Food Demand in Canada: A Microeconometric Model Using Microdata

By 55

Edmund Kalabe Mupondwa

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FOOD DEMAND IN CANADA:

A MICROECONOMETRIC MODEL USING MICRODATA

BY

EDMUND KALABE MUPONDWA

A Thesis submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

DOCTOR OF PHILOSOPHY

DEDICATION

To My Beloved Mother and Father
Regina and Peter Kalabe Mupondwa:
For the Gift of Life.

IN MEMORY

... of My late Brothers and Sisters:
Evaristos Mupondwa, Fidelis Mupondwa,
Bernadette Mupondwa, and Angela Mupondwa...
.... tragically taken away at the height of my doctoral work.
This thesis is yours!!
....Rest In God's Peace, My Beloved Ones.

ACCREDITATION

This analysis is based on Statistics Canada 1984, 1986, and 1990 Food Expenditure Survey Microdata tapes which contain anonymized data collected in the 1984, 1986, and 1990 Food Expenditure Surveys. All computations on these microdata were prepared by the author and the responsibility for the use and interpretation of these results is entirely that of the author.

Abstract

Food Demand in Canada:
A Microeconometric Model Using Microdata
By Edmund K Mupondwa

Major Advisor:
Professor Barry T. Coyle, Ph.D
Advisory Committee Members:
Professor James A. Macmillan, Ph.D
Professor Wayne Simpson, Ph.D
External Examiner
Professor Xiao-Yuan Dong, Ph.D

This study uses Canadian microdata tapes to specify a microeconometric model in order to provide a matrix of price, expenditure, and demographic parameters for a system of food commodities in a theoretically consistent manner that permits a determination of how households allocate expenditures among disaggregated food commodities. Homogeneity, symmetry, and concavity are evaluated. The sensitivity of model parameters to different functional form specifications including sample selection bias is also evaluated.

Estimated results were quite plausible and consistent with *a priori* expectations. Demographic variables were found to have relatively significant effects on Canada's household food consumption patterns. The theoretical restriction of homogeneity was not rejected. However, the symmetry restriction showed inconsistency between the theory and the data. All elasticities were in compliance with the negativity condition of the Slutsky substitution matrix.

Sample selection bias was addressed via a generalized Tobit model incorporating censoring latent variables. Selection bias was found not to be a significant problem for the level of aggregation employed. An evaluation of the sensitivity of model parameters to different functional form specifications using an approach nesting the ALIDS and the Translog shows that these two models are more or less identical in terms of both explanatory power and estimated parameters.

The joint model was slightly superior statistically, but its elasticity estimates were close to those of the other two models.

The demand parameters can be used by policy makers and industry analysts in sensitivity analysis and in forecasting changes in food demand that are consistent with the changing structure of household food preferences in Canada. To our knowledge, this is the first study to successfully employ Canadian microdata in this way and represents a departure from previous studies that are predominantly based on time series.

Acknowledgements

Many people have played very important roles in the course of my graduate studies as well as in the eventual completion of this dissertation. I wish to make a variety of specific acknowledgements.

I owe a great intellectual debt to my advisory committee for their guidance and support. I thank my major advisor Dr. Barry Coyle for his invaluable help and for giving me unconstrained access to his creativity, knowledge and experience as well as helping me to see beyond my monstrous data set. Dr. James MacMillan and Dr. Wayne Simpson continued to provide sound technical help with both the theoretical and empirical implementation of various aspects of my model in spite of my voluminous drafts. In addition, Dr. MacMillan also provided a major stimulus for me to undertake this subject area at a crucial time when data limitations had forced me to abandoned an earlier study. I also thank my external examiner, Dr. Xiao-yuan Dong for her invaluable feedback and comments. These individuals have been collectively responsible for a substantial improvement in methodological approach, precision, and clarity.

I thank my colleagues Dr. Christie Ezeife for introducing me to the wonderful world of computer programming, and Dr. Rale Gjuric for his slide software and expertise. I owe my gratitude to Dr. Al (R.M.A.) Loyns and Dr. John Loxley for their guidance, support, and encouragement when I undertook my earlier dissertation topic. For financial support during the entire course of my studies, I wish to thank Dr. Loyns and Dr. MacMillan for the opportunity to work as coordinator of research management training programs of the Department. Special thanks are also due to Agriculture Canada for a research grant and to Dr. Len Siemens for providing administrative support. I also appreciate the courtesy accorded me by Ms. Robin Chaplin and Mr. Iain Clogg of Statistics Cananda. I owe considerable intellectual debt to the staff of the Departments of Agricultural Economics and Economics. I extend my appreciation to the support staff of my Department, especially Debra Henry, Bonnie Warkentine, Elaine Negrych, Vydehi Venkataraman, and Neil Longmuir for their invaluable administrative support as well as creating a cordial working environment, and to Mrs. Helen Agar of the Faculty of Graduate Studies for her courtesy in expediting the process leading up to my convocation. To my fellow graduate students: in the refuge of our ANNEX, we toiled and redefined the axiom of revealed preference.

I express my special thanks to my family the Katepas and the Mupondwas for always being there - thousands of kilometers away, and yet ever so present. Behind this "success story" are my lovely wife and friend Dr. Felicitas Katepa Mupondwa and my incomparable son Master Lwando Mundi Kizito Mupondwa. They bore the brunt of my long hours of absence from home. No amount of poetry can adequately characterize their inspiration, strength, friendship, and unconditional love. Thanks. I love you too!!

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Chapter 1

Introduction

1.1 Statement and Scope of the Problem

Canadian household expenditures on food have averaged $31 billion over the past decade, representing a very significant proportion of the food marketing bill. For instance, household food expenditure on meat alone has averaged $10.5 billion during this period while at the farm level, farm cash receipts from livestock sales have totalled $3.1 billion, representing 25 percent of total on-farm cash receipts. Clearly, retail demand for food products is important for the vitality of the food industry as a whole and an understanding of the structure of household consumption should be an integral part of agricultural policy analysis. In particular, knowledge of how various economic variables such as prices and expenditure affect the structure and pattern of household food consumption can be beneficial to policy makers and planners both in government and the private sector in the formulation and evaluation of various food, nutrition, income, and agricultural support programs and policies. Managers in the food industry could use such information for strategic planning.

A number of studies in Canada and the United States of America have provided empirical evidence and explanations regarding the apparently changing structure of food consumption. Canadian studies include Moschini and Moro [1993], Toichoa, MacMillan, and Coyle [1993], Chen and Veeman [1991], Reynolds and Goddard [1991], Goddard [1983], Atkins, Kerr, and McGivern [1989], and Green, Hassan, and Johnson [1979]. U.S. studies include Moschini and Meilke [1989], Eales and Unnevehr [1988,1993], Chalfant and Alston [1988], Heien and Pompelli [1988], and Thurman [1987]. The first explanation is based on a phenomena called structural change which attributes changes in food consumption to dramatic shifts in consumer preferences due to health consciousness among households, in particular that overconsumption of foods high in cholesterol and monosaturated fats leads to heart disease and other health problems. This has induced household preferences to shift away from foods such as red meats which contain more cholesterol and monosaturated fats relative to white meats like poultry and fish.

Changes in the demographic composition of the population have also been reported. For instance, it has been observed that there has been an increase in the number of two-income or single person households. Such a family unit, it is argued, has a stronger preference for "convenience" in the kitchen. Statistics Canada [1991] reports that the proportion of dual -earner families increased from 33 percent in 1967 to 62 percent in 1989. Similarly, there has been a dramatic increase in the number of women with employment income: from 44 percent in 1970 to 60 percent in 1986. In a U.S. study, Eales and Unnevehr [1988] report that between 1960 and 1985, the proportion of women who work outside the home increased from 35 percent to 50 percent, households headed by women increased from 18 percent to 28 percent, and single-person households increased from 13 percent to 24 percent of all households. Given that traditional food products demand more preparation time, it is normal to expect that more families of this type would prefer food products that are easier to prepare. Related to this point is the dramatic growth in the fast food industry, and in particular, the introduction of franchise chicken fast food chains and restaurants. Statistics Canada [1990] reports that the proportion of food spent away from home has doubled. [See Goddard, 1983, for a more systematic analysis of food away from home].

The second explanation is based on traditional variables such as relative prices, and income as opposed to a dramatic change in consumer preferences. This second aspect is not considered structural change since structural parameters in this case are invariant with respect to changes in prices, income, and demographics.

Although the conclusions from these studies are mixed, there are strong indications that North American households in general are becoming less sensitive to prices and incomes when allocating their household budget to various food categories. Clearly, these observed changes in the structure of food demand have major implications for the Canadian food industry as a whole, especially if these trends continue in future years.

In view of these considerations, it is important to obtain reliable and valid parametric measures of the impact of prices, expenditure and other variables which can then be employed to explain current economic conditions in the food sector as well as forecast short run and long run movements in consumption patterns that are consistent with anticipated changes in the structure of these demand relationships.

Although significant progress has been made in understanding the existing structure of Canadian food demand to date, the modelling of Canada's retail demand has been based primarily on aggregate time series demand analysis.[1] We know from econometric theory that the estimation of complete demand systems based on time series data provide price and income elasticities for all households as a whole but yield few implications for demand by demographic attributes. This is basically because much of the variation in demographic attributes occurs across households within regions at a specific point in time rather than across regional average values or time periods. Hence, it does not necessarily follow that the expenditure elasticity obtained from a cross-section of households is conceptually similar to that pertaining to the behaviour of an aggregate household. In particular, time series data usually comprise annual or quarterly observations, which means that the most we can get from such data are short run elasticities owing

[1] Exceptions are Green, Hassan, and Johnson [1979], and Nicol [1987,1988]. Green *et. al.* used a Linear Expenditure System while Nicol employed a third order Translog. However, both studies are conducted at very high levels of aggregation in which food was one of the food aggregates considered. Further more, both studies utilized Family Expenditure Surveys which do not disaggregated by food using the universal classification code.

to the fact that households do not completely and instantaneously adjust to changes in prices or total expenditure due to habit formation.

By far the most acute problems associated with aggregate data has to do with modelling microeconomic relationships. First, it is well known that the utility maximization framework enables us to define restrictions on our model so as to reduce the number of parameters in a demand system. However, data on prices and expenditures are available only at the aggregate level over time, thus creating what is known as the aggregation problem in the sense that there is no reason why microeconomic theory which is couched it terms of an individual economic agent should be directly applicable to aggregate data. Since microeconomic relationships cannot simply be added together to provide macro relationships of the same form, the relevant question is one of consistent aggregation: under what conditions can consumer theory be consistent with behaviour at the aggregate or market level? This issue has been addressed by Lau [1977, 1978, 1982], Muellbaeur [1977], and Jorgenson, Lau, and Stoker [1982], *inter alia*, who have defined conditions for consistent aggregation. However, the conditions which guarantee unbiasedness in the use of aggregate data are very restrictive and are not likely to be satisfied in practice.

By contrast, the use of household level data allows us to estimate disaggregated price and expenditure elasticities consistent with the demographic profile of a given group in the population. It also permits us to analyze socioeconomic variables and their impact on household consumption decisions. In addition, we have greater flexibility in the choice of functional form and size of model since the problem of degrees of freedom typically associated with aggregate models is minimized.

In view of the fact that previous Canadian studies have generally employed aggregate data, with a few exceptions, it is hoped in this study that estimating a theoretically consistent complete demand system using Statistics Canada's comprehensive Microdata tapes will provide updated estimates of disaggregated household food demand that are consistent with utility theory and which accurately reflect food consumption behaviour among Canadian households.

1.2 Study Objectives

In the light of the above context, the overall objective of this study is to investigate the demand side of the food sector in Canada using comprehensive household survey data for the years 1984, 1986, and 1990. The research will mainly focus on the consumption behaviour of the household in order to ascertain the socio-economic and demographic factors that influence food expenditure. It is hoped that this emphasis on the micro level involving a sufficiently disaggregated set of foods helps to bridge the gap between theoretical and empirical demand analysis in Canada. An econometric framework based on a flexible system of demand equations is employed to achieve the following specific objectives:

1. To manage a new Microdata set in a manner that accurately represents the food market in Canada;
2. To specify and estimate an appropriate flexible functional form based on duality theory and a two-stage budgeting procedure in order to provide a complete set of demand parameters (own price and cross price, and expenditure elasticities) for a system of food commodity groups in a theoretically consistent manner that permits a determination of how households allocate expenditure among disaggregated food commodity groups.
3. To determine the degree of substitutability among disaggregated foods.
4. To evaluate the empirical validity of theoretical restrictions on demand systems;
5. To evaluate the sensitivity of model parameters to different functional form specifications;
6. To assess the significance of sample selectivity bias;

7. To evaluate the significance of demand parameters and elasticities in the context of Canada's food and agricultural policies and the food industry in general.

1.3 Organization of Study.

The rest of this study is organized as follows. Chapter 2 presents a review of consumer demand theory as it relates to food demand in Canada. This will include issues such as aggregation, separability, and how to incorporate demographic variables. Chapter 3 discusses data sources and preparation. Chapter 4 presents a stage-two analysis of household demand for a disaggregated set of food commodities employing the Almost Ideal Demand System (ALIDS). This includes tests of theoretical restrictions. Chapter 5 estimates a generalized Tobit to evaluate the significance of sample selection bias. Chapter 6 presents a study comparing two popular flexible functional forms using a nested framework suggested by Lewbel. All the models are extended to incorporate demographic variables. Summary and conclusions are presented in Chapter 7.

Chapter 2

Theoretical Considerations

2.1 Introduction

This study employs a demand systems approach based on consumer theory to calculate a complete demand matrix for food commodity groups in Canada. In this Chapter, a review of neoclassical utility theory is presented, including separability properties of consumer preferences, and the incorporation of demographic variables into a theoretically plausible complete demand system. Since the theory of demand has been extensively treated, this study will present only an overview of the theory. Detailed treatment of the subject can be found in Varian [1992], Pollak and Wales [1992], Theil and Clements [1987], Deaton and Muellbaeur [1980], Deaton [1986], Phlips [1983], and Johnson, Hassan and Green [1984].

This chapter is divided into six sections. Section 2.2 presents a summary of the theoretical foundations of household utility theory and the demand systems approach, including restrictions derived from demand theory. Section 2.2 reviews the duality approach to deriving a complete demand system. Section 2.3 discusses aggregation over commodities including separability conditions and two stage budgeting. Aggregation over agents is presented in Section 2.4 while Section 2.5 presents methods of incorporating demographic variables.

2.2 The Demand Systems Approach: A Theoretical Framework

The utility maximization problem can be written as

$$V(P,Y) = \underset{x}{Max}[U(X) \colon P^{T}X = Y] \tag{2.1}$$

where $U(X)$ is a utility function corresponding to consumer preferences, and $V(P,Y)$ is the dual indirect utility function relating maximum utility to prices P and income Y. $V(P,Y)$ has the following properties:

1) $V(P,Y)$ is decreasing in P, and increasing in Y.

2) $V(P,Y)$ is homogeneous of degree zero in (P,Y).

3) $V(P,Y)$ is quasi-convex in P.

