	6.292	3.082
Y87Q3	1.875	2.161	0.595	10.133	2.720	7.706	2.895
Y87Q4	2.609	2.330	1.472	6.038	3.615	7.029	2.329
Y88Q1	2.228	2.332	1.821	6.451	4.079	6.975	3.500
Y88Q2	1.907	2.406	1.153	9.516	3.346	7.352	3.113
Y88Q3	2.050	2.297	0.605	12.824	3.541	7.642	2.856
Y88Q4	2.973	2.346	1.285	6.193	3.636	6.831	2.633
Y89Q1	2.437	2.680	1.604	6.619	3.819	8.294	2.542
Y89Q2	2.402	3.048	1.069	9.636	3.204	7.095	3.019
Y89Q3	1.925	3.061	0.585	12.629	3.030	9.350	3.848
Y89Q4	2.722	2.884	1.623	6.696	3.675	7.754	3.097
Y90Q1	2.730	2.858	1.662	5.892	3.966	7.777	3.434
Y90Q2	2.639	2.640	1.491	9.139	3.932	7.646	3.775
Y90Q3	1.930	2.804	0.980	11.202	3.385	8.039	3.764
Y90Q4	3.295	2.918	1.833	6.060	4.670	8.386	3.984

FRUIT PRICE DATA

YEAR	APPLE	BANANA	ORANGE	OTHER FRUIT	FRESH FRUIT
Y82Q1	97.333	98.333	81.567	95.133	92.733
Y82Q2	105.167	102.267	98.300	105.767	103.467
Y82Q3	107.833	92.200	127.600	99.300	106.833
Y82Q4	84.900	91.533	110.267	90.667	94.233
Y83Q1	85.333	96.400	78.467	92.000	88.000
Y83Q2	93.500	118.600	81.133	100.733	96.733
Y83Q3	106.167	114.667	93.400	106.133	104.133
Y83Q4	93.433	94.300	79.567	96.167	91.500
Y84Q1	99.867	98.867	81.700	98.600	94.933
Y84Q2	105.700	103.033	98.933	104.167	103.100
Y84Q3	116.800	99.800	140.433	102.767	114.067
Y84Q4	103.933	90.000	128.733	108.567	110.267
Y85Q1	109.267	102.433	117.600	117.733	114.267
Y85Q2	116.333	110.700	125.333	123.367	121.033
Y85Q3	117.567	98.200	126.800	121.567	119.367
Y85Q4	109.300	88.467	109.167	117.000	110.400
Y86Q1	119.033	101.933	100.867	119.733	113.100
Y86Q2	130.867	117.767	105.567	124.633	120.600
Y86Q3	155.300	101.900	114.000	121.233	124.000
Y86Q4	117.233	98.467	113.833	123.067	116.900
Y87Q1	128.367	105.000	113.133	139.533	128.500
Y87Q2	142.067	107.167	124.667	148.667	137.833
Y87Q3	146.467	102.867	156.633	129.000	132.467
Y87Q4	106.900	101.667	149.300	140.000	129.267
Y88Q1	115.033	115.233	122.667	146.567	132.367
Y88Q2	123.833	128.567	139.900	156.033	143.367
Y88Q3	163.667	115.033	159.233	153.067	150.400
Y88Q4	134.267	118.133	156.567	154.967	145.733
Y89Q1	142.833	121.200	128.600	163.600	148.300
Y89Q2	143.900	149.300	140.267	163.367	154.067
Y89Q3	147.767	128.900	166.567	156.967	152.367
Y89Q4	127.400	125.767	152.500	173.767	154.700
Y90Q1	135.667	140.767	155.500	197.033	170.933
Y90Q2	141.967	138.200	161.367	200.833	174.600
Y90Q3	163.267	145.400	169.900	182.767	171.600
Y90Q4	148.933	128.300	155.733	186.700	166.400

FRUIT PRICE DATA

YEAR	CANNED FRUIT	FRUIT JUICE	FROZEN FRUIT
Y82Q1	94.500	97.100	97.900
Y82Q2	95.767	96.800	97.167
Y82Q3	97.600	96.367	95.667
Y82Q4	97.700	97.067	96.433
Y83Q1	98.667	97.833	96.533
Y83Q2	99.067	97.100	94.700
Y83Q3	100.367	96.933	94.200
Y83Q4	100.600	97.333	95.300
Y84Q1	102.533	101.267	102.033
Y84Q2	104.067	106.500	109.300
Y84Q3	105.167	107.267	110.067
Y84Q4	104.000	108.400	110.667
Y85Q1	105.267	110.100	113.267
Y85Q2	105.733	111.900	115.833
Y85Q3	107.267	111.933	114.867
Y85Q4	107.300	110.433	112.933
Y86Q1	107.367	108.267	107.400
Y86Q2	107.533	105.300	101.500
Y86Q3	108.333	103.967	98.400
Y86Q4	108.100	104.433	99.200
Y87Q1	109.533	107.600	102.800
Y87Q2	110.867	110.100	105.667
Y87Q3	111.933	111.000	106.533
Y87Q4	111.633	111.400	106.933
Y88Q1	113.167	118.233	116.033
Y88Q2	114.833	124.067	123.000
Y88Q3	115.933	124.967	122.333
Y88Q4	116.333	126.333	124.567
Y89Q1	117.633	126.867	124.633
Y89Q2	119.100	126.233	123.767
Y89Q3	120.433	128.167	126.333
Y89Q4	120.100	127.400	124.900
Y90Q1	121.000	133.567	134.033
Y90Q2	121.100	143.633	146.767
Y90Q3	122.467	144.333	146.500
Y90Q4	122.367	140.567	139.233