4) Roy's theorem applies: i.e. given $V(P,Y)$, we can apply Roy's identity which states that if we take a Marshallian demand $X_i(P,Y)$ for the i^{th} product and $P>0$ and $Y>0$, then it is equal to:

$$-\frac{\frac{\partial V(P,Y)}{\partial P_i}}{\frac{\partial V(P,Y)}{\partial Y}} = X_i(P,Y) \qquad 2.2$$

which is our envelope theorem for the Marshallian consumer demand model.

Assuming local nonsatiation and continuity of $U(X)$, a commodity vector X^* solves the above utility maximization problem if and only if it solves the following expenditure minimization problem:

$$E(P,U) = \underset{x}{Min}\ [P^TX : U(X) = U*] \qquad 2.3$$

where $U^* \equiv U(X^*)$, and $E(P,U)$ is the dual expenditure function relating minimum cost to prices P and utility level U. The expenditure function has the following properties:

1) it is linearly homogeneous and concave in P;

2) it is increasing in (P,U).

3) the partial derivative of $E(P,U)$ with respect to prices generates Hicksian demand functions, the derivative property called Shephard's lemma: i.e.

$$\frac{\partial E(P,U)}{\partial P} = X^c(P,U) \qquad 2.3$$

Note of course that in actual empirical work, we work with Marshallian demands. Since these demands are derived from competitive utility maximization behaviour, they must be integrable up to a macro function, *V(P,Y)* or equivalently, *E(P,U*)*. Utility maximization implies that Marshallian demands are homogeneous of degree zero in *(P,Y)* and the matrix of Slutsky terms

$$\left(\frac{\partial X_i^m(P,Y)}{\partial P_j} + \frac{\partial X_j^M(P,Y)}{\partial Y} X_j(P,Y)\right)_{NxN} = \left(\frac{\partial X_i^c(P,U*)}{\partial P_j}\right)_{NxN} = [s_{ij}]_{NxN} \qquad 2.4$$

is symmetric negative semidefinite. In turn, this symmetry condition establishes integrability. The Slutsky equation decomposes the demand change induced by a price change into two effects: substitution effect and income effect. The term on the right hand side is the substitution effect of a price change which is always negative for S_{ii}. The first term on the left hand side is the total effect. The second term is the income effect and it is negative for inferior goods. The Slutsky matrix is often used to group commodities into substitutes and complements. Hence,$[S_{ij}] < 0 \Rightarrow$ good i and j are complements; $[S_{ij}] > 0 \Rightarrow$ good i and j are substitutes. For a detailed discussion, see Henderson and Quandt [1980], Varian [1992], and Phlips [1983].

A major advantage of the dual approach to modelling consumer behaviour is that closed form solutions for demands can be obtained using flexible functional forms to approximate the dual. Examples of flexible functional form specifications of demand systems include the generalized Cobb-Douglas demand system (Diewert, 1973), the indirect Translog (Christensen, Jorgenson, and Lau, 1975), the generalized Leontief (Diewert, 1974), the Almost Ideal Demand System (ALIDS) (Deaton and Muellbauer, 1980) derived from an expenditure function with a

PIGLOG preference structure, and the normalized quadratic expenditure function (Diewert and Wales, 1988). In addition to these are the Miniflex Laurent demand systems (Barnett, 1985; Barnett and Lee, 1985; Barnett, Lee, and Wolfe, 1987): i.e. the Miniflex Generalized Leontief and the Miniflex Translog which not only appear to violate theoretically approximate curvature conditions less often than the indirect Translog and the Generalized Leontief, but also have the added advantage of exhibiting regions where the violation of curvature conditions occur.

Apart from these flexible parametric demand systems, applied econometricians have also developed what can be referred to as Semiparametric demand systems: these are the Fourier demand systems (Gallant 1981,1984) and the asymptotically ideal model (Barnett and Yule, 1988) based on the Muntz-Szatz series expansion. Both the Fourier and the asymptotically ideal models possess properties of global flexibility as well as ease in testing or imposing theoretical regularity conditions. Empirical applications of these Semiparametric forms include Gallant [1984], Chalfant and Gallant [1985], and Chalfant [1987]. This study will adopt a flexible functional form in order to exploit the full advantages implied by these specifications.

2.3 Aggregation over Commodities

One of the most challenging tasks in applied demand analysis is the large number of commodities the consumers must choose from. Estimating this behaviour can indeed be an onerous task since for any completely unrestricted model of n commodities, a total of $n(n+1)$ parameters must be estimated: that is, n^2 own- and cross-price elasticities, and n income elasticities. In order to manage econometric estimation, general restrictions (homogeneity, adding-up, and symmetry) can be imposed, thereby reducing the number of parameters to $[\frac{1}{2}n(n+1)] - 1$, which clearly may still be too large for estimation [Capps and Havlicek, 1987]. A convenient way is to use the idea of separability to reduce the dimensionality of the estimation problem and hence increase the degrees of freedom in estimation. In the next paragraphs, we discuss the concept of separability and how it can be used to achieve the objectives of our study.

2.3.1 Weak Separability

This is a less restrictive form of separability. According to Goldman and Uzawa [1964], a utility function is weakly separable with respect to a partition of a commodity space $(X_1,...,X_s)$ (where s is the number of mutually exclusive and exhaustive subsets) if and only if $U(X)$ is of the nonadditive form:

$$U(X_1,X_2,...,X_n) = F[U_1(X_1),\ U_2(X_2),...,\ U_s(X_s)] \tag{2.5}$$

and the marginal rate of substitution

$$\frac{\partial\left(\dfrac{U_i}{U_j}\right)}{\partial X_k} \qquad \forall\ i,j \in G_s \quad k \in G_s \quad s=1,...,S \tag{2.6}$$

between any two goods in the group is independent of the quantity of any commodity outside the group, so that we can also write $U(X_1,..,X_g,\ X_h,...,X_n)$ as

$$U = U\ [f_a(X_1,...,X_g),\ f_a(X_h,...,X_j),\ f_c(X_k,...,X_n)] \tag{2.7}$$

The utility function is said to be weakly separable since it is expressed in terms of the aggregates (e.g. food, clothing, etc.) Thus, weak separability imposes some restrictions on the degree of substitutability between commodities in different subsets. For instance, if groups a and b are substitutes for each other, all pairs of commodities, one from each group, must also be substitutes or complements. Weak separability has a number of important implications. First, all cross-price elasticities between commodity groups require only the knowledge of the income elasticities and at least one intergroup coefficient. The intergroup coefficients are measures of the degree of substitutability among commodity groups. Second, the cross-price elasticities among commodity groups are proportional to the relevant income elasticities. These relationships suggest a substantial number of parameter restrictions which reduce the number of parameters to be estimated [Raunikar and Huang, 1987].

2.3.2 Two-Stage Budgeting Procedure.

In most applied work, we are interested in weak separability because we can use it to justify not only the inclusion of aggregates (quantities and prices) to represent single commodities, but also to justify the so-called two-stage or multi-stage budgeting. As shown by Gorman [1959] and Blackorby *et al.* [1970], weak separability is equivalent to Strotz's [1957] utility tree and is a precondition for the consistency of the two-stage budgeting procedure. Gorman in particular has shown how weak separability or two-stage budgeting permits expenditure allocations within groups to be determined solely by the within-group relative prices and the allocations of expenditure to that group.

The fundamental idea of Stroz's utility tree (and Brown and Heien's [1972] S-branch utility) is that we can classify commodities into some familiar groups by looking at their relationships in terms of complementarity, substitutability, and independence.[2] Thus, at the first stage, households allocate total expenditure to broad categories of commodities (e.g. food, nonfood). At subsequent stages, expenditure is allocated to more disaggregated commodities (e.g. red meat, white meat, grain cereals, etc.) This procedure continues until each of the specific commodities is attained along one of the branches of the utility tree. Hence, Stroz's utility tree

[2] This can be shown by examining the second order condition for utility maximization: if $U_{ij}>0$, then the commodities are complements; if $U_{ij}<0$, they are substitutes; and if $U_{ij}=0$, they are independent. Notice that these second order partials are directly related to the Hessian matrix and hence provide information about how consumers rank their preferences. This issue is taken up in Chapter 4 when we discuss results.

enables the entire demand system to be subdivided into smaller subdemand systems, each of which is conditional on prices and expenditures in that subset only [Pollak, 1969,1971]. For instance, the demand for the i^{th} commodity in subsystem s is a function of prices of commodities and expenditures on commodities in that s group only. Notice the obvious econometric advantage in this budgeting procedure: the household's consumption behaviour is explained by a much smaller number of explanatory variables.

Let X_i^h represent a possible n-vector of commodities for household h with a corresponding price vector P. Also let M^h denote that household's expenditure. The assumption of two-stage budgeting implies that we can partition X and the corresponding price vector into subsets ranging, say, from a to s and each subset has N commodities, so that in total there are $N_a + N_b + \ldots + N_s$ commodities. In this case, the household's indirect utility preferences are separable in X_i^{Ni} and P_i^{Ni} $i=1,..,s$ if and only if

$$V(P,Y) = H[V_a(\cdot),\ldots,V_s(\cdot)] \qquad 2.8$$

and H inherits all the properties of the indirect utility function. First the consumer solves a utility maximization problem in which she allocates total expenditure $Y = Y_a + \ldots + Y_s$ to broad commodity groups $X_a,\ldots,X_s$ where Y^* is the optimal amount that she spends on X_i $(i=a,\ldots,s)$. Stage two involves intersectoral allocation in which the consumer decides to allocate broad-group expenditures $Y^* = Y_a^* + Y_b^* + \ldots + Y_s^*$ in an optimal way among the commodities within each group by solving a set of subutility maximization problems defined over all individual commodities in that group. This makes it possible to derive a demand function for any good i within, say, group a as a function of total within-group expenditure Y_a and prices P_a within that group only. Hence,

$$X_a^i = X_a^i(P_a, Y_a) \qquad 2.9$$

which implies that consumer preferences are weakly separable.[3]

As stated earlier, a utility function is weakly separable with respect to a partition of a commodity space $X_a,\ldots,X_s$. if and only if some macro utility function $U(X)$ is of the nonadditive form;

$$U(X) = \bar{U}\,[U^a(X_a^1,\ldots,X_a^{Na}),\ldots,U^s(X_s^1,\ldots,X_s^{Ns})] \qquad 2.10$$

Maximizing subutility functions U^i conditional on group expenditures $Y_a,\ldots,Y_s$ generates the same solution X^* if and only if $U(X)$ is weakly separable. This macroutility function implies that the marginal rate of substitution between any two commodities in the same group is independent of the quantity demanded of any commodity outside that group.

Several important results follow from this. From the demand function for commodity i in group a, $(X_a^i(P_a,Y_a))$, we can observe the effect of prices outside group a on X_a^i. Taking the partial derivative of X_a^i with respect to P_b (the price of a commodity in group b), we have

$$\frac{\partial X_a^i}{\partial P_b} = \frac{\partial X_a^i}{\partial Y_a}\frac{\partial Y_a}{\partial P_b} \qquad 2.11$$

for any good $i=1,\ldots,N_a$ in group a and $j=1,\ldots,N_b$ in group b. And for any i in group a, we can assess the effect of a change in total expenditure, Y, on X_a^i. Differentiating, we have

$$\frac{\partial X_a^i}{\partial P_b} = \frac{\partial Y_a/\partial P_b}{\partial Y_a/\partial Y}\frac{\partial X_a^i}{\partial Y} \qquad 2.12$$

What we are basically saying here is that as the price of commodity $j=1,\ldots,N_b$ not in group a varies, the cross-price responses of all commodities $i=1,\ldots,N_a$ within group a are proportional to their expenditure responses. It is clear that prices outside group a affect commodity-group a

[3] Notice that Y_a is endogenous. For estimation, we need to use a GLS or IV method. This point is taken up in Chapter 4.

demands, X_a^i, only via changes in the optimal expenditure level Y_a for the group.

Thus, while weak separability imposes substantial restrictions on the degree of substitutability between commodities in different groups, it enables us to truncate the multitude of commodities faced by a consumer to a manageable level. In addition, substitution between commodities within the same group is not influenced by our weak separability assumption.[4] In so doing, we can appeal to the theory and avoid ad hoc procedures.

It must be pointed out nevertheless that weak separability is only a necessary but not sufficient condition for two-stage budgeting: if $U(X)$ is weakly separable, then the second stage exists. However, it is not sufficient for the existence of the first stage. A sufficient condition for the existence of the first stage, given a weakly separable utility function is homotheticity of the individual subutility functions $U^a(X_a),...,U^s(X_s)$. Given these conditions, the first stage maximization problem generates the same distribution of expenditures $Y_a,...,Y_s$ as the general maximization problem.

In actual empirical work, we would proceed as follows in implementing these ideas:

1. Given a weakly separable IUF, our conditional IUF can be written as:

$$V(P,Y) = H[V_1(P_1,Y_1),...,V_m(P_m,Y_m)] \qquad 2.13$$

where $Y = (Y_1,...,Y_m)$ is an m-vector of sectoral expenditure allocations.

2. Roy's identity can be applied to a specified form of V^r to obtain conditional subdemand functions, i.e.:

$$X_i^r = g_i^r(P^r,Y^r) = -\frac{\partial V^r(P^r,Y^r)/\partial P_i^r}{\partial V^r(P^r,Y^r)/\partial Y^r} \qquad 2.14$$

[4] Note that this same standard must continue to apply to the substitution of commodities in, say, group a for commodities in group b. This relationship between commodities in different groups is best summarized by Deaton and Muellbauer [1980b] who state that "since the branches of the tree are the only means of contact between goods in different groups, responses to price changes and total expenditure changes must use the same channels and hence bear a close relation to one another" [p.129]

for $i=1,...,N_r$, $r=1,...,m$, where N_r is the number of commodities in group r.

3. Estimates of the m subdemand systems can be derived given sectoral prices P^r and expenditures Y^r, and consumption X_i^r.

4. The parameter estimates of the m subsystems can be used to derive the sectoral expenditure allocation Y^r as a solution to the following:

$$V^r(P,Y) = \underset{Y^1,...,Y^m}{Max} \{H[V^1(P^1,Y^1),V^2(P^2,Y^2),...] : \Sigma Y^r \leq Y,\ Y^r \geq 0\} \qquad 2.15$$

In order to make this useful for empirical purposes, an aggregate price index for each group must be specified.

5. Substituting $V^r(P,Y)$ into the conditional demand function, $g_i^r(P^r,Y^r)$ generates the complete demand system

$$X_i^r = g_i^r[(P^r,Y^r(P,Y)] \quad \forall\ i,\ r \qquad 2.16$$

The complete demand system which combines the treatment of a household's characteristics and the nature of its preferences is:

$$X_i^r = g_i^r[(P^r,Y^r(P,Y,\Omega),\Omega] \qquad 2.17$$

$i=1,...,n_r$; $r=1...,m$, where the demographic variables, Ω, enter through translation, scaling, or direct fashion. Section 2.5 discusses the incorporation of demographic variables in detail.

Econometrically, the two-stage budgeting procedure described above does nevertheless entail very restrictive assumptions about the covariance of the error terms across various equations. These restrictive assumptions are required if the parameter estimates of the subsystems of conditional demand functions are to retain their optimal properties. Thus, the covariances between error terms in the various subdemand systems must vanish and there must exist no correlation between the error term of each conditional demand equation and the group error terms. Further, the error terms in a given subsystem must be uncorrelated with the errors in all other subsystems. For details, see Blackorby *et. al.*[1978].

2.4 Aggregation Over Agents

In any study using time series (aggregate) data, the issue of aggregation over agents is of fundamental concern and receives inadequate attention in a number of empirical studies. The aggregation problem has been referred to in Chapter One and has to do with the question: under what conditions can micro relationships be added together to provide a macrorelationship of the same form? In other words, how can consumer theory which refers to an individual's demand for individual food and nonfood products be consistent with behaviour at the aggregate level? Are the theoretical restrictions which relate to data at the individual level consistent with data that has been aggregated over consumers? The theory of aggregation, which we now turn to, provides sufficient conditions for exact aggregation, i.e. conditions under which aggregate consumer behaviour can be treated as though it resulted from the actions of a single utility maximizing individual. In the absence of these conditions, we cannot justifiably apply the theory of the consumer to aggregate level data.

In order to show conditions for exact linear aggregation over individuals, let a household's demand for commodity i be given by

$$X_i^h = f_i^h(P,Y^h) \qquad 2.18$$

If we let H be the total number of households, then summing over h households yields the aggregate (market) demand function

$$\sum_h X_i^h(P,Y^h) = X_i(P, \Sigma Y^h) \qquad 2.19$$

which is the condition for the existence of the aggregate demand function. For H households, the average demand, X° is

$$X_i = f_i(P, Y^1, Y^2, ..., Y^H) = \frac{1}{H} \sum_h X_i^h(P, Y^h) \qquad \forall f_i, i. \tag{2.20}$$

A comparison of 2.19 and 2.20 brings out an important fact. In equation 2.19, X_i depends on the distribution of expenditures Y^h and 2.20 depends only on average income, implying that in the latter case, the marginal propensity to consume across n households are identical. In other words, the allocation of expenditures by rich households is the same as that for poor households. This is clear if we differentiate 2.19 with respect to Y^h:

$$\frac{\partial X_i(P, \Sigma_h Y^h)}{\partial Y^h} = \frac{\partial X_i^h(P, Y^h)}{\partial Y^h} \tag{2.21}$$

noting that $Y=\Sigma_h Y^h$ with linear aggregation. This implies that the n different marginal propensities to consume for all consumers are the same: a reallocation of a dollar from one household to another does not affect market demands. Relating to 2.20, this interpretation is obvious: changes in expenditure allocation that preserve the mean, $\hat{Y}$, do not affect market demand, which is basically the standard condition of parallel linear Engel curves credited to Gorman [1953, 1961] who has shown that in order for the marginal propensities to consume to be identical across households, the indirect utility function must have the form

$$V^h(P, Y^h) = \alpha^h(P) + \beta(P) Y^h \tag{2.22}$$

where α^h and β are such as to ensure V^h is an indirect utility function. This specification is called the *Gorman Polar Form*. It can be shown by Roy's identity that the h^{th} household demands associated with these preferences are also of the Gorman polar form:

$$X_i^h = a_i(P) + b_i^h(P) Y^h \tag{2.23}$$

where

$$a_i(P) = -\frac{1}{\beta(P)}\frac{\partial\alpha^h}{\partial P_i} \quad , \quad b_i^h = -\frac{1}{\beta(P)}\frac{\partial\beta}{\partial P_i} \qquad 2.24$$

Note that $b(P)$ and $\beta(P)$ are independent of h, i.e. constant across households, so that a dollar transfer from any one household to another will not alter the pattern of aggregate demand. In this case, the (Marshallian) aggregate demand for the i^{th} commodity will be

$$X_i(P,Y_1,Y_2,...,Y_n) = \Sigma_h X_i^h = a_i(P) + b_i(P)Y \qquad 2.25$$

where $Y=\Sigma_h Y^h$, and $bi(P)=\Sigma b_i^h(P)$, and the representative indirect utility function associated with it is

$$V(P,Y) = \alpha(P) + \beta(P)Y \qquad 2.26$$

It is of course important to note the correspondence between the indirect utility function (and hence the Marshallian demands) and its inverse, the expenditure function, $E(P,U)$ (and hence the Hicksian demands). In order for the IUF $V^h(P,Y^h)$ to have a Gorman polar form, the corresponding expenditure function, $E^h(P,U^h)$, must have the Gorman polar form

$$E^h(P,U^h) = a^h(P) + \beta(P)U^h \qquad 2.27$$

and the aggregate demand functions derived from it are integrable irrespective of how expenditure is distributed over households. In other words, the aggregate demand functions $X=\Sigma_h X^h$ can be treated as if they were generated by maximizing an aggregate utility function subject to an aggregate budget constraint wherein the latter would state that aggregate demands must not exceed aggregate income. In this Gorman polar form, $a^h(P)$ which can differ between households, is independent of utility level and can thus be interpreted as subsistence expenditure at prices P or the cost of living when utility is zero. $b(P)$ is identical for all consumers.

The restrictions implied by the Gorman polar form are clearly too restrictive for the use of average household expenditure as an explanatory variable in the aggregate household demand function. To see this, just note the Gorman polar form specification implies parallel linear Engel curves or quasi-homothetic preferences, i.e. $\partial X/\partial Y = b_i(P)$, so that not only are preferences identical and homothetic, but the intercept must pass through the origin (zero subsistence expenditure). Hence, although linear Engel curves or quasi-homothetic preferences are necessary and sufficient conditions for aggregation, they are too stringent: if we want to work with level of total household expenditure, we can only work with linear income expansion paths.

In a 1975 article, Muellbauer set out the most general conditions under which consistency between macro and micro relations holds. Muellbauer's condition for exact aggregation is called *Generalized Linearity.* The concept of generalized linearity refers to the fact that the analysis now incorporates both linear and nonlinear income expansion paths. It is also referred to as conditions for exact nonlinear aggregation. The terminology itself relates to: 1) the generalization of the linear aggregation results; and 2) the fact that the budget shares for all goods are linearly related in Y to one another.

Generalized linearity is expressed in terms of three alternative but equivalent restrictions: value shares, marginal value shares, which are independent of income or utility; and the expenditure function which is the cost of utility since it shows the minimum cost of attaining utility U at prices P. In contrast to exact linear aggregation which required the aggregate market demands to be a function of aggregate total expenditure (i.e. working with quantities), exact nonlinear aggregation aggregates over different expenditure patterns of different households. Below we provide a brief sketch.

Under Muellbauer's conditions for exact aggregation, we should be able to define some representative level of total household expenditure, $Y_o(P)$ such that the market pattern of demands is a weighted average of the individual household patterns, and the weights are proportional to the expenditure of each household. The average aggregate value share for the i^{th} good, $\hat{w}_i$, can be expressed as

$$\bar{w}_i = \frac{[P_i \Sigma_h X_i^h(Y^h,P)/H}{\Sigma_h(Y^h/H)} = \sum_h \frac{Y^h}{\Sigma Y^h} w_i^h(Y^h,P) = w_i[Y_o(Y_1,...,Y_N,P)] \qquad 2.28$$

i.e.the average budget share, $\bar{w}$ is a function of each household's total expenditure $(Y_1,...,Y_N)$ and prices. H is the number of households with varying amounts of total expenditure.

The point of departure is straight forward: aggregation under the first approach (linear Engel curves) restricts w_i to be a function of prices and *average* expenditure only - thus producing conditions for linear income expansion paths which we want to avoid. Under Muellbauer's approach, the average budget share, $\bar{w}_i$, is required only to be a function of prices and a *representative* level of total expenditure, $Y_o(P)$ which, as defined earlier, is itself a function of the income distribution vector $(Y_1,...,Y_n)$ and prices P. If this holds, then the market demand is consistent with and representative of the utility maximizing behaviour of a representative household with total expenditure Y_o and facing prices P. Equation 2.28 therefore defines the requirements for exact nonlinear aggregation.

Muellbauer has defined a special class of generalized linear preferences which occurs when the representative expenditure level is independent of prices and depends only on the distribution of expenditures. It is a generalization in which the expenditure level is a CES PIGL function

$$E^h(P,U^h) = A^h[a(P)^\rho(1 - U^h) + b(P)^\rho U^h]^{\rho^{-1}} \qquad 2.29$$

where A^h and ρ are scalars. The representative expenditure function is given by

$$E(P,U_o) = [a(P)^\rho(1 - U_o) + b(P)^\rho U_o]^{\rho^{-1}} \qquad 2.30$$

The logarithmic transformation of PIGL, when logs are taken, becomes what is called PIGLOG:

$$\log E(P,U) = (1 - U_o) \log a(P) + U_o \log b(P) \qquad 2.31$$

where as before, $a(P)$, and $b(P)$ are linear homogeneous concave functions in the prices. Note of course that the exact form of the budget demand functions would depend on the algebraic form of $a(P)$ and $b(P)$. A look at the behaviour of ρ shows how crucial that parameter is in determining the nonlinearity of Engel curves, and hence the relationship between average expenditures and representative expenditures. For instance, when $\rho = 1$, the PIGL is basically the Gorman polar form, and Engel curves are linear; $\rho = -1$ implies quadratic Engel curves; $\rho = 0$ produces the AIDS and Working-Leser forms as special cases.

The importance of theoretical work of aggregation is not restricted to issues of reconciling the shape of Engel curves (i.e. linearity and nonlinearity). Within the context of our present study, the incorporation of demographic characteristics of a household is important. The basic question is : How can we systematically specify aggregate demands that allow for both nonlinear Engel curves and individual household characteristics? Can individual preferences be recovered from such aggregate demand systems? The work by Jorgenson, Lau, and Stoker [1982], Lau [1982], and Stoker [1984] has considered more general forms of aggregation that go beyond Muellbauer's PIGL in which household attributes are incorporated. The Fundamental Theorem of Exact Aggregation [Lau, 1982] establishes the necessary and sufficient conditions which generalize the concept of aggregate demand function to one which depends on general symmetric functions of individual preferences and characteristics. Hence, Gorman's [1981] theorem provides us with functional form specifications that are required in order to relate quantities to expenditures. Lau's FTEA on the other hand extends Gorman's results and provides a useful compromise between standard aggregation (as a function of mean income) and demographic variables.

Related to this context, recent work by Stoker [1982, 1984] has tried to link statistical and economic theories of aggregation. The most striking of these is Stoker's finding that the estimated parameters from cross-section regressions will estimate the corresponding macro-functions not only under the Gorman perfect aggregation conditions, but also if the independent variables are independently distributed with exponential family of distributions. In the context of demand analysis, Deaton [1986] notes that the marginal propensity to consume from a cross-section regression would consistently estimate the impact of a change in mean income on mean consumption either with linear Engel curves or with nonlinear Engel curves and income distributed according to some exponential family distribution. Since one of the reasons we are interested in aggregation is to be able to move from micro to macro in this way, these results open up new possibilities. Stoker [1984] also carries out the process in reverse and derives completeness (or identification) conditions on the distribution of exogenous variables that allow recovery of micro behaviour from macro relationships.

Overall, it can be said that Muellbauer, Lau, Jorgenson, and Stoker have provided generalizations of the theory of aggregation especially with respect to the incorporation of impacts of distribution on aggregate demand functions. However, Jorgenson, Lau, and Stoker have gone a step further by showing that their aggregate demand functions do not require the idea of representative consumer. In other words, their approach can be applied to individual consumers with different preferences. This is in contrast to Muellbauer's whose conditions for the existence of a representative consumer can be viewed as a special case with the number of indices equal to two. Jorgenson, Lau, and Stoker [1984] have shown that the representative consumer interpretation fails for the case of more than two index functions.

This section has endeavoured to critically review the theory of aggregation starting with Gorman's [1953] characterization of individual behaviour (the Gorman polar form), to

Muellbauer's generalized model of the representative consumer in which individual preferences are identical but not necessarily homothetic. In addition, amounts consumed may be nonlinear functions of expenditure rather than linear functions, as in Gorman [1953]. As noted earlier, this nonlinearity means that aggregate demand functions are functions of the distribution of expenditure among individuals.

In the next section, we will consider the important issue of how socioeconomic variables may be incorporated in the models.

2.5 Incorporating Demographic Variables

In this section, we consider a theoretically plausible way in which demographic variables enter the utility function, i.e. the incorporation of variables such as household size and composition into a complete system of demand equations which describe the allocation of expenditures among a finite set of consumption bundles. Since demographic variables affect consumption patterns and expenditure behaviour (just as prices and income do), their incorporation in Engel functions and demand systems allows analysts to obtain better estimates of demand parameters.

A common approach to incorporating socioeconomic variables uses equivalent scales which are simply budget deflators used to derive the relative amounts of income required by two different types of households to attain the same standard of living. Equivalent scales play an important role in government welfare policies as well as in defining the poverty line for different household types. For food processors, this information is useful for targeting their promotional activities.

Equivalent scales were originally developed by Engel [1895]. Prais and Houthakker [1955] represent early work using commodity specific household equivalent scales and a general scale for deflating total expenditure. However, their approach is not consistent with utility maximization. Barten [1964] introduced the idea of scaling within the context of a theoretically plausible system of demand equations. Subsequent work by Muellbauer [1974, 1977, 1980], Gorman [1976], Pollak and Wales [1980, 1981], Ray [1980], Lewbel [1985], and Jorgenson and Slesnick [1987], have reformulated the model further using duality. In the following discussion, we focus on two alternative specifications first employed by Pollak and Wales [1978, 1981] in which parameters of a demand system depend on the demographic variables: the two specifications are demographic translating and demographic scaling. The specification involves three separable but interrelated steps: 1) specification of a class of demand system for every admissible demographic profile; 2) specification of which parameters are a function of demographic variables and which are not; 3) specification of functional form for each relevant parameter.

2.5.1 Demographic Translating

Demographic translating introduces n parameters $d_1,\ldots,d_n$ (called translating parameters) such that for every good i, there is a minimum or subsistence level, d_i below which utility is not defined. This corresponds to a translation of the origin of the consumption space from the zero-vector to the vector $(d_1,\ldots,d_n)$. Demographic variables, denoted Θ, are introduced into each demand system in the class by postulating that only the parameters d_i are a function of the demographic variables, i.e. $d_i = d_i(\Theta)$. Specifically, once the vector of quantities X is adjusted by d_i, the direct utility function becomes:

$$U(X) = \breve{U}\ (X_1 - d_1, X_2 - d_2, \ldots, X_n - d_n) \qquad 2.32$$

and each demand system in the class

$$X_i = \breve{X}_i(P,Y) \qquad 2.33$$

is replaced by the modified system

$$X_i(P,Y) = d_i + g_i\ (P,\ Y - \sum_{k=1}^{n} P_k\ d_k) \qquad \forall\ i \tag{2.34}$$

Each of the d_i translating parameters is related to the N demographic variables $(\theta_1,...,\theta_N)$ by postulating an appropriate functional form. The functions relating d's to the Θ's are denoted by

$$D: \{d_i = D^i(\Theta)\} \tag{2.35}$$

where it is clear that any effect of Θ on X_i comes via d_i and income.[5] Pollak and Wales [1981] estimate a linear demographic translating of the form

$$D^i\ (\Theta) = d_i^* + \sum_{r=1}^{N} \delta_{ir}\theta_r \tag{2.36}$$

in which (n x N) independent parameters are added to the original demand system and does not include the constant term d_i*.