FRUIT ADVERTISING DATA

YEAR	APPLES	BANANA	ORANGE	OTHER FRUIT	CANNED FRUIT	FRESH FRUIT	FROZEN FRUIT
Y82Q1	1116.4	0.1	2168.8	1108.7	4307.1	10811.7	6062.5
Y82Q2	459.4	71.5	1602.3	1471.9	3558.1	8174.7	6673.8
Y82Q3	16.1	1.0	1.0	3118.7	3342.5	9629.5	2596.9
Y82Q4	894.2	50.5	43.4	2931.7	9836.6	8001.2	1854.1
Y83Q1	14.6	296.3	900.1	380.2	1504.9	4090.0	7834.4
Y83Q2	154.8	66.6	1301.4	639.8	1034.8	446.7	9994.1
Y83Q3	63.7	23.9	1606.9	979.7	71.8	1520.0	5452.2
Y83Q4	810.3	122.7	488.6	3902.2	264.7	8960.0	8967.9
Y84Q1	53.8	0.4	510.9	3761.1	2729.6	4893.0	9185.0
Y84Q2	50.5	1115.3	1519.3	1691.0	48.0	1448.5	11909.0
Y84Q3	7.6	412.3	1308.4	1296.0	437.2	1907.5	12990.6
Y84Q4	28.8	269.0	130.1	1762.2	1599.5	5332.7	16983.5
Y85Q1	1189.1	69.4	570.0	745.0	654.6	4381.7	11842.8
Y85Q2	1043.0	3859.9	1308.4	550.5	103.8	3095.3	9570.9
Y85Q3	57.4	433.7	761.5	5990.7	1714.2	1256.6	6350.0
Y85Q4	10.8	2496.0	1029.3	591.5	1224.4	5004.9	17332.1
Y86Q1	71.4	178.6	499.7	8700.6	2465.9	3245.9	13077.9
Y86Q2	1430.6	524.5	928.3	1529.0	1647.1	1237.0	5141.7
Y86Q3	193.6	69.4	1477.0	1325.1	58.5	112.7	12035.9
Y86Q4	7.4	239.2	572.1	4494.5	1191.7	7820.3	13554.5
Y87Q1	1097.6	2294.7	2229.6	1757.3	130.1	3858.2	13799.0
Y87Q2	1075.2	6136.9	5994.4	304.2	1112.6	716.5	14322.3
Y87Q3	52.0	82.0	2234.8	2044.8	380.9	1227.3	15522.5
Y87Q4	580.6	64.6	894.3	3638.2	154.4	3063.5	15708.7
Y88Q1	461.6	50.9	1367.8	3990.7	293.6	5686.0	25021.9
Y88Q2	555.3	133.1	1635.2	3629.7	1483.5	1985.7	9696.4
Y88Q3	18.3	6.1	2198.0	5105.8	437.6	1782.0	14213.0
Y88Q4	3649.0	66.0	3702.4	1799.8	2252.0	9267.6	17526.6
Y89Q1	27.4	940.4	2248.5	4953.7	275.3	6436.9	19380.8
Y89Q2	45.5	1125.6	1406.9	1163.4	1520.8	1844.6	28449.4
Y89Q3	32.0	210.2	625.7	1593.0	85.0	3400.2	19375.3
Y89Q4	200.6	77.5	579.6	2860.5	1431.2	9837.9	15121.3
Y90Q1	2587.4	2179.6	3980.5	2296.5	809.5	2204.1	21288.7
Y90Q2	1468.0	4371.9	1918.1	2441.0	170.1	618.3	19930.9
Y90Q3	10.4	2405.8	3375.8	3273.4	474.3	143.6	18888.6
Y90Q4	1809.6	5345.6	35.3	3783.4	6507.6	39586.4	6795.7