If the original (uncompensated) demand system is theoretically plausible, then so is the modified one.[6] Thus, if the original demand system was generated by the IUF $V(P,Y)$ (or the DUF $\tilde{U}(X)$, then it can be shown that the modified demand system satisfies the first order conditions corresponding to

$$V(P,Y) = \tilde{V}(P,Y - \Sigma P_k\ d_k) \tag{2.37}$$

or

$$U(X) = \tilde{U}(X_1 - d_1,\ ...,\ X_n - d_n) \tag{2.38}$$

---

[5] It should be noted that nothing prevents the d's from taking negative values. Not only are negative d's ridiculous, but their economic interpretation becomes more difficult.

[6] According to Pollak and Wales, the modified demand system satisfies Slutsky symmetry conditions, but the substitution matrix need not be negative semidefinite except when all d_i's are zero. The modified system is theoretically plausible for demands d's close to zero. A global result is therefore not possible.

Using the modified demand system, one can evaluate the direct and indirect effect of a change in Θ on total expenditure. For instance, from the modified equation, the effect of a change in Θ_t (noting that we have multiplied through by price) is:

$$\frac{\partial P_i X_i}{\partial \theta_t} = P_i \frac{\partial D^i}{\partial \theta_t} - \frac{\partial P_i X_i}{\partial Y} \Sigma P_k \frac{\partial D^k}{\partial \theta_t} \tag{2.39}$$

where $\partial P_i X_i / \partial Y$ is the marginal budget share of the i^{th} good. A change in Θ_t results in a reallocation of expenditure among the consumption bundles. However, since total expenditure is invariant, any increases in the consumption of some commodities must be compensated by reductions in the consumption of others. The sign of $\partial P_i X_i / \partial \theta_t$ is not obvious just from looking at how θ_t affects d_i. An increase in Θ, e.g. family size, does not necessarily imply an increase in d_i. This is because changes in the d's imply an expenditure reallocation and leave total expenditure unaltered, irrespective of the direction of the changes in the d's.

2.5.2 Demographic Scaling

Demographic scaling is essentially an adjustment of the quantity consumed of each commodity by the corresponding number of adult equivalents. It amounts to basically demographically varying constant terms in the demand equations. This is done by first introducing n parameters, $(m_1,...,m_n)$, into the original demand system. The n parameters are postulated to be solely a function of the demographic variables. Each demand system in the original demand system is replaced by the modified system

$$X_i(P,Y) = m_i f_i(P_1 m_1, ..., P_n m_n, Y) \qquad \forall \; i \tag{2.40}$$

where f_i is the corresponding modified set of uncompensated demand functions, and $P_i m_i$ is the adjusted price vector. Each of the m_i scaling parameters is related to the N demographic variables by postulating an appropriate functional form. The functions relating the m's to the Θ's are denoted by

$$M_i \{m_i = M^i(\Theta)\} \quad \forall \; i \qquad 2.41$$

As in the case of translating, it can be shown that the modified ("scaled") system is theoretically plausible (for m_i close to 1) if the original demand function is theoretically plausible. Thus, if the original demand system was generated by the IUF $V(P,Y)$ (or the DUF $\tilde{U}(X)$), the modified system is generated by

$$V(P,Y) = \tilde{V}(P_1 m_1, ..., P_n m_n, Y) \qquad 2.42$$

or equivalently by the DUF

$$U(X) = \tilde{U}(\frac{X_1}{m_1}, ..., \frac{X_n}{m_n}) \qquad 2.43$$

where X_i/m_i $i = 1,...,n$ is interpreted as commodity specific consumer equivalent scales. In other words, the specification corrects for the number equivalent adults. Since both the utility functions and demands are scaled by m, preferences and consumer behaviour can be viewed in terms of demographically scaled prices and quantities. Note that in general, the scaling functions are made commodity specific. Given this scaling, it can be seen that a change in the j^{th} demographic variable θ_j entails a direct effect via m_i, and an indirect effect via $P^* = (P_1 m_1,...,P_n m_n)$, on X_i, i.e.

$$\frac{\partial X_i}{\partial \theta_j} = (\frac{\partial m_i}{\partial \theta_i}) F_i + m_i \sum (\frac{\partial F_i}{\partial P_k}) (\frac{\partial P_k^*}{\partial m_k}) (\frac{\partial m_k}{\partial \theta_j})$$

2.5.3 Gorman's Specification

Gorman's specification is another way to introduce demographic variables into the demand system. It involves first scaling and then translating the original demand systems. To do this, the expenditure function is specified as:

$$E(P, U, \Theta) = \Sigma\, d_i(\Theta)\, P_i + E\,[P\, m(\Theta),\, U]$$

where Θ is a vector of demographic variables, d_i and m_i are translating and scaling parameters both of which are functions of Θ. In other words, household attributes change the prices perceived by the household from P to $P^* = P\, m(\Theta)$. Note, however, that not only does the incorporation of demographic variables lead to an adjusted price vector, but it also entails an introduction of a fixed cost element (minimum level) $\Sigma d_i(\Theta) P_i$ into the household expenditure function. If $d_i(\Theta)=0$ for each i, Gorman's specification reduces to what Pollak and Wales refer to as scaling (which is essentially Barten's specification). $m_i(\Theta) = 1$ implies translating.

A more general method which introduces functions of Θ's, P's, and Y's into an expenditure function of a demand system was recently developed by Lewbel [1985]. Lewbel extended and modified Gorman's [1976] model. It permits complicated interactions of demographic variables with prices and expenditures. The resulting functions are integrable and are given explicitly as functions of the original demand functions and the modifying functions of Θ. The method is general because it is interpreted as modifying a household's technology as well as embodying adult equivalent scales and related methods.

This study employs the translation approach to introduce demographic effects into the Canadian demand system for foods. The next Chapter discusses data and methods used to construct variables.

Chapter 3

Data

3.1 Introduction and Organisation of Chapter

This chapter describes the data employed in this study. A clear understanding of the Food Expenditure Survey data is necessary in order to understand how the computations on these data were conducted as well as the construction and definition of key variables. We shall also present some basic descriptive statisitics.

This chapter is organised as follows. Section 3.2 describes data sources. Sample size and selection are discussed in section 3.3. Section 3.4 discusses commodity grouping and the definition of key variables. Key variables include prices, expenditure, income, demographic attribute. In particular, this section explicitly considers the two stage budgeting procedure in the definition of commodity groups. Section 3.5 presents some descriptive statistics pertaining to the key variables of interest in this study.

3.2 Data Sources

This study requires data on the following major components of our analysis: expenditure shares for each food group; total food expenditure for households at given points in time; food prices; demographic attributes for individual household units; and income. With respect to prices, it is assumed prices, demographic attributes, and total expenditures may vary between households.

Data on these variables are drawn from Surveys of Family Food Expenditure Public Use Microdata Tapes conducted by Statistics Canada. The Public Use Microdata Tapes (PUMDTs) contain anonymized data collected in 1984, 1986, and 1990. It should be noted that although

Statistics Canada conducted five such surveys between 1978 and 1990, PUMDTs are only available for 1984, 1986, and 1990.

The PUMDTs are organised into two files: a summary file and a detailed file for each of the five regions. The summary file contains information on household characteristics, income of the household, summary household food expenditures, and population weights. The summary expenditure information relates to weekly expenditure on 12 aggregate food commodities as reported in the Family Expenditure Survey publication (Statistics Canada 1984, 1986, 1990). The summary file does not contain information on price or quantities.

The detailed file is organised by household and food code. It records quantities and weekly expenditures for each household using detailed food codes at the Universal Code Classification (UCC) level. The total of the purchases of an item by a household in a week in a type of store constitutes a record, and no record is present if the household did not make purchases of an item.

Each of the surveys was designed to provide information on families and unattached individuals living in private households across Canada. The tapes are organised by five regions: Atlantic, Quebec, Ontario, Prairies, and Pacific. For 1986, Alberta appears as a separate region. However, for our analysis, we have merged Alberta with the Prairies in order to maintain uniformity with 1984 and 1990.

The survey samples were drawn from the Labour Force Survey (LFS) sampling frame and involved: i) the selection of clusters from predetermined LFS rotation groups within each city; ii) the selection of dwellings within these selected clusters. These are probability sample surveys employing stratified random sampling procedures. To ensure that data collection is evenly distributed over each entire calender year, the samples are drawn for the whole year and divided into 12 different monthly sub-samples. This also allows for seasonal and other changes during the survey year. The eligible population includes only civilian noninstitutional individuals residing in regular housing. In order to reflect the idea that the population characteristics are estimated from a probability sample survey in which each sampled unit represents a certain number of unsampled units in the population, a weight is assigned to each consumer unit, the weight being the weekly record or the ratio of samples to population households and represents the number of households in the population that a given household in the sample is supposed to represent. These weights vary between households to compensate for varying sampling rates between regions and differences in sampling rates between different household types. These weights are essentially intended to restore the importance of each region with respect to national coverage since samples for each region were not allocated strictly proportional to the population. For details of how weights are derived, see FES (1984, 1986, 1990).

Data collection is undertaken by two separate documents: a questionnaire and a diary. The questionnaire was used to obtain data on a consuming unit's socio-economic attributes such as age, sex, household income, marital status, education, and race. A household's "away from home" purchasing habits and expenditures are also recorded in the questionnaire. In addition, each consumer unit keeps a diary of all its food expenditures on a variety of food items for two consecutive one-week periods. Each diary provides detailed descriptions of daily food purchases, total expenditures, and where the food was purchased (e.g. supermarket).

3.3 Sample Size and Selection

Table 3.1 presents the number of observations in the original sample for each of the five regions. These are defined in terms of the number of families and weekly records in the PUMDTs for the three years under study. The figures represent an overall response rate of 83.2%, 78.9%, and 68% for 1984, 1986, and 1990 respectively. The response rates are calculated by treating

Table 3.1 Food Expenditure Survey Sample Size and Number of Weekly Records by Region

	TOTAL	ATLANTIC	QUEBEC	ONTARIO	PRAIRIES	PACIFIC
1984:						
Households	5,915	1,296	907	1,284	1,726	707
Weekly Records	11,783	2,574	1,810	2,561	3,438	1,400
1986:						
Households	10,919	2,191	2,084	2,632	2,598	1,413
Weekly Records	21,510	4,315	4,097	5,164	5,128	2,806
1990:						
Households	4,793	1,039	701	1,029	1,340	684
Weekly Records	9,396	2,032	1,381	2,026	2,603	1,348
Total Sample	21,627					
Total Records	42,689					

each week's diary independently for a given household. Here, the number of observations (weekly records) is two times the number of household units. Over this period, the total number of observations is over 42,000, and from an econometric vantage point, it is almost impossible to employ such huge data in empirical estimation. Furthermore, there are over 500 separate classification codes for food expenditure. Hence, several manipulations of the PUMDTs are required in order to construct a desirable data base. All the data constructions are achieved using SAS (SAS Institute, 1993).

First, we merge the data from various files in such a way that each record in the newly merged file contains information about each household, including information on each household unit member. Households are indexed by $h=1,2,...,H$. There are H households in total. Second, we need to define the dependent variable as average weekly food expenditure so that the level of analysis is weekly household consumption. To achieve this, we average the consumer unit's expenditure for each week that the consumer unit filled a diary.

Next, all households reporting zero total food expenditure are deleted from the sample. In addition, we also eliminate households located outside the Census Metropolitan Area as defined in the FES. This point is important specifically with respect to the 1986 FES which was carried out in urban and rural areas of the 10 provinces as well as in Whitehorse and Yellowknife. In order to avoid a downward bias in food expenditure, gifts received by the households are excluded since such gifts do act as a replacement for food normally bought and hence making available discretionary income. We also drop households in which the gross income reported of the head of the household is zero.

Thus, sample selection is not accounted for in the estimation of each system. It must be pointed out here that ignoring the limited dependent variable problem may introduce some bias. However, our a preliminary look at the data suggests that the number of people reporting zero expenditures is a small proportion of the total sample. This is clearly an empirical issue that may warrant further investigation, especially if the distribution of non-purchasers nonstochastic and systematically distributed. In Chapter 5, we investigate this issue further by estimating a Tobit model using Heckman's procedure in order to assess the importance of modelling zero expenditures.

3.4 Commodity Grouping and Variable Definition

In order to specify our unrestricted complete demand system, it is necessary to define our variables and describe the procedure used to select the variables. The PUMDTs have hundreds of food expenditure items. For our study, we need to aggregate over fewer categories in order for our econometric estimates to have a degree of asymptotic validity. Here, we are concerned with the degree of freedom problem since we know that in a typical flexible functional form (e.g. the translog or the almost ideal demand system), the number of parameters that must be estimated increases quadratically while the number of available observations increases linearly.

3.4.1 Two Stage Budgeting

In order to determine the precise number of groups at each stage, it is essential to examine the structure of the PUMDTs. The PUMDTs provide two levels of expenditure data: a broad expenditure class and a four-digit universal classification code. The later is available only for food-at-home and there are over 500 of these detailed food codes, thus making it practically impossible to successfully model this number of expenditure items given that the number of parameters that need to be estimated will 'explode'. The parameter space must therefore be restricted since it is impractical to estimate a demand system which contains all commodities. In any case, if one considers that households do not take into consideration all commodities but only a subset of related goods when they make their purchase decisions, then we only need to model a demand system containing commodities of interest, as long as such a system is appropriately defined to be an appropriate representation of the household's behaviour. By imposing certain separability assumptions, we can offer a plausible description of this behaviour.

In order to cope with this problem, a two-stage budgeting procedure, separability and the theory of aggregation over commodities is employed to represent the household's expenditure decision-making process and to define the set of commodities to be included in the demand system. These issues were discussed in detail in Chapter 2. Our objective here is to make the actual allocation of total expenditure to food and nonfood food groups as well as the allocation of each subgroup's expenditure over commodities contained in them more explicit.

To implement our two-stage budgeting procedure, we begin by constructing a utility tree in which branches represent expenditure categories while nodes represent commodities contained in each of the expenditure categories. The first leaf on the tree represents all available goods. The process used by a household to purchase a particular commodity can be established by following each of these branches. Thus, in our PUMDTs, we postulate the following two-stage budgeting procedure: in the first stage, group expenditures are derived by allocating total expenditure among three broad categories: food at home (FAH), food away from home (FAFH) and nonfood (NF) with reference only to price indices for each group. This stage expenditure allocation is operationalized by ensuring that stage II prices are represented by a single price index. Using the summary component of the PUMDTs, total FAH expenditures are obtained by adding up all reported non-gift expenditures on the disaggregated food items. Similarly, total FAFH expenditures are extracted by summing food purchased from restaurants, including table service, fast foods, and cafeteria. Total FAH and FAFH are used to derive total nonfood expenditure residually with reference to the summary PUMDT and the Survey of Family

Expenditure. The PUMDT also records each household's reported income before tax. (Income-after tax is clearly desirable, however this is not available in the PUMDTS, and neither can one estimate it easily from tax rates owing to the manner in which Statistics Canada has defined the five survey regions). The distinction between the Food Expenditure Survey (FES) and the Survey of Family Expenditure (SFE) should be noted. The SFE is the primary survey conducted by Statistics Canada and involves highly aggregated items. Hence, only an aggregate estimate of food expenditure is recorded. The FES on the other hand is designed to complement the SFE by providing detailed expenditure coverage on food commodities.

The second stage is called decentralization and involves the allocation of group expenditures within a group. As noted, the PUMDT universal classification code is provided only for FAH. Hence, we postulate that the second stage decision involves allocation of total FAH expenditure to various commodities making up FAH. In order to reduce the number to a manageable level, we grouped FAH into 12 plausible working subcategories. In order to argue that this procedure is a plausible representation of the household's decisions, it is necessary to assume that the household's preferences are weakly separable according to the branches of the utility tree. Weak separability implies that each branch of the utility tree can be defined by a separate subutility, namely, $U_{FAH}(X_{FAH}),U_{FAFH}(X_{FAFH})$, and $U_{NF}(X_{NF})$, which are subutility functions corresponding to FAH, FAFH, and NF; X is quantity. It is therefore obvious that two stage budgeting and separability provide a sound theoretical basis for demand systems which contain only a subset of the commodities available by allowing the demand system to be derived from subutility functions containing only commodities of interest, thereby permitting both a great simplification in the estimation of large demand systems and offering a plausible description of household behaviour. It follows from this discussion that two-stage budgeting involves both aggregation (to form broad groups) and separable decision making (for each of the subgroup utility maximization problems). The importance of separability restrictions and two-stage aggregation is not restricted to consumption decisions. Coyle [1993a], for instance, has incorporated allocation decisions into a two-stage aggregation model of multioutput production decisions.

In order to ensure that we can manage the allocation of expenditures at the first stage, we need price indices P_{FAH}, $P_{FAFH,}$ and P_{NF} for each of the three first stage commodity groups such that the utility maximization problem corresponding to Stage I yields an optimal allocation of expenditure across the three subgroups. As noted above, a sufficient condition for Stage I is homotheticity of all subutility functions $U_{FAH}(X_{FAH})$, $U_{FAFH}(X_{FAFH})$, and $U_{NF}(X_{NF})$, given weak separability of the utility function of each consuming unit, i.e. the utility function for each household is not required to be additive.

Formally, let the utility function $U(X)$ be:

$$U(\tilde{X}) = \mathrm{U}[U_{FAH}(X_{FAH}), U_{FAFH}(X_{FAFH}), U_{NF}(X_{NF})] \tag{3.1}$$

The Stage I maximization problem solved by the household is

$$\text{Max } U(\tilde{X}) = \mathrm{U}[U_{FAH}(X_{FAH}), U_{FAFH}(X_{FAFH}), U_{NF}(X_{NF})]$$

$$\text{s.t.} \quad \tilde{P}\tilde{X} = M \tag{3.2}$$

where $\tilde{P} = (P_{FAH}, P_{FAFH,} P_{NF})$ and $\tilde{X} = (X_{FAH}, X_{FAFH}, X_{NF})$ denote aggregate prices and commodities for Stage I broad groups. Thus total expenditure M is being allocated among the three broad groups as follows:

$$\sum_{i=1}^{N_{FAH}} P^i_{FAH} X_{FAH} = M_{FAH}$$

$$\sum_{i=1}^{N_{FAFH}} P^i_{FAFH} X_{FAFH} = M_{FAFH}$$

$$\sum_{i=1}^{N_{NF}} P^i_{NF} X_{NF} = M_{NF}$$

$$\text{s.t.} \quad M_{FAH} + M_{FAFH,} + M_{NF} = M \tag{3.3}$$

Our second stage involves allocation of M_{FAH} to 12 commodity groups, hence the household gets to Stage II with a subutility maximization problem:

$$Max \quad U_{FAH}(X^1_{FAH}, X^2_{FAH}, ..., X^{12}_{FAH})$$

$$\text{s.t.} \sum_{i=1}^{12} P^i_{FAH} X^i_{FAH} = M_{FAH} \qquad 3.4$$

where the household is choosing X^*_{FAH} given M_{FAH}. The indirect utility function corresponding to this maximization problem can be expressed as

$$V_{FAH}(P_{FAH}, M_{FAH}) \qquad 3.5$$

and applying Roy's Theorem, we get Marshallian demands as

$$X^*_{FAH} = X^*_{FAH}(P_{FAH}, M_{FAH}) \qquad 3.6$$

which are functions of prices P_{FAH} and group expenditure M_{FAH} that was allocated in Stage I: but the other prices P_{FAFH} and P_{NF} influence demands X_{FAH} only via changes in the optimal level of group expenditure M_{FAH}. For an elaboration of the Hicksian substitution effects implied by this weak separability, see Deaton and Muellbauer [1980].

We can now express 3.5 in terms of Muellbauer's [1975, 1976] PIGLOG expenditure function which is of particular interest in our study. The PIGLOG expenditure function is given by

$$\log e_{FAH}(U_{FAH}, P_{FAH}, D^h) = A(P_{FAH}, D^h) + U_{FAH}(B(P_{FAH}, D^h) \qquad 3.7$$

and it can be shown that the corresponding PIGLOG indirect utility function obtained by inverting the PIGLOG expenditure function 3.7 can be expressed as

$$V(P_{FAH}, M_{FAH}, D^h) = \left[\frac{\log(M_{FAH}) - A(P_{FAH}, D^h)}{B(P_{FAH}, D^h)}\right] \qquad 3.8$$

or taking logs, we have

$$\log V(P_{FAH}, M_{FAH}, D^h) = \log\left[\log\left(\frac{M_{FAH}}{A(P_{FAH}, D^h)}\right)\right] - \log B(P_{FAH}, D^h) \qquad 3.9$$

where D^h allows the indirect utility function to also depend on the household's demographic characteristics in addition to P_{FAH} and M_{FAH}, and it is incorporated via translating (see my discussion in Chapter 2 and Chapter 4); A and B are functions of FAH prices. Applying Shephard's lemma to the PIGLOG expenditure function and then using the PIGLOG indirect utility function (3.9) gives the Deaton and Muellbauer budget share equations. The precise specification is taken up in Chapter 4. However, an important 'virtue' of the PIGLOG form is worth stressing. Muellbauer showed that as long as a household's preferences are of the price independent generalized logarithmic form, the PIGLOG demand system (such as Deaton and Muellbauer's ALIDS) permits perfect aggregation without assuming that preferences are additive. Lewbel [1987], developing the work of Gorman [1959] has shown that the indirect utility function of any PIGLOG demand system can be expressed as a group subutility function in the Gorman Polar Form (GPF), and Stage I expenditure allocation is possible if the Stage II subutility function satisfies the Generalized Gorman Polar Form (GGPF). Lewbel goes on to show that all budget share models that are linear in the log of expenditure (income) can be derived from GPF subutility functions. This generalization is important for our two stage budgeting process because it allows the conditional demands corresponding to Stage II subutility function of FAH (i.e. $U_{FAH}(X_{FAH})$) to be modelled by Deaton and Muellbauer's ALIDS (or indeed Christensen, Yorgenson, and Lau's Translog) since its corresponding indirect utility function possesses a GGPF. Following Blackorby, Primont, and Russell [1978], this implies that we can write the utility function as a function of $A(P_{FAH})$, $B(P_{FAH})$, P_{FAFH}, P_{NF}, M_{FAH}, M_{FAFH}, M_{NF}, and D^h, i.e.

$$\tilde{V}(P,M,D) = \tilde{V}\left[[A(P_{FAH}),D^h),B(P_{FAH}),D^h),P_{FAFH},P_{NF},M_{FAH},M_{FAFH},M_{NF}]\right] \qquad 3.10$$

or more explicitly

$$\tilde{V}(P,M,D) = \log\left[\log\left(\frac{M_{FAH}}{A(P_{FAH},D^h)}\right)\right] - \log B(P_{FAH},D^h) + U_{FAFH}\left[\frac{M_{FAFH}}{P_{FAFH}}\right] + U_{NF}\left[\frac{M_{NF}}{P_{NF}}\right] \qquad 3.11$$

The Stage II maximization problem (3.2) solved by the household will yield a 3-equation Stage I ALIDS demand system:

$$W_{FAH} = \alpha_1 + \gamma_{11}\log P_{FAH} + \gamma_{12}\log P_{FAFH} + \gamma_{13}\log P_{NF} + \beta_1 \log\left(\frac{M}{P^*}\right)$$

$$W_{FAFH} = \alpha_2 + \gamma_{21}\log P_{FAH} + \gamma_{22}\log P_{FAFH} + \gamma_{23}\log P_{NF} + \beta_2 \log\left(\frac{M}{P^*}\right)$$

$$W_{NF} = \alpha_3 + \gamma_{31}\log P_{FAH} + \gamma_{32}\log P_{FAFH} + \gamma_{33}\log P_{NF} + \beta_3 \log\left(\frac{M}{P^*}\right) \qquad 3.12$$

where log P^* is Stone's price index for Stage I and P_{FAH} is the Stage II Stone's price index. We defer the derivation of the Stage II system of equations to Chapter 4 since this is the focus of this study for reasons explained later. Table 3.2 defines the 12-commodity grouping as well as each of the variables that enter the econometric model specified in subsequent chapters. In defining the 12 commodity grouping in Table 3.2, an important point needs to be made regarding the budgeting procedure. Since the 12 groups whose allocation (expenses) is determined in the second stage are broad groups (e.g. beef, dairy, cereal), we are implicitly assuming a third stage, e.g. allocation of beef expenditures to individual beef products. This implies that our second stage model assumes weak separability for these 12 groups as well as homothetic weak separability between the third stage groups. Thus, weak separability for the 12 groups and homotheticity of their 12 subutility functions U^1, U^2, ..., U^{12} implies homothetic weak separability of U_{FAH}, i.e.

$$U_{FAH} = \tilde{U}_{FAH}\left[U^1(X_{11},\ldots\ldots,X_{1N_1}),\ldots\ldots\ldots,U^{12}(X_{12,1},\ldots\ldots,X_{12N_{12}})\right] \qquad 3.13$$

The difficulty associated with forming commodity groupings needs to be pointed. As Buse [1987] points out, although the theoretical literature develops the separability concept, it is of little or no practical help to a researcher faced with aggregating thousands of different expenditure categories into theoretically acceptable but practical groups. Attempts have been made to adopt more systematic approaches to approximating the structure of consumer preferences. For instance, Young [1977] endeavoured to employ cluster analysis while Bieri [1969] tried Canonical Correlation analysis to group commodities in cross-sectional surveys. However, their results cannot be interpretted easily. Bieri and de Janvry [1972] tested for separability in broad and highly aggregated commodities. Pudney [1981] and, more recently, Eales and Unnevehr [1988], Wahl and Hayes [1990], Baccouche and Laisney [1991], and Nayga and Capps [1994] have used parametric tests of separability in highly disaggregated commodities. Nonparametric tests based on Afriat's [1967] revealed preference axioms include studies by Swofford and Whitney [1986], and Varian [1982, 1983, 1985, 1990]. No attempt is made in this study to adopt these procedures due to resource contraints caused by the sheer size of our data.

Table 3.2 Definition of Variables Used in Stage I and Stage II Models.

Variable	Definition	Symbol
STAGE I:		
X_{FAH}	Food At Home	FAH
X_{FAFH}	Food Away From Home	FAFH
X_{NF}	Nonfood	NF
STAGE II:		
X_1	Beef	BEEF
X_2	Pork	PORK
X_3	Chicken	CHIC
X_4	Other Meat	OMEAT
X_5	Fish and Seafood	FISH
X_6	Cereal and products	CEREALS
X_7	Vegetables, Fruits	VEGES
X_8	Sugar and preparations	SUGARS
X_9	Dairy products, eggs	DAIRY
X_{10}	Fats and Oils	FATS
X_{11}	Nonalcoholic beverages	NALCO
X_{12}	Other food preparations	OTHER

Short of these statistical procedures, one should ultimately be guided by the specific objectives of one's study, as well as *a priori* knowledge and econometric considerations. The important factor is that the groups so defined must be reasoble (at least in terms of weak separability assumptions) in order to ensure that the requirements for the existence of legitimate commodity aggregates are satisfied.

3.4.2 Calculating Prices for the Categories

The exclusive use of cross sectional data in this study raises the important question of cross sectional price variability which has critical econometric implications. Given that we are conducting the analysis at the household level at a single point in time, it is reasonable to assume that prices are constant in a given cross section for each food group. Hence, it is tempting to conclude that we cannot empirically identify price effects in the absence of price variation and proceed to estimate Engel functions, leaving cross sectional price effects to be captured by dummies. This approach is typical in traditional Engel curve analysis of Prais and Houthakker [1955], George and King [1971], and Allen and Bowley [1935]. Other studies such as Jorgenson, Lau, and Stoker [1982], Ray [1982], and Pollak and Wales [1978] combine time series and cross sectional data to empirically identify price effects.

However, considerable price variation has been shown to exist in a number of cross sectional data sets (Goldman and Grossman [1978], Deaton[1988, 1990]], Cowling and Raynor[1970], Nelson [1990, 1991], and Cramer [1973]). In this view, researchers like Cox and Wohlgenant [1986] have argued that traditional Engel analysis may be inappropriate if prices are in fact not constant, leading to biased and misleading demand elasticities [Polinsky 1977]]. Quiggin and Bui-Lan [1984] have examined this problem as it relates to studies of production. They observed that most studies, especially those using profit functions to test for relative efficiency between firms not only ignore the issues of price variation between firms at a single point in time but proceed to adopt procedures that create spurious variations in measured prices, such as dividing total factor payments by the aggregate of total services of each factor even when it is recognized that most inputs are heterogeneous in quality and that firms will use inputs of various levels of quality in different proportions. Hence, without regard to quality differences, price and quality differences will be confounded.

Within the context of our study, we are confronted with this fundamental problem since our PUMDTs record only expenditure and quantity for each household such that the only option left for the researcher appears to be the derivation of unit prices. Although a number of studies (Capps and Havlicek 1984; Timmer and Alderman 1979; Purcell and Rauniker 1971; and Pitt 1983) have shown that unit prices offer reasonable approximations of prices, the use of unit prices should be treated less casually since *ad hoc* derivations may be difficult to defend in light of the observations that unit values have been shown to be a function of quality of goods and market prices. Hence, it is not obvious that changes in unit prices can be interpreted as arising from changes in market prices. We shall pursue this issue further in Chapter 4.

To cope with the price data problem, we shall use unit values as the basis for deriving appropriate indices. In the next section, we discuss the calculation of price indices including a brief theoretical overview of index numbers. All the derivations of indices pertain to Stage II of the two stage budgeting procedure since it is the level of analysis used in this study.

3.4.2.1 Index Numbers

A number of indices are traditionally available and they include Paasche, Laspeyres, Fisher, and Divisia indices. The Laspeyres and Paasche involve simple base period weighting schemes. It can be shown that conditions under which the Laspeyres and Paasche satisfy exactness are extreme, i.e. linear indifference curves (perfect substitution between commodities), and right-angled indifference curves (zero substitution). In general, both these indices are prone to distort the contribution of commodities to the household's utility.

In view of this, this study selects the Divisia index which is based on a Tornquist approximation and which Diewert [1976, 1978] has shown to be superlative. Assuming homotheticity and a Translog unit cost function, a Tornquist price index is exact, i.e. equal to the ratio of unit costs for different households. Thus, errors in aggregation of prices are small to the extent that a second order approximation to preferences is adequate, as is the case when price variation is relatively small between households. This index can track any aggregation function following a theoretical exact aggregation function with no error at all (especially in continuous time series). As Barnett and Serletis [1990] have noted, this is a remarkable result which holds irrespective of the form of the unknown exact aggregate function. The only requirement is that certain assumptions for the existence of any exact aggregate function hold.