Models for Testing Homogeneity
Category: Alcoholic Beverages and Cigarettes

Products Tested: Beer, Liquor and Wine

AIDS

$$w_{beer} = \alpha_{beer} + \gamma_{beer,beer}\log p_{beer} + \gamma_{beer,liqr}\log p_{liqr} + \gamma_{beer,wine}\log p_{wine} + \beta_{beer}\log(\frac{M}{P})$$

$$w_{liqr} = \alpha_{liqr} + \gamma_{liqr,beer}\log p_{beer} + \gamma_{liqr,liqr}\log p_{liqr} + \gamma_{liqr,wine}\log p_{wine} + \beta_{liqr}\log(\frac{M}{P})$$

$$w_{wine} = \alpha_{wine} + \gamma_{wine,beer}\log p_{beer} + \gamma_{wine,liqr}\log p_{liqr} + \gamma_{wine,wine}\log p_{wine} + \beta_{wine}\log(\frac{M}{P})$$

where M = Expenditure on beer, liquor, wine, and

$$P = w_{beer}.\log p_{beer} + w_{liqr}.\log p_{liqr} + w_{wine}.\log p_{wine}$$

Models for Testing Homogeneity

Category: Alcoholic Beverages and Cigarettes (Continued)

Products Tested: Beer, Liquor and Wine (continued)

SAIDS

$$w_{beer} = \alpha_{beer} + \gamma_{beer,beer}\log(\frac{p_{beer}}{a_{beer}}) + \gamma_{beer,liqr}\log(\frac{p_{liqr}}{a_{liqr}}) + \gamma_{beer,wine}\log(\frac{p_{wine}}{a_{wine}}) + \beta_{beer}\log(\frac{M}{P})$$

$$w_{liqr} = \alpha_{liqr} + \gamma_{liqr,beer}\log(\frac{p_{beer}}{a_{beer}}) + \gamma_{liqr,liqr}\log(\frac{p_{liqr}}{a_{liqr}}) + \gamma_{liqr,wine}\log(\frac{p_{wine}}{a_{wine}}) + \beta_{liqr}\log(\frac{M}{P})$$

$$w_{wine} = \alpha_{wine} + \gamma_{wine,beer}\log(\frac{p_{beer}}{a_{beer}}) + \gamma_{wine,liqr}\log(\frac{p_{liqr}}{a_{liqr}}) + \gamma_{wine,wine}\log(\frac{p_{wine}}{a_{wine}}) + \beta_{wine}\log(\frac{M}{P})$$

where M = Expenditure on beer, liquor, wine, and

$P = w_{beer}.\log p_{beer} + w_{liqr}.\log p_{liqr} + w_{wine}.\log p_{wine} + w_{cigs}.\log p_{cigs}$

Models for Testing Homogeneity
Category: Alcoholic Beverages and Cigarettes (continued)

Products Tested: Alcoholic Beverages (as a group) and Cigarettes

AIDS

$$w_{alc} = \alpha_{alc} + \gamma_{alc,alc}\log p_{alc} + \gamma_{alc,cig}\log p_{cig} + \beta_{alc}\log(\frac{M}{P})$$

$$w_{cig} = \alpha_{cig} + \gamma_{cig,alc}\log p_{alc} + \gamma_{cig,cig}\log p_{cig} + \beta_{cig}\log(\frac{M}{P})$$

where M = Expenditure on alcoholic beverages, cigarettes and

$$P = w_{alc}.\log p_{alc}+w_{cig}.\log p_{cig}$$

SAIDS

$$w_{alc} = \alpha_{alc} + \gamma_{alc,alc}\log(\frac{p_{alc}}{a_{alc}}) + \gamma_{alc,cig}\log(\frac{p_{cig}}{a_{cig}}) + \beta_{alc}\log(\frac{M}{P})$$

$$w_{cig} = \alpha_{cig} + \gamma_{cig,alc}\log(\frac{p_{alc}}{a_{alc}}) + \gamma_{cig,cig}\log(\frac{p_{cig}}{a_{cig}}) + \beta_{cig}\log(\frac{M}{P})$$

where M = Expenditure on alcoholic beverages, cigarettes and

$$P = w_{alc}.\log p_{alc}+w_{cig}.\log p_{cig}$$

Models for Testing Homogeneity

Category: Alcoholic Beverages and Cigarettes (continued)

Products Tested: Individual Alcoholic Beverages (Beer, Liquor, and Wine) and Cigarettes