In order to calculate the Divisia, we adopt the following specific procedure. In step one, all expenditures for each commodity group are obtained by adding all reported weekly expenditures on all food items in that group. In step two, these expenditures are multiplied by the reciprocal of the reported quantity to obtain nominal unit values which are then used to compute superlative indices for the 12-commodity groups as follows:

$$\log P_i^g - \log P_i^h = \frac{1}{2}\sum_j (w_{ij}^h + w_{ij}^g)\,[\log P_{ij}^g - \log P_{ij}^h] \qquad 3.14$$

where $w_{ij}{}^g$ and $w_{ij}{}^h$ are g^{th} and h^{th} household's expenditure share of commodity j in group i respectively. Note that the standard definition of the Divisia is usually presented as an intertemporal construct to the extent that two time periods are referenced. Since we are dealing with cross sectional households at a single point in time, the index defined by 3.14 can be interpreted as an interhousehold Tornquist approximation to the Divisia where g and h in our case correspond to g^{th} and h^{th} distinct households at the same point in time, so that $\log P_{ij}^{g}$ and $\log P_{ij}^{h}$ reflect interhousehold unit value differences for commodity j in group i. In this regard, the index is related to Jorgenson and Nishimizu's [1978] and Caves, Christensen, and Diewert's [1982] interspatial Translog index. See for instance Denny and Fuss [1983].

Finally, a relevant question in this exercise has to do with the choice of base. There is no generally accepted way of going about choosing a household to be used as the base. Since interhousehold price variations are critical to the definition of a superlative index, it is essential to ensure that price variations for the base are as small as possible. Hence, for our base, we have chosen a household whose observed unit value is closest to the sample mean value. All computations were performed using SAS. Table 3.3 presents descriptive statistics showing minimum and maximum unit prices and their corresponding means. The coefficients of variation suggest that a significant amount of interhousehold unit price variation is apparent in our samples.

3.4.3 Expenditures and Income

Total FAH expenditure per household will be used as the proxy for income in stage II of the budgeting process, and it is simply the summation of individual household expenditures over all food categories. For the first stage, we use total food expenditure by all households. The conceptual issues related to the use of expenditure as a regressor are discussed in Chapter 4.

3.4.4 Demographic Variables

Demographic variables for the h^{th} household are split into three categories: household size, age of household head, region of residence, and season in which the household was surveyed. These are defined by a vector D primarily containing elements with binary (0 or 1) values based on whether or not such a household possesses such an attribute. These variables are defined in Table 3.4.

Table 3.3 Descriptive Statistics for Prices of Selected Food Prices for Canada

	1984			1986			1990		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Beef	5.8098	2.0986	14.0666	5.6450	1.9400	15.4815	6.8155	1.9425	24.4053
Pork	5.9100	1.3067	11.0253	5.9588	1.1023	12.9139	6.7213	1.6887	17.8938
Chicken	4.1889	1.0511	11.5789	4.9470	1.1590	12.4832	4.8731	1.0602	17.5164
Omeat	5.3488	1.3000	16.6666	5.2527	1.8450	30.5000	8.5037	1.7200	47.8800
Fish	8.2959	2.1143	24.9687	8.8700	1.5625	37.0796	10.4091	2.1102	37.7190
Cereal	4.5066	0.4762	14.2857	4.5728	0.6167	13.8889	4.8410	0.4776	19.7484
Veges	2.2453	0.1307	6.9333	2.4462	0.1000	7.7000	1.5427	0.1764	11.1765
Sugar	1.2970	0.4367	25.0112	5.8437	0.4425	26.9412	6.8760	0.5233	41.4587
Dairy	1.6617	0.6662	8.2059	1.6341	0.5850	12.0010	10.0361	0.5396	19.6479
Fats	2.6513	0.7933	22.6363	2.7210	0.8317	14.4366	3.8115	0.8297	21.7617
Nalco	1.2470	0.1900	2.6667	1.2944	0.2708	8.0010	1.4954	0.2902	6.7254
Other	4.6179	0.6300	31.6670	5.0549	0.4150	53.6508	6.4950	0.8883	66.6176

Table 3.4 Definition of Demographic Variables

Variables	Definition
Age of Reference Person:	This is a dichotomous categorical variable equal to 1 if household has that attribute, 0 otherwise:
	A_1 = 1 if head is aged 25-34, else 0;
	A_2 = 1 if head is aged 35-44, else 0;
	A_3 = 1 if head is aged 45-54, else 0;
	A_4 = 1 if head is aged 55-65, else 0;
	A_5 = 1 if head is aged over 65, else 0;
Household Size:	This is a dichotomous categorical variable equal to 1 if household has that attribute, 0 otherwise:
	H_1 = 1 if household has 1 person, else 0;
	H_2 = 1 if household has 2 persons, else 0;
	H_3 = 1 if household has 3 persons; else 0;
	H_4 = 1 if household has 4 persons, else 0;
	H_5 = 1 if household has 5 persons, else 0;
	H_6 = 1 if household has 6 persons, else 0;
	H_7 = 1 if household has > 6 persons, else 0;
Region:	Dichotomous categorical variable for region of residence of the household:
	R_1 =1 if household resides in Atlantic, else 0;
	R_2 =1 if household resides in Quebec, else 0;
	R_3 =1 if household resides in Ontario, else 0;
	R_4 =1 if household resides in Prairies, else 0;
	R_5 =1 if household resides in Pacific, else 0;
Season:	Dichotomous categorical variable for quarter in which household was surveyed:
	QT_1 =1 if household surveyed in winter, else 0;
	QT_2 =1 if household surveyed in spring, else 0
	QT_3 =1 if household surveyed in summer, else 0
	QT_4 =1 if household surveyed in fall, else 0;

3.5 Descriptive Statistics

Descriptive statistics enable us to show general trends of the variables selected for use in our stage I and stage II econometric model. In the next sub-sections, we present a summary.

3.5.1 Food Expenditures

Table 3.5 presents average weekly food expenditures and budget shares for food-at-home categories for the 1984, 1986, and 1990. The Table reveals a number of interesting changes in food consumption pattern over this period. First, total food expenditures in nominal terms, have increased by 18.23% between 1984 and 1990 from $80.23 to $110.20. It should be particularly noted that the share of the food dollar spent on food away from home (i.e. food purchased from restaurants) increased from 29.05% in the 1984 sample to 31.8% in the 1990 sample. Second, while the figures show that expenditures on FAH and FAFH have been increasing, the share of these two categories have had totally opposite trends. The expenditure share of food at home declined from 70.9% in 1984 to 69.5% in 1990. A look at the demographic composition of the sample suggests that factors such as the structure and size of the household unit, single parent, women participation in the labour force, and life style, may explain some of the observed trend in food expenditures. Third, significant changes occurred in the composition of FAH expenditure. The expenditure share for meat declined from 26.7% in 1984 to 23.9% in 1990. Within the meat category, it is worth noting that chicken share increased from 14% to 17.5% while beef and other red meats fell. Specifically, beef expenditure fell to 34.2% from 37.6%. Dairy and eggs commodity group also registered a decline from 16.9% to 15.3% over the same sample period. On the other hand, bakery and cereal products rose from 12.4% to 14.1%. Similarly, vegetables fruits, and nuts, and fish and seafood registered substantial increases in expenditures. Increases in expenditures are also indicated for non-alcoholic beverages, (although these account for only a small proportion of the food expenditure budget.

Overall, it is interesting to observe that the food commodities associated with an increase in expenditure are perceived as healthy food: (lower cholesteral and fats, and high in fibre content.) These include meats (chicken, fish, and turkey), fruits and cereals. There is also an apparent shift from monosaturated fats and oils (lard, butter) to polysaturated vegetable based oils (margarine, canola oil). Convenience foods such as frozen prepared foods and other prepared foods included in the miscellaneous foods commodity group have also increased. These changes in the pattern of household food expenditure may reflect health concerns and time value of the household unit and could have significant policy for public policy and the food processing industry, especially to the extent that both traditional economic variables (relative prices and income) and non traditional factors such as shifts in the demographic structure of households, tastes, and preferences are significant factors in a household's decision making process. Ideally, it would be desirable to incorporate the time value of the household unit and health concerns into our analysis. To do this, we need to establish that these factors are correlated with price, income, and a number of demographic variables over time. The amount of work involved in reconstructing variables in the PUMDT limits the extent to which all these aspects can be addressed.

3.5.2 Income

Table 3.6 presents household income distribution by region for 1984, 1986, and 1990. Table 3.7 presents distribution of food expenditure and household income by income class. During this period, income, in nominal terms has increased on average from $29,283 to $43,784, an increase of 49.5%. The regions with the highest incomes (before tax) are Ontario, Quebec, and Pacific. In terms of weekly expenditure between income class, households in the lowest income

Table 3.5 Stage I and Stage II Household Budget Shares

Expenditure Category	1984 Expenditure Share $	1984 Expenditure Share %	1986 Expenditure Share $	1986 Expenditure Share %	1990 Expenditure Share $	1990 Expenditure Share %
STAGE I:						
TOTAL FOOD EXPENDITURE	80.23		90.41		110.20	
Food At Home	56.92		65.24		76.58	
Food Away From Home	23.31		24.17		35.06	
STAGE II:						
Food At Home						
Meat:	15.18	26.7	16.70	25.6	18.28	23.9
Beef	5.71		6.16		6.26	
Pork	1.97		1.93		1.75	
Chicken	2.13		2.26		3.20	
Turkey	0.42		0.42		0.56	
Other Meat	4.90		5.87		5.39	
Fish	1.53		1.60		2.60	
Other Marine Products	0.47		0.48		0.86	
Dairy and Eggs:	9.64	16.9	11.65	17.8	11.72	15.3
Fluid Whole Milk	1.24		1.40		1.07	
Lowfat (2%)	2.29		2.94		2.56	
Butter	0.82		0.93		0.82	
Cheese	2.66		--		3.20	
Other	1.56		1.91		2.43	
Eggs	0.84		1.06		0.99	
Bakery and Cereal Products	7.04	12.4	8.68	13.3	10.83	14.1
Bakery	4.78		5.99		7.29	
Pasta	0.49		0.61		0.75	
Cereals	1.78		2.08		2.78	

Table 3.5(Continued)

Expenditure Category	1984 Expenditure Share $	1984 Expenditure Share %	1986 Expenditure Share $	1986 Expenditure Share %	1990 Expenditure Share $	1990 Expenditure Share %
Fruits:	5.92	10.4	6.86	10.5	8.96	11.7
Fresh Fruit	3.52		4.18		5.53	
Other Fruit and Preps	2.40		2.68		3.44	
Nuts	0.31		0.37		0.53	
Vegetables and Veg Preps:	5.14	9.0	5.90	9.0	7.70	10.1
Fresh Fruit	3.59		4.10		5.71	
Frozen Fruit	0.37		0.42		0.58	
Dried Fruit	0.06		0.06		0.10	
Canned Fruit	1.12		1.33		1.31	
Condiments, Spices, Vinegar	1.32		1.70		2.06	
Coffee and Tea:	1.29		1.58		1.96	
Coffee	1.14		1.44		1.23	
Tea	0.34		0.43		0.40	
Fats and Oils:	0.95	1.66	1.03	1.58	0.98	1.28
Margarine	0.51		0.63		0.54	
Shortening	0.04		0.07		0.03	
Lard	0.03		0.04		- -	
Salad/Cooking Oil	0.37		0.29		0.39	
Other Foods and Food Preps	3.32		4.25		5.26	
Non Alcoholic Beverages	2.09		2.57		3.22	

Table 3.6 Mean Household Income and Food Expenditures by Region

Average Weekly Amount Per Household	ATLANTIC $(mean)	QUEBEC $(mean)	ONTATIO $(mean)	PRAIRIES $(mean)	PACIFIC $(mean)
1984:					
Income Before Tax	28,357	27,549	32,949	29,905	27,658
Food Expenditure	72.45	82.84	82.68	74.51	77.20
1986:					
Income Before Tax	27,998	29,244	35,020	31,536	31,943
Food Expenditure	86.17	94.89	89.44	87.88	89.93
1990:					
Income Before Tax	37,219	43,762	52,504	42,020	43,415
Food Expenditure	91.32	110.32	119.48	99.25	107.39

Table 3.7 Household Distribution By Family Size, Expenditure, and Income.

Family Size	1984			1986			1990		
	Number of Families in Sample	Expenditure	Income	Number of Families in Sample	Expenditure	Income	Number Families in Sample	Expenditure	Income
1	1,417	44.10	17,716	2,272	50.52	16,794	1,009	61.58	23,438
2	1,777	75.78	32,686	3,379	84.98	31,567	1,557	107.25	47,269
3	1,014	90.87	37,260	2,002	107.64	38,034	923	128.93	54,005
4	1,064	109.34	40,785	2,062	125.55	40,380	861	131.92	59,950
5	643	120.18	41,273	1,204	153.78	43,165	443	176.82	64,667

class spent $44.90 on average in 1984 while households earning over $50,000 spent $124.90 per week. The period between 1984 and 1990 increases in household food expenditure of $61 for the lowest income class to $170, representing an average increase of 35% for the lowest income class and 36% for the highest income group. These changes in the pattern of household food expenditure by income class reflect the increased proportions taken by FAFH as household incomes increased by 49.5% over the entire sample period. The most significant components of income are wages and salaries, self employment, investment, and government transfers.

3.5.3 Demographic Variables

Table 3.8 presents sample means of family size and shows that average weekly expenditure on food varied by family size. In 1984, one-person households spent on average $44.10 while 5-or-more-persons households spent $120.18. These amounts increased to $61.58 per one-person households to $176.82 for 5-person households in 1990, an increase ranging from 39.6% for one-person households to 47.1% for the 5-person households. The increase in income is quite clear over the sample period.

The importance of family size in explaining the proportion of food expenditure spent on FAFH is obvious: one-person households spent 37.1% of their food dollar on FAFH while 5-person households spent 21.8% in 1990 compared to 18% and 22.5%.

Other demographic variables of interest are age, sex, level of education, household type, and occupation. The relevant statistics for each of these are not given here in view of the focus of this study.

3.6 Quality Assessment of Data

Almost all surveys have sampling and non-sampling errors which have implications for the reliability of sample estimates. Sampling errors occur due to the fact that inferences about a given population are based on information provided only by a sample of the population. Non-sampling errors include coverage errors, response errors, non-response error, and processing errors. In order to ensure that the data contained in the final PUMDTs are as reliable as possible, Statistics Canada undertakes strict quality control procedures which involve: 1) reviewing each questionnaire and diary for general quality; 2) coding item descriptions as well as other variables; 3) entering data into an interactive data capture and editing system and setting limits on items reported in the diary; and 4) scrutinizing and correcting the data for extreme values as well as identifying and imputing values for non-response fields. Overall, weights are applied to each sampled unit in order to reflect the idea that each unit represents a certain number of unsampled households in the population.

3.7 Data Construction and Management

A challenging aspect of this study had to do with data construction and management. The sheer size and complexity of the PUMDTs coupled with restrictions on resources made this a

Table 3.8 Household Distribution By Family Size, Total Expenditure, and FAFH

	1984			1986			1990		
Family Size	Total Food Expend$	FAFH $	FAFH %	Total Food Expend$	FAFH $	FAH %	Total Food Expend$	FAFH $	FAFH %
1	44.10	18.10	41.0	50.52	21.78	43.1	61.58	22.78	37.0
2	75.78	25.76	34.0	84.98	28.00	32.9	107.25	38.89	36.3
3	90.87	23.19	25.5	107.64	29.51	27.4	128.93	38.74	30.1
4	109.34	27.47	25.1	125.55	29.13	23.2	151.14	41.52	27.5
5	120.18	22.52	18.7	153.78	33.69	21.9	176.82	38.63	21.9

thankless task. For this reason, all data management, construction, and estimation were undertaken using SAS on a Sunsparc UNIX workstation. For specialized programming, FORTRAN was also employed. The greatest advantage of SAS is its ability to handle any data size. Since it works with just one observation at a time, memory is never the constraint but disk space. However, PUMDTS take up hundreds of megabytes of storage space. This disk storage is severely aggravated once temporary and permanent SAS libraries have been created. Hence, a lot of time is spent on splitting and concatenating data sets to stay within disk quota allocation.

In terms of actual estimation, the down side to SAS is that it is extremely lacking in features most relevant for econometric work while its massive and voluminous manuals can be intimidating to a first user. This is not assisted by the fact that it employs statistical jargon based on ANOVA which is not entirely the analytical testing paradigm of economists. However, SAS handles linear systems estimation very well, including testing of restrictions. SAS has no built in procedures for handling limited dependent variables, which means that a user who intends to run a censored regression must either write his or her own program within SAS, or construct the relevant data inside SAS, and then transport this data to econometric software such as SHAZAM and LIMDEP which have specific routines for handling censoring within an economic framework.

Chapter 4

Food At Home Consumption in Canada: An Almost Ideal Demand System Analysis using Microdata

4.1 Introduction

This chapter specifies a set of individual household demand equations for estimating household allocation of total expenditure to food based on a two-stage budgeting procedure. We have two major objectives in this chapter. The first objective is to evaluate the impact of income and demographic variables on a household's allocation of total food expenditure to disaggregated food commodities. The second objective is to test the theoretical restrictions of neoclassical theory.

In order to achieve these objectives, the Almost Ideal Demand System (ALIDS) of Deaton and Muellbauer [1980a] will be used to model a two-stage expenditure allocation whereby food-at-home (FAH), food-away-from-home (FAFH), and nonfood (NF) comprise the first stage budgeting groups: i.e., a household first allocates total food expenditure to FAH, FAFH, and NF (Stage I) and subsequently FAH expenditures are allocated to 12 food categories (Stage II). Consistent with our theoretical discussion in preceding sections, our application of the two-stage budgeting procedure assumes homothetic separability in the sub-utility function for all commodity groups, i.e. the utility function for each household need not be additive. Hence, we are treating individual FAH as homothetically separable from FAFH and NF. Similarly, as noted in Chapter 3 (Section 3.4.1), my 12 food groups implicitly assume homothetic weak separability for these 12 groups as well as homothetic weak separability between the three first stage groups. The household level model is extended to explicitly take into account the incorporation of demographic variables as recorded in the Public Use Microdata Tapes (PUMDTs) by allowing household preferences to depend on demographic variables.

4.2 Organization of Chapter

This chapter is organised as follows. In Section 4.3, a brief discussion of the household ALIDS model is presented, including advantages of using the ALIDS over alternative functional forms such as the Rotterdam, the Addilog, the Linear Expenditure System, and the Translog. Section 4.4 presents a derivation of the ALIDS while in Section 4.5, we incorporate demographic variables before considering econometric estimation in Section 4.6. In Sections 4.7 and 4.8, parameter estimates, tests of restrictions, and model validation are presented.

4.3 Choice of Functional From

Choice of functional form without any statistical criteria is not always without controversy.[7] In this study, the Almost Ideal Demand System (ALIDS) of Deaton and Muellbaeur [1980a] is adopted for analysis because of its flexibility and linearity as well as the fact that it is a complete demand system: it can be restricted to satisfy the general restrictions of adding-up, homogeneity, and symmetry. Specifically, the ALIDS has the following advantages:

1. It satisfies the theoretical restrictions implied by demand theory and the general restrictions are invariant to changes in total expenditure and prices. These can be expressed wholly in terms of budget share equation parameters.

[7] This issue is addressed in Chapter 6 where we have used a nested approach to compare the ALIDS and the Translog flexible functional forms.

2. It is compatible with a known set of cost functions which not only provide a local second-order approximation to the underlying cost function, but also generate a set of budget share equations with sufficient parameters to be considered as a local first-order approximation to any demand system

3. Since the cost function from which the ALIDS is derived belongs to the PIGLOG class (which is nonhomothetic and nonadditive), its budget share equations can be perfectly aggregated and the aggregate equations can also be expected to obey the general restrictions. Perfect aggregation involves a "representative level of total expenditure" and hence does not require homothetic utility functions, i.e. parallel linear Engel curves or additive preferences. The consistent aggregation from micro level to market demand property of the ALIDS model removes a possible source of aggregation bias.

4. The use of budget shares rather than expenditure of quantity demanded as endogenous variables is advantageous because i) budget shares involve less heteroscedasticity; ii) budget shares are dimensionless, hence, permitting comparisons to be made across household units and time without need for conversions; iii) greater attention can be paid to household budget allocation given that households budget shares sum to unity by construction.

Thus, in terms of alternative functional forms, we see immediately that based on the above general criteria, we can rule out Theil's and Barten's Rotterdam model which has been shown to be consistent with utility theory only if the underlying utility function is additive and homothetic.[8]

[8] Deaton and Muellbauer [1980] attribute this particular observation to an unpublished work by McFadden. For proof, see Theil [1975].

We also rule out Houthakker's Direct Addilog model and Stone's Linear Expenditure System because of their direct additivity property. This property which implies that the utility generated by one commodity is not affected by the consumption of any other excludes the possibility of cross-substitution effects but also rules out inferior and complementary commodities [Phlips 1984; Theil 1967]. In fact, in terms of the indirect utility function, Houthakker [1960] has shown that additivity is not desirable because it suggests that cross-price elasticities depend only on the commodity whose price is changing and not on the commodity whose price is responding. In terms of elasticities discussed later in this chapter, Phlips has shown that additivity of the indirect utility function implies that own price and expenditure elasticities are equal to unity while all cross price elasticities are equal to zero. Within the context of our study, this property is clearly undesirable since we are dealing with highly disaggregated commodities for which direct additivity is implausible. This of course implies that direct additivity may be plausible at much higher levels of aggregation when commodities have been broadly defined.

Finally, note that like the ALIDS, the Translog of Christensen, Jorgenson, and Lau [1975] in general meets the criteria set out above. However, the ALIDS is preferred because unlike the Translog, its share equations are easy to interpret and the system of share equations involve less nonlinearity in estimation. The latter point more accurately relates to the linear approximate version of the ALIDS which, as suggested by Blanciforti and Green, is completely linear such that if cross equation restrictions of symmetry are not imposed, the entire system can be estimated equation by equation. The econometric issues relating to this point are taken up later in this Chapter. Empirically, the ALIDS has been shown to represent survey data very well in applications such as Ray [1980], *inter alia*. In addition, a number of these studies (e.g Lewbel 1987) have suggested that the ALIDS appears to be more consistent with two-stage budgeting, and is generally free of restrictive assumptions of homotheticity and additivity while retaining weak separability. Recently, Lee, Brown, and Seale [1994] estimated differential demand models combining features of the Rotterdam and the ALIDS and found that the ALIDS-type demand provided better description of consumer behaviour, a result that seems to contradict Alston and Chalfant [1993] and suggests that ultimately, issues of model choice are essentially empirical.

4.4 Derivation of ALIDS Model

As illustrated in Chapter 3, the ALIDS model can be derived from a class of expenditure functions called PIGLOG (Price Independent Generalised Logarithmic) [Muellbauer, 1975] of the form:

$$\log e^{h}(p,U^{h}) = (1-U^{h})\log A(p) + U^{h}\log B(p) \qquad 4.1$$

where $e^h(p,U^h)$ is the h^{th} household's minimum expenditure necessary to attain utility level U^h at prices p_i $(i=1,2,...,n)$; $A(p)$ and $B(p)$ are linear homogeneous, concave functions of prices p, and are chosen as follows:

$$\log A(p) = \alpha_0 + \sum_i \alpha_i \log p + \frac{1}{2}\sum_i \sum_j \gamma_{ij} \log p_i \log p_j \qquad 4.2$$

$$\log B(p) = \log A(p) + \beta_0 \prod_i p_j^{\beta_j} \qquad 4.3$$

where α_i, β_i, and γ_{ij} are parameters. By substituting (4.2) into (4.1), the constrained utility maximizing expenditure function for household h can be written as:[9]

$$\log e^{h}(p,U^{h}) = \alpha_0 + \sum_i \alpha_i \log p_i + \frac{1}{2}\sum_i \sum_j \gamma_{ij} \log p_i \log p_j + U\beta_0 \prod_i p_i^{\beta_j} \qquad 4.4$$

[9] Notice that 4.4 is linear in U which may imply that the expenditure function has a Gorman Polar Form. See my discussion in Chapter 3, and refer to equations 3.7 - 3.11 with regard to this point.

By applying a special case of the envelope theorem called Hotelling-Shephard's Lemma to (4.4) and using the result $u^{*}= v(p,m)$, we can derive the generalised ALIDS budget share demand equations for household h as:[10]

$$w_i^h = \alpha_i + \sum_{j=1}^{n} \gamma_{ij}\log p_j + \beta_i \log\left(\frac{m^h}{P^h}\right) \qquad i=1,2,...,n \tag{4.5}$$

where there are H households indexed by $h=1,2,...,H$; α_i, γ_{ij}, and β_i are parameters; w_i^h is h^{th} household's budget share of the i^{th} commodity where price and quantity are given by p_i and x_i respectively; $m^h = \sum p_i x_i$ is total food expenditure for h^{th} household; P^h is a price index defined by

$$\log P^h = \alpha_0 + \sum_i \alpha_i \log p_i + \frac{1}{2}\sum_i \sum_j \gamma_{ij}\log p_i \log p_j + \frac{1}{2}\sum_i \sum_j \gamma_{ij}\log p_i \log p_j \tag{4.6}$$

and the parameters of (4.6) are defined by

$$\gamma_{ij} = \frac{1}{2}(\gamma_{ij}^{*} + \gamma_{ji}^{*}) = \gamma_{ji} \tag{4.7}$$

The ALIDS is defined by (4.5) - (4.7). Deaton and Muellbauer note that (4.5) can be considered as a first order approximation to the general unknown relations between w, $\log m$, and the $\log P$'s.

The ALIDS system of budget share equations sum to total expenditure (therefore $\sum w_i=1$) and are homogeneous of degree zero in prices and total expenditure, and satisfy Slutsky symmetry (i.e. symmetric in the substitution matrix) if and only if the following general restrictions hold globally, i.e. at every data point:

a). Adding up: $\sum_i \alpha_i=1$, $\sum_i \beta_i=0$, $\sum_i \gamma_{ij}=0 \quad j=1,2,...,m$ 4.8

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[10] It can easily be shown that the price derivatives of the expenditure function equal the quantity demanded. More conveniently, the log derivative of the expenditure with respect to the prices generates budget share demand equations. See Deaton and Muellbauer [1980] and Deaton [1986] for details.

b). Homogeneity: $\sum_j \gamma_{ij}=0$ 4.9

c). Symmetry: $\gamma_{ij}=\gamma_{ji}$ 4.10

d). Concavity of the expenditure function or the negative semi-definiteness of the substitution matrix. The parametric representation of this restriction in the ALIDS is not obvious but it can be checked by calculating the eigenvalues of the Slutsky matrix. See later discussion.

From an econometric point of view, the ALIDS has amenable features because it is quite close to being linear. The price index expression P (equation 4.6) which introduces the nonlinearity can be approximated by a simpler index used by Stone as follows:

$$\log P^* = \sum_i w_i \log p_i \qquad 4.11$$

Deaton and Muellbauer note that in practical situations where prices are relatively collinear, Stones index is not too restrictive an assumption and provides a very good approximation to the actual index defined by (4.6) and selection of a particular index is likely to be trivial. Anderson and Blundell [1983] and Blanciforti and Green [1983], *inter alia* , have also provided empirical evidence indicating that using Stone's geometric index does not have any significant effect on the value of the log likelihood function. Hence, in the rest of this study, we shall adopt Stone's index and the ALIDS will be understood to be the linear approximate ALIDS in the sense of Blanciforti and Green. Stone's index has an added advantage in that it can be calculated directly prior to estimation so that estimation becomes a straight forward matter. Again, this contrasts with budget shares obtained from the Translog which necessitate maximum likelihood procedures requiring nonlinear estimation.

Note that in the absence of any restrictions, the ALIDS like any complete demand, leaves too many parameters to be estimated, i.e. for n commodities, we have n α_i's, n β_i's, and n^2 γ_i's, for a total of $2n+n^2$. The imposition of general restrictions allows us to reduce significantly the number of parameters while making our model consistent with the theory of consumer behaviour. Thus, first we estimate $n-1$ of the share equations, and then use the adding up restriction to estimate parameters of the remaining equations. Next, we can impose $\frac{1}{2}(n^2-n)$ cross-equation symmetry restrictions. Finally, the homogeneity restriction reduces the number of free parameters by $n-1$. The total number of restrictions equals $\frac{1}{4}(n^2+3n-4)$ and the imposition of the restrictions reduces the number of free unknown structural parameters to $\frac{1}{2}(n^2+3n-4)$. As will be seen later, this is a definite advantage especially when the incorporation of demographic variables adds to the number of parameters to be estimated.

4.5 Household ALIDS with Demographic Variables

The model presented in (4.5) does not explicitly incorporate demographic variables and implicitly assumes that households with different socioeconomic attributes have identical preference structures. The validity of this assumption is quite limited since it is now widely recognised that socioeconomic attributes exert a noticeable influence on a household's consumption behaviour. In this section, we extend the ALIDS by incorporating demographic variables. These variables can be incorporated in a variety of ways and their explicit specification is an empirical issue.