AIDS

$$w_{beer} = \alpha_{beer} + \gamma_{beer,beer}\log p_{beer} + \gamma_{beer,liqr}\log p_{liqr} + \gamma_{beer,wine}\log p_{wine} + \gamma_{beer,cigs}\log p_{cigs} + \beta_{beer}\log(\frac{M}{P})$$

$$w_{liqr} = \alpha_{liqr} + \gamma_{liqr,beer}\log p_{beer} + \gamma_{liqr,liqr}\log p_{liqr} + \gamma_{liqr,wine}\log p_{wine} + \gamma_{liqr,cigs}\log p_{cigs} + \beta_{liqr}\log(\frac{M}{P})$$

$$w_{wine} = \alpha_{wine} + \gamma_{wine,beer}\log p_{beer} + \gamma_{wine,liqr}\log p_{liqr} + \gamma_{wine,wine}\log p_{wine} + \gamma_{wine,cigs}\log p_{cigs} + \beta_{wine}\log(\frac{M}{P})$$

$$w_{cigs} = \alpha_{cigs} + \gamma_{cigs,alc}\log p_{beer} + \gamma_{cigs,liqr}\log p_{liqr} + \gamma_{cigs,wine}\log p_{wine} + \gamma_{cigs,cigs}\log p_{cigs} + \beta_{cigs}\log(\frac{M}{P})$$

where M = Expenditure on beer, liquor, wine, cigarettes and

$$P = w_{beer}.\log p_{beer} + w_{liqr}.\log p_{liqr} + w_{wine}.\log p_{wine} + w_{cigs}.\log p_{cigs}$$

<u>Models for Testing Homogeneity</u>
Category: Alcoholic Beverages and Cigarettes (continued)

Products Tested: Individual Alcoholic Beverages (Beer, Liquor, and Wine) and Cigarettes (continued)

SAIDS

$$w_{beer} = \alpha_{beer} + \gamma_{beer,beer}\log(\frac{p_{beer}}{a_{beer}}) + \gamma_{beer,liqr}\log(\frac{p_{liqr}}{a_{liqr}})$$
$$+ \gamma_{beer,wine}\log(\frac{p_{wine}}{a_{wine}}) + \gamma_{beer,cigs}\log(\frac{p_{cigs}}{a_{cigs}}) + \beta_{beer}\log(\frac{M}{P})$$

$$w_{liqr} = \alpha_{liqr} + \gamma_{liqr,beer}\log(\frac{p_{beer}}{a_{beer}}) + \gamma_{liqr,liqr}\log(\frac{p_{liqr}}{a_{liqr}})$$
$$+ \gamma_{liqr,wine}\log(\frac{p_{wine}}{a_{wine}}) + \gamma_{liqr,cigs}\log(\frac{p_{cigs}}{a_{cigs}}) + \beta_{liqr}\log(\frac{M}{P})$$

$$w_{wine} = \alpha_{wine} + \gamma_{wine,beer}\log(\frac{p_{beer}}{a_{beer}}) + \gamma_{wine,liqr}\log(\frac{p_{liqr}}{a_{liqr}})$$
$$+ \gamma_{wine,wine}\log(\frac{p_{wine}}{a_{wine}}) + \gamma_{wine,cigs}\log(\frac{p_{cigs}}{a_{cigs}}) + \beta_{wine}\log(\frac{M}{P})$$

$$w_{cigs} = \alpha_{cigs} + \gamma_{cigs,alc}\log(\frac{p_{beer}}{a_{beer}}) + \gamma_{cigs,liqr}\log(\frac{p_{liqr}}{a_{liqr}})$$
$$+ \gamma_{cigs,wine}\log(\frac{p_{wine}}{a_{wine}}) + \gamma_{cigs,cigs}\log(\frac{p_{cigs}}{a_{cigs}}) + \beta_{cigs}\log(\frac{M}{P})$$

where M = Expenditure on beer, liquor, wine, cigarettes and

$$P = w_{beer}\cdot\log p_{beer} + w_{liqr}\cdot\log p_{liqr} + w_{wine}\cdot\log p_{wine} + w_{cigs}\cdot\log p_{cigs}$$

Models for Testing Homogeneity
Category: Fruit Products

Products Tested: Apples, Bananas, Oranges, Other Fruits

AIDS

$$w_{appl} = \alpha_{appl} + \gamma_{appl,appl}\log(p_{appl}) + \gamma_{appl,bana}\log(p_{bana}) + \gamma_{appl,orng}\log(p_{orng}) + \gamma_{appl,othr}\log(p_{othr}) + \beta_{appl}\log(M/P)$$

$$w_{bana} = \alpha_{bana} + \gamma_{bana,appl}\log(p_{appl}) + \gamma_{bana,bana}\log(p_{bana}) + \gamma_{bana,orng}\log(p_{orng}) + \gamma_{bana,othr}\log(p_{othr}) + \beta_{bana}\log(M/P)$$

$$w_{orng} = \alpha_{orng} + \gamma_{orng,appl}\log(p_{appl}) + \gamma_{orng,bana}\log(p_{bana}) + \gamma_{orng,orng}\log(p_{orng}) + \gamma_{orng,othr}\log(p_{othr}) + \beta_{orng}\log(M/P)$$

$$w_{othr} = \alpha_{othr} + \gamma_{othr,appl}\log(p_{appl}) + \gamma_{othr,bana}\log(p_{bana}) + \gamma_{othr,orng}\log(p_{orng}) + \gamma_{othr,othr}\log(p_{othr}) + \beta_{orng}\log(M/P)$$

where M = Expenditure on apples, bananas, oranges, other fruits and

$$P = w_{appl}.\log(p_{appl}) + w_{bana}.\log(p_{bana}) + w_{orng}.\log(p_{orng}) + w_{othr}.\log(p_{othr})$$

Models for Testing Homogeneity
Category: Fruit Products (continued)

Products Tested: Apples, Bananas, Oranges, Other Fruits (continued)

SAIDS

$$w_{appl} = \alpha_{appl} + \gamma_{appl,appl}\log(\frac{p_{appl}}{a_{appl}}) + \gamma_{appl,bana}\log(\frac{p_{bana}}{a_{bana}}) + \gamma_{appl,orng}\log(\frac{p_{orng}}{a_{orng}}) + \gamma_{appl,othr}\log(\frac{p_{othr}}{a_{othr}}) + \beta_{appl}\log(\frac{M}{P})$$

$$w_{bana} = \alpha_{bana} + \gamma_{bana,appl}\log(\frac{p_{appl}}{a_{appl}}) + \gamma_{bana,bana}\log(\frac{p_{bana}}{a_{bana}}) + \gamma_{bana,orng}\log(\frac{p_{orng}}{a_{orng}}) + \gamma_{bana,othr}\log(\frac{p_{othr}}{a_{othr}}) + \beta_{bana}\log(\frac{M}{P})$$

$$w_{orng} = \alpha_{orng} + \gamma_{orng,appl}\log(\frac{p_{appl}}{a_{appl}}) + \gamma_{orng,bana}\log(\frac{p_{bana}}{a_{bana}}) + \gamma_{orng,orng}\log(\frac{p_{orng}}{a_{orng}}) + \gamma_{orng,othr}\log(\frac{p_{othr}}{a_{othr}}) + \beta_{orng}\log(\frac{M}{P})$$

$$w_{othr} = \alpha_{othr} + \gamma_{othr,appl}\log(\frac{p_{appl}}{a_{appl}}) + \gamma_{othr,bana}\log(\frac{p_{bana}}{a_{bana}}) + \gamma_{othr,orng}\log(\frac{p_{orng}}{a_{orng}}) + \gamma_{othr,othr}\log(\frac{p_{othr}}{a_{othr}}) + \beta_{orng}\log(\frac{M}{P})$$

where M = Expenditure on apples, bananas, oranges, other fruits and

$$P = w_{appl}.\log(p_{appl}) + w_{bana}.\log(p_{bana}) + w_{orng}.\log(p_{orng}) + w_{othr}.\log(p_{othr})$$

Models for Testing Homogeneity
Category: Fruit Products (continued)

Products Tested: Fresh Fruits and Fruit Juice

AIDS

$$w_{\substack{fresh\\fruit}} = \alpha_{\substack{fresh\\fruit}} + \gamma_{\substack{fresh,\\fruit}\substack{fresh\\fruit}}\log(p_{\substack{fresh\\fruit}}) + \gamma_{\substack{fresh,\\fruit}\substack{fruit\\juice}}\log(p_{\substack{fruit\\juice}}) + \beta_{\substack{fresh\\fruit}}\log(M/P)$$

$$w_{\substack{fruit\\juice}} = \alpha_{\substack{fruit\\juice}} + \gamma_{\substack{fruit,\\juice}\substack{fresh\\fruit}}\log(p_{\substack{fruit\\juice}}) + \gamma_{\substack{fruit,\\juice}\substack{fruit\\juice}}\log(p_{\substack{fruit\\juice}}) + \beta_{\substack{fruit\\juice}}\log(M/P)$$

where M = Expenditure on fresh fruits as a group, fruit juice and

$$P = w_{\substack{fresh\\fruit}}.\log(p_{\substack{fresh\\fruit}}) + w_{\substack{fruit\\juice}}.\log(p_{\substack{fruit\\juice}})$$

SAIDS

$$w_{\substack{fresh\\fruit}} = \alpha_{\substack{fresh\\fruit}} + \gamma_{\substack{fresh,\\fruit}\substack{fresh\\fruit}}\log[(p_{\substack{fresh\\fruit}})/(a_{\substack{fresh\\fruit}})] + \gamma_{\substack{fresh,\\fruit}\substack{fruit\\juice}}\log[(p_{\substack{fruit\\juice}})/(a_{\substack{fruit\\juice}})] + \beta_{\substack{fresh\\fruit}}\log(M/P)$$

$$w_{\substack{fruit\\juice}} = \alpha_{\substack{fruit\\juice}} + \gamma_{\substack{fruit,\\juice}\substack{fresh\\fruit}}\log[(p_{\substack{fresh\\fruit}})/(a_{\substack{fresh\\fruit}})] + \gamma_{\substack{fruit,\\juice}\substack{fruit\\juice}}\log[(p_{\substack{fruit\\juice}})/(a_{\substack{fruit\\juice}})] + \beta_{\substack{fruit\\juice}}\log(M/P)$$

where M = Expenditure on fresh fruits as a group, fruit juice and

$$P = w_{\substack{fresh\\fruit}}.\log(p_{\substack{fresh\\fruit}}) + w_{\substack{frozen\\fruit}}.\log(p_{\substack{frozen\\fruit}})$$

Models for Testing Homogeneity
Category: Fruit Products (continued)

Products Tested: Fresh Fruits and Frozen Fruit

AIDS

$$w_{fresh\,fruit} = \alpha_{fresh\,fruit} + \gamma_{fresh\,fruit,\,fresh\,fruit}\log(p_{fresh\,fruit}) + \gamma_{fresh\,fruit,\,frozen\,fruit}\log(p_{frozen\,fruit}) + \beta_{fresh\,fruit}\log(M/P)$$

$$w_{frozen\,fruit} = \alpha_{frozen\,fruit} + \gamma_{frozen\,fruit,\,fresh\,fruit}\log(p_{fresh\,fruit}) + \gamma_{frozen\,fruit,\,frozen\,fruit}\log(p_{frozen\,fruit}) + \beta_{frozen\,fruit}\log(M/P)$$

where M = Expenditure on fresh fruits as a group, frozen juice and

$$P = W_{fresh\,fruit}.\log(p_{fresh\,fruit}) + W_{frozen\,fruit}.\log(p_{frozen\,fruit})$$

SAIDS

$$w_{fresh\,fruit} = \alpha_{fresh\,fruit} + \gamma_{fresh\,fruit,\,fresh\,fruit}\log[(p_{fresh\,fruit})/(a_{fresh\,fruit})] + \gamma_{fresh\,fruit,\,frozen\,fruit}\log[(p_{frozen\,fruit})/(a_{frozen\,fruit})] + \beta_{fresh\,fruit}\log(M/P)$$

$$w_{frozen\,fruit} = \alpha_{frozen\,fruit} + \gamma_{frozen\,fruit,\,fresh\,fruit}\log[(p_{fresh\,fruit})/(a_{fresh\,fruit})] + \gamma_{frozen\,fruit,\,frozen\,fruit}\log[(p_{frozen\,fruit})/(a_{frozen\,fruit})] + \beta_{frozen\,fruit}\log(M/P)$$

where M = Expenditure on fresh fruits as a group, frozen juice and

$$P = W_{fresh\,fruit}.\log(p_{fresh\,fruit}) + W_{frozen\,fruit}.\log(p_{frozen\,fruit})$$

Models for Testing Homogeneity
Category: Fruit Products (continued)

Products Tested: Processed Fruits and Frozen Fruit

AIDS

$$w_{\substack{procsd\\fruit}} = \alpha_{\substack{procsd\\fruit}} + \gamma_{\substack{procsd,\\fruit}\substack{procsd\\fruit}}\log(p_{\substack{procsd\\fruit}}) + \gamma_{\substack{procsd,\\fruit}\substack{frozen\\fruit}}\log(p_{\substack{frozen\\fruit}}) + \beta_{\substack{procsd\\fruit}}\log(M/P)$$

$$w_{\substack{frozen\\fruit}} = \alpha_{\substack{frozen\\fruit}} + \gamma_{\substack{frozen,\\fruit}\substack{procsd\\fruit}}\log(p_{\substack{procsd\\fruit}}) + \gamma_{\substack{frozen,\\fruit}\substack{frozen\\fruit}}\log(p_{\substack{frozen\\fruit}}) + \beta_{\substack{frozen\\fruit}}\log(M/P)$$

where M = Expenditure on processed fruits as a group, frozen fruit and

$$P = W_{\substack{procsd\\fruit}}.\log(p_{\substack{procsd\\fruit}}) + W_{\substack{frozen\\fruit}}.\log(p_{\substack{frozen\\fruit}})$$

SAIDS

$$w_{\substack{procsd\\fruit}} = \alpha_{\substack{procsd\\fruit}} + \gamma_{\substack{procsd,\\fruit}\substack{procsd\\fruit}}\log[(p_{\substack{procsd\\fruit}})/(a_{\substack{procsd\\fruit}})] + \gamma_{\substack{procsd,\\fruit}\substack{frozen\\fruit}}\log[(p_{\substack{frozen\\fruit}})/(a_{\substack{frozen\\fruit}})] + \beta_{\substack{procsd\\fruit}}\log(M/P)$$

$$w_{\substack{frozen\\fruit}} = \alpha_{\substack{frozen\\fruit}} + \gamma_{\substack{frozen,\\fruit}\substack{procsd\\fruit}}\log[(p_{\substack{procsd\\fruit}})/(a_{\substack{procsd\\fruit}})] + \gamma_{\substack{frozen,\\fruit}\substack{frozen\\fruit}}\log[(p_{\substack{frozen\\fruit}})/(a_{\substack{frozen\\fruit}})] + \beta_{\substack{frozen\\fruit}}\log(M/P)$$

where M = Expenditure on processed fruits as a group, frozen fruit and

$$P = W_{\substack{procsd\\fruit}}.\log(p_{\substack{procsd\\fruit}}) + W_{\substack{frozen\\fruit}}.\log(p_{\substack{frozen\\fruit}})$$

Models for Testing Homogeneity
Category: Fruit Products (continued)

Products Tested: Processed Fruits and Fresh Fruits

AIDS

$$w_{\text{procsd fruit}} = \alpha_{\text{procsd fruit}} + \gamma_{\text{procsd fruit, procsd fruit}} \log(p_{\text{procsd fruit}}) + \gamma_{\text{procsd fruit, fresh fruit}} \log(p_{\text{fresh fruit}}) + \beta_{\text{procsd fruit}} \log(M/P)$$

$$w_{\text{fresh fruit}} = \alpha_{\text{fresh fruit}} + \gamma_{\text{fresh fruit, procsd fruit}} \log(p_{\text{procsd fruit}}) + \gamma_{\text{fresh fruit, fresh fruit}} \log(p_{\text{fresh fruit}}) + \beta_{\text{fresh fruit}} \log(M/P)$$

where M = Expenditure on processed fruits as a group, fresh fruit and

$$P = W_{\text{procsd fruit}} \cdot \log(p_{\text{procsd fruit}}) + W_{\text{fresh fruit}} \cdot \log(p_{\text{fresh fruit}})$$

SAIDS

$$w_{\text{procsd fruit}} = \alpha_{\text{procsd fruit}} + \gamma_{\text{procsd fruit, procsd fruit}} \log[(p_{\text{procsd fruit}})/(a_{\text{procsd fruit}})] + \gamma_{\text{procsd fruit, fresh fruit}} \log[(p_{\text{fresh fruit}})/(a_{\text{fresh fruit}})] + \beta_{\text{procsd fruit}} \log(M/P)$$

$$w_{\text{fresh fruit}} = \alpha_{\text{fresh fruit}} + \gamma_{\text{fresh fruit, procsd fruit}} \log[(p_{\text{procsd fruit}})/(a_{\text{procsd fruit}})] + \gamma_{\text{fresh fruit, fresh fruit}} \log[(p_{\text{fresh fruit}})/(a_{\text{fresh fruit}})] + \beta_{\text{fresh fruit}} \log(M/P)$$

where M = Expenditure on processed fruits as a group, fresh fruit and

$$P = W_{\text{procsd fruit}} \cdot \log(p_{\text{procsd fruit}}) + W_{\text{fresh fruit}} \cdot \log(p_{\text{fresh fruit}})$$

Products Tested: Processed Fruits and Fresh Fruits

AIDS

$$w_{\substack{procsd\\fruit}} = \alpha_{\substack{procsd\\fruit}} + \gamma_{\substack{procsd\\fruit},\substack{procsd\\fruit}} \log(p_{\substack{procsd\\fruit}}) + \gamma_{\substack{procsd\\fruit},\substack{fresh\\fruit}} \log(p_{\substack{fresh\\fruit}}) + \beta_{\substack{procsd\\fruit}} \log(M/P)$$

$$w_{\substack{fresh\\fruit}} = \alpha_{\substack{fresh\\fruit}} + \gamma_{\substack{fresh\\fruit},\substack{procsd\\fruit}} \log(p_{\substack{procsd\\fruit}}) + \gamma_{\substack{fresh\\fruit},\substack{fresh\\fruit}} \log(p_{\substack{fresh\\fruit}}) + \beta_{\substack{fresh\\fruit}} \log(M/P)$$

where M = Expenditure on processed fruits as a group, fresh fruit as a group and

$$P = W_{\substack{procsd\\fruit}} \cdot \log(p_{\substack{procsd\\fruit}}) + W_{\substack{fresh\\fruit}} \cdot \log(p_{\substack{fresh\\fruit}})$$

SAIDS

$$w_{\substack{procsd\\fruit}} = \alpha_{\substack{procsd\\fruit}} + \gamma_{\substack{procsd\\fruit},\substack{procsd\\fruit}} \log[(p_{\substack{procsd\\fruit}})/(a_{\substack{procsd\\fruit}})] + \gamma_{\substack{procsd\\fruit},\substack{fresh\\fruit}} \log[(p_{\substack{fresh\\fruit}})/(a_{\substack{fresh\\fruit}})] + \beta_{\substack{procsd\\fruit}} \log(M/P)$$

$$w_{\substack{fresh\\fruit}} = \alpha_{\substack{fresh\\fruit}} + \gamma_{\substack{fresh\\fruit},\substack{procsd\\fruit}} \log[(p_{\substack{procsd\\fruit}})/(a_{\substack{procsd\\fruit}})] + \gamma_{\substack{fresh\\fruit},\substack{fresh\\fruit}} \log[(p_{\substack{fresh\\fruit}})/(a_{\substack{fresh\\fruit}})] + \beta_{\substack{fresh\\fruit}} \log(M/P)$$

where M = Expenditure on processed fruits as a group, fresh fruit as a group and

$$P = W_{\substack{procsd\\fruit}} \cdot \log(p_{\substack{procsd\\fruit}}) + W_{\substack{fresh\\fruit}} \cdot \log(p_{\substack{fresh\\fruit}})$$

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Educational Background

Ph.D. Virginia Polytechnic Institute and State University, Spring 1994
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MBA South Gujarat University, India, Spring 1985
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Honors and Awards

Department nominee for University-wide Graduate Student Teaching Award
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Research Interests

The effect of marketing mix elements on demand
Statistical issues in consumer research
Use of quantitative techniques to model marketing phenomena and consumer behavior

Teaching Interests

Marketing core courses: Marketing Strategy, Marketing Management, Product Management, Pricing Strategy, Advertising Management, International Marketing
Quantitatively oriented courses: Marketing Research, Multivariate Analysis

Dissertation

"The Effects of Price, Advertising, and Income on Consumer Demand: An Almost Ideal Demand System Investigation" (George R.Franke, Advisor)

In estimating sales response functions, marketing researchers have traditionally focused on the effects of marketing mix variables for individual products or brands. Economists, on the other hand, have shown a growing interest in the effects of price and income on systems of demand for broad product categories, while largely ignoring the effects of marketing mix variables. This dissertation integrates both research streams. Specifically, the Almost Ideal Demand System (AIDS) model is being used to examine patterns of consumer demand for food products.

This dissertation tests a fundamental assumption in consumer demand analysis, that demand is homogeneous of degree zero (i.e., that proportional changes in both price and budget constraints have no effect on consumer demand). An important issue in this context is determining how the marketing mix of one product affects the demand for other products. Both issues are addressed by using the AIDS approach to estimating demand.

This dissertation expands the AIDS model to include advertising effects. It provides an empirical framework for investigating the structure of consumers' mental accounts. It also sheds light on the patterns and effects of competition at the product level. Thus, this dissertation has potential implications for methodology, theory, and marketing management.

Refereed Publications

Mentzer, J. T. and V. H. Vashi, "Market Pricing of Real Estate Units: A Knowledge-Based System Approach," in 1993 Academy of Marketing Science Conference Proceedings.

Vashi, V. H. and M. J. Sirgy, "Toward an Attribution Model of Brand Loyalty," in Developments in Marketing Science, Vol. 15, 1992, Victoria L. Crittenden, ed. Chestnut Hill, MA: Academy of Marketing Science, 100-104.

Parsa, H. G., M. Khan and V. H. Vashi, "Assessment of Royalty Fee Structures in the Hospitality Franchise Systems: An Econometric Alternative," in 1991 Annual Council on Hotel, Restaurants and Institutional Education (CHRIE) Conference Proceedings, Houston, TX, 346-47.

Research in Progress

"The Use of Response Surface Methodology to Optimize Logistics Simulation Models," with Carol Bienstock and John T. Mentzer. Under second review at Journal of Business Logistics.

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Teaching Experience

Instructor, Department of Marketing, Virginia Polytechnic Institute and State University (Virginia Tech).

Term/Year	Course Title	Evaluation
Spring 1993	Product and Price Management, Senior level, 2 Sections	4.08, 4.38
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Summer 1992	Business Marketing Transactions, Senior level, 1 Section	4.18
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Fall 1991	Marketing Management, Junior level, 2 Sections	4.28, 4.50
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Instructor evaluations for tenure-track faculty across all undergraduate classes in the Virginia Tech Marketing Department have averaged between 3.80 and 3.90 over the past five years. Evaluations are measured on a 1-5 scale, with 5 = Excellent and 1 = Unsatisfactory.

Professional Affiliations

Academy of Marketing Science
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Industry Experience

May 1985- Aug. 1987	<u>Marketing Executive, Export Division,</u> <u>Unique Pharmaceutical Labs., Bombay, India</u>. Devised corporate marketing strategy for the company's pharmaceutical products in international markets. Responsible for overseas sales including overseas sales trips. Oversaw company's joint-venture project in Nigeria.
Apr. 1984- June 1984	<u>Summer Trainee, Travel Corporation (India)</u> <u>Ltd., Bombay, India</u>. Contributed to designing and implementing marketing programs to increase travel and tourism in India. Company adopted suggestions for improved handling of customer inquiries.
May 1979- June 1983	Free Lance Field Investigator and Analyst for various market research companies, India. Designed, conducted, and analyzed market surveys for various industrial and consumer products.

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