In this study, we adopt demographic translating and incorporate demographic variables by decomposing the intercept term by allowing the intercept in (4.5) to be a linear function of demographic attributes, D^h $(h=1,2,...,H)$ where households are indexed by h, i.e.

$$\alpha_i^h = \alpha_{i0} + \sum_j^N \delta_{ij} D_j^h \qquad 4.12$$

where α_{i0} is the 'true' intercept and δ_{ij} are parameters associated with D_j, the j^{th} demographic variable of which there are N. As we shall see later, δ_{ij} are represented by binary variables and they measure the effect of household size, age of household head, and region of residence. Our ALIDS model incorporating D can now be written as:

$$w_i^h = \alpha_{io} + +\sum_j \gamma_{ij} \log p_j + \beta_i \log(\frac{m^h}{P}) + \sum_j \delta_{ij} D_j^h \qquad 4.13$$

where it is clear that individual characteristics D_j enter only via the intercept. Here, the data on D_i may simply be a column of dummy or dichotomous categorical variables 0's and 1's (i.e. a binary variable that takes on the value of 1 if the household has the attribute and zero otherwise). The role of the dummy variables in the model is to exhibit any differential constant effect on the dependent variable. Notice how the translated coefficients have an intuitive interpretation. With the extended ALIDS, the adding up constraint now requires

$$\sum_{i=1}^{n} \alpha_{io} = 1; \quad \sum_{i=1}^{n} \delta_{ij} = 0 \quad j=1,2,...,J; \quad \sum_{i=1}^{n} \gamma_{ij} = \sum_{i=1}^{n} \beta_i = 0 \qquad 4.14$$

It can be shown that this extended version of the ALIDS still satisfies first order conditions for expenditure minimization and can be derived from the following expenditure function generalization of the original ALIDS:

$$\log e(p,u,D) = \alpha_0 + \sum_i (\alpha_i + \delta_{ij} \log D_i) \log p_i + \frac{1}{2} \sum_1 \sum_j \gamma_{ij}^* \log p_i \log p_j + u \Pi p_i^{\beta_i} \qquad 4.15$$

which is homogeneous of degree one in prices provided $\Sigma\beta_{ij}$,$\Sigma\gamma_{ij} = \Sigma\gamma_{ji} = \Sigma(\alpha_i + \Sigma\delta_{ij} \log D_i)$ $= 0$. In general, the ALIDS with demographics is obtained via the dual expenditure function minimization problem:

$$e^h[p,u(x-\alpha_i^h)] = \min_{x-\alpha_i^h} [p^T(x-a_i^h): u(x-\alpha_i^h) = u^*] \qquad 4.16$$

where $e[p,u(x-a)]$ denotes the relationship between minimum expenditure and prices and utility level and corresponds to the primal utility maximization problem:

$$Max\ u(x - a_i) : p^T(x - a_i) \leq (m - p^T a),\ (x - a) \geq 0 = u[(x - a)^*] \qquad 4.17$$

in which the household chooses $(x - a)$ bundle subject to a price vector p^T and income $(m - p^T a)$. In terms of application, this duality between utility maximization and expenditure minimization is equivalent to saying that the Hicksian and Marshallian demands $x^h[p,u(x-a)]$ and $x[p,(m-a)]$ are equal when evaluated at a utility level $u=u^*$. The extent to which this correspondence holds in practice is an empirical matter which we have investigated later on in this Chapter and basically involves checking curvature of the expenditure function for violations of concavity.

In equation (4.13), it is possible to use translating in which the allocation of expenditure m^h is allowed to depend on demographic variables as well. For instance, if we allow the marginal budget shares, β_i to vary with household size, we can write:

$$\beta_i^h = \beta_0 + \eta_i D_i^h \qquad 4.18$$

Substituting (4.18) into (4.13), we obtain the following revised ALIDS model:

$$w_i^h = \alpha_{io} + + \sum_j \gamma_{ij} \log p_j + (\beta_0 + \eta_i D_i^h) \log(\frac{m^h}{P}) + \sum_j \delta_{ij} D_j^h \qquad 4.19$$

In this specification, we have allowed binary variables to shift both the intercept and the expenditure coefficient, so that the allocation of expenditure is also now allowed to depend on demographic variables. However, this is for theoretical interest only. All the analysis in this study will be based on the estimation of equation (4.13).

4.6 The Household ALIDS and the Unit Value Problem

Prices employed in equation (4.12) are Divisia indices based on unit values and these are used to estimate the parameters of the γ_{ij} matrix. However, as pointed out in our earlier discussion, we need to take into account the fact that these prices are implicit and may not entirely approximate market prices. As indicated in Chapter 3, unit values have been shown to be functions of quality of commodities (which is endogenous to the households) and market prices (which are presumably exogenous to the households). Households choose the quality of their purchase and the unit values may reflect that choice. As Deaton [1988, 1990] has argued, quality choice itself may reflect the influence of prices as households respond to prices by adjusting quality and quantity, i.e. the composition of their purchases within a commodity category. Hence, it is argued that estimating demand systems based on such prices will not yield price elasticities that reflect households' responses to exogenous price changes such as those due to supply.

To eliminate possible measurement error and quality effects from unit prices, Deaton employed a cluster technique in which real price variation is assumed to exist only across clusters while that within clusters is constant, such that any observed unit value variations between geographic areas imply either measurement error or quality choice. Unfortunately, the structure of our PUMDTs (including the definition of region) makes it difficult to operationalize Deaton's cluster technique. And besides, the assumption that within-cluster relative price differences are constant appears to be too restrictive: if one took say the Prairies (Manitoba, Saskatchewan, and Alberta) as a cluster, it would be unrealistic to argue that intra-Prairie relative price differences are constant. Nevertheless, if it were at all possible to finely identify observations by region, say observations corresponding to Winnipeg at a given point in time, then one could impose identical (aggregate) prices on these observations as follows: first calculate Divisia price indices for each observation as done in my earlier calculation above; then calculate the average of these indices over those individuals and use these average indices as the prices for these individuals in Winnipeg at the given time. We intend to explore these alternatives in future research work.

Other researchers such as Cox and Wohlgenant [1986] identified price variability from quality effects using household characteristics (and hence underlying quality characteristics) as proxies for household preferences for unobserved quality attributes. This is the standard hedonic price model. Once the effects of these variables have been controlled for, any observed variation in household level unit values can be assumed to represent real market price variation, The results of Cox and Wohlgenant as those of others such as Nelson [1990, 1991] which replicate Deaton's model using USA household expenditure data suggest that there appears to be no appropriate procedure to specify cross-sectional price effects that reflect quality effects. The essential point however is lucid: failure to sufficiently specify cross sectional price effects could result in biased and misleading elasticities, as Polinsky [1977] has shown. It is now easy to see how ignoring this quality problem and the expenditure endogeneity problem in our estimating equation can aggravate the bias associated with our estimates.

For this reason, our ALIDS model has been extended to incorporate 17 demographic variables representing household size, age of houshold, region of residence, and seasonal dummies corresponding to the season (quarter) in which a given household was surveyed. It can be asserted that incorporating this number of demographic variables in a theoretically consistent manner does aid in adequately representing and characterizing the unobservable differences in tastes and preferences between households, regions, and seasons in our model, based of course on the reasonable assumption that endogenous quality effects in unit values result from these variations in taste. Hence, we believe we have taken into account several dimensions to quality effects, and, in this sense, we can claim that our model is more precise than models that ignore this problem altogether. For instance, by incorporating household size dummies, we are allowing for economies of size in purchasing and household consumption and production activities. Indeed, as Prais and Houthakker have shown, larger families pay lower prices due to the existence of these economies. It is possible to incorporate a price-income interaction term using Cramer's [1973] suggestion to allow for possible price-income relationships to the extent that higher income households tend to buy more marketing services and therefore pay higher prices on average for commodities. Future research may incorporate this aspect.

Based on the above discussion, we believe it is possible to empirically identify and estimate the parameters of the γ_{ij} matrix such that in each of the i equations, the budget share is a function of an intercept, Divisia unit price indices, household expenditure, and demographic variables. The intercept, α_i, represents average budget shares when real food expenditure, prices, and demographic variables are constant; γ_{ij} delineates the change in the i^{th} budget share due to a unit change in price p_j holding expenditure constant; β_i represents the effect of a percentage change in real total food expenditure on the i^{th} budget share, *ceteris paribus*. Again, by the adding up requirement, $\sum\beta_i=0$, i.e. coefficients of β_i sum to zero. Furthermore, $\beta_i < 0$ implies that the expenditure elasticity $(\epsilon_{iM} = 1 + \beta_i/w_i)$ is less than unity, i.e. the commodity is a necessity. $\beta_i > 0$ implies the commodity is a luxury. Thus, for $\beta_i > 0$, the budget share for the h^{th} household, w^h_i, will increase with an increase in total expenditure, while for $\beta_i < 0$, there will be a decrease. The effect of demographic variables on the budget share are captured by δ_{ij}.

4.7 Estimation of the Household ALIDS

In order to estimate equation (4,13), we append additively a stochastic error term ϵ_{ih} to each equation. The 12-equation model can be rewritten explicitly as:

$$w_i = \alpha_{i0} + \beta_i \log(\frac{m}{P^*}) + \sum_{j=1}^{12} \gamma_{ij} \log p_j + \sum_{j=2}^{7} \delta^H_{ij} H_j + \sum_{j=2}^{5} \delta^A_{ij} A_j + \sum_{j=2}^{5} \delta^R_{ij} R_j + \sum_{j=2}^{4} \delta^{QT}_{ij} QT_j + e_i \qquad 4.20$$

The set of regressors explaining each of the 12 budget share equations is identical. For each share equation, there are 12 prices, one real food expenditure term, and 17 binary variables representing 7 household sizes, 5 age categories for head of household, 5 regions, and 4 seasons, for a total of 372 parameters including 12 intercepts. The stochastic error term, ϵ_{ih} is intended to account for stochastic errors in household optimizing behaviour as well as heterogeneity across households. PUMDT data for each year is used separately to identify and estimate the intercepts, the coefficients of price and total food expenditure, and the demographic coefficients associated with the model.

The complete set of variables used to estimate model 4.20 are defined in Chapter 3. The demographic variables are defined for the h^{th} household and each household falls into exactly one of these categories. Because the groups are discrete, we need to represent the attributes by integer valued variables. Hence, each of the attributes are defined either by a vector D containing elements with binary values (0,1) depending on whether or not such household possesses such an attribute or not, or an integer variable equal to the number of persons in that household in the case of household size. The categories are age of household head, household size, region of residence, and season. Based on our earlier discussion regarding exact aggregation, each of these demographic variables are represented linearly in the function that determine household expenditure shares for a particular food. In the case of household size, this is an important consideration. In Table 3.4 (Chapter 3), our family size variable is defined as equal to the number of persons in that household. Defining family size in this manner imposes an *a priori* constraint on the way in which different family sizes affect household food expenditure patterns. Hence, in order to capture and estimate the effects of different family sizes, we simply define a binary variable for each family size. Based on definitions for demographic variables presented in

Chapter 3, model (4.20) would normally be estimated using a two-stage procedure which is invoked based on the assumption of price exogeneity and weak separability as follows:

Stage I: Estimate only the aggregate food (FAH, FAFH, and NF) equation system.

Stage II: Estimate the disaggregated 12-food equation system.

The explicit specification of the Stage I household share demand equations requires the definition of the following variables:

w^h_{FAH} = $p^h_{FAH}x^h_{FAH}/m^h$ = expenditure share of food at home (FAH) in the budget of household h, $(h=1,2,...,H)$;

w^h_{FAFH} = $p^h_{FAFH}x^h_{FAFH}/m^h$ = expenditure share of food away from home (FAFH) in the budget of household h, $(h=1,2,...,H)$;

w^h_{NF} = $p^h_{NF}x^h_{NF}/m^h$ = expenditure share of nonfood (NF) in the budget of household h, $(h=1,2,...,H)$;

m^h_{FAH} = $p^h_{FAH}x^h_{FAH}$ = expenditure by h^{th} household on FAH;

m^h_{FAFH} = $p^h_{FAFH}x^h_{FAFH}$ = expenditure by h^{th} household on FAFH;

m^h_{NF} = $p^h_{NF}x^h_{NF}$ = expenditure by h^{th} household on NF;

m^h = $m^h_{FAH} + m^h_{FAFH} + m^h_{NF}$ = total food expenditure by household h.

Thus, at this stage, total food expenditures m^h for household h are allocated between FAH, FAFH, and NF such that $m^h_{FAH} + m^h_{FAFH} = m^h$. However, as noted earlier, we are compelled to focus on stage II because price data for FAFH and NF which is critical for the implementation of stage I is not available and no reasonable proxies can be found.

Thus, concentrating on stage II, our two-stage budgeting procedure generates an ALIDS system for the allocation of food group expenditure m^h_{FAH} (determined in Stage I) to 12 disaggregated commodities defined in Table 3.2 in which we are treating the individual FAH as being homothetically separable from FAFH and NF . Homotheticity of preferences clearly implies that each of the 12 disaggregated food demands are proportional to total FAH expenditure, and so it must be possible to express the demand for each of the 12 commodities as a function of total expenditure on the group (FAH), and the price of commodities and demographic attributes of the h^{th} household unit within that group alone. The expenditure of each food category was derived by summing the reported expenditures on all foods in that group. The PUMDTs code households into numerous classes based on the occupation of the household head. This number is clearly restrictive from a computational stand point, hence in this study, we choose only a limited number.

In terms of econometric estimation, these ALIDS share equations have two complications. First, they automatically satisfy the adding up restriction: for all commodities, they sum to unity by construction for each household in each time period $(\sum_i w_{ih}=1)$. For any equation, the error term is a linear combination of the errors of all the other equations, implying that errors for all commodities sum to zero for each household unit $(\sum_i \epsilon_{ih}=0 \ \forall \ h)$. In other words, although each equation is serially independent, the random variable relations of the system are contemporaneously dependent, i.e. the errors are not independently distributed. This means that the variance-covariance matrix, Ψ, for the 12 commodity share demand system will be singular and cannot be inverted since the shares sum to one, implying that $Var(\epsilon_{th}) = \Psi_t \, (h=1,2,...,H; t=1,2,...,T)$ is nonnegative definite with rank at most equal to N-1 where N is the number of commodities or equations. We assume that the variance-covariance matrix has rank N-1. And hence, application of ordinary least squares (OLS) would not be efficient since the vector of error terms in this case is not homoscedastic across equations. Moreover, applying OLS to all N equations jointly (given this linear dependence) apparently is possible only to the extent that the computer makes round-off errors.

For purposes of estimation, we adopt the common procedure of deleting one of the equations, rendering the remaining $(N-1)\times(N-1)$ variance-covariance matrix nonsingular. We can still recover the elasticities for the deleted equation residually by simply using symmetry and homogeneity restrictions. Hence, from an econometric stand point, there is no loss of information. Judge *et. al.* [1985], and Chavas and Segerson [1987] have shown that an appropriate modification of the GLS (ML) procedure ensures that the econometric results are invariant with respect to which equation is actually dropped. Note that for the same reason that we drop one share equation to avoid singularity of the variance-covariance matrix, we must also assign zero values to the first row in the *[D]* matrix of demographic variables such that from a total of 17 dummies, we are left with 14. In equation (4.20), these still enter as distinct attributes of the households in estimating the effects of demographic variables on the distribution of food expenditure.[11]

There is a second complication regarding the estimation of our system (4.20) and it has to do with the use of FAH expenditure, m^h, as a regressor. Most empirical studies treat m^h as exogenous in the second stage on the assumption that household preferences are separable. In turn, these conditional demands are estimated as functions of a subset of relevant commodity prices and total expenditure within that subgroup and the system is estimated using Zellner's seemingly unrelated regression (SURE) which is simply an appropriately modified GLS procedure applying OLS in successive stages. However, La France [1991] has shown that expenditure m^h as specified in equation (4.20) cannot be weakly exogenous while Blundell [1988], and Blundell, Pashardes, and Weber [1993] have argued that it is imperative to account for expenditure endogeneity in demand systems estimated with cross sectional data. This problem has been recognized and addressed variously by Eales and Unnevehr [1988, 1993], Brown, Behr, and Lee

[11] In general, if we had *N-1* equations and *N-1* dummy variables, perfect multicollinearity would result since the intercept (which is essentially a column of *1's* would equal the sum of *N-1* dummies. Hence, assigning a zero value to one of the dummies eschews perfect multicollinearity.

[1994], and Egerton [1993]. The work by Eales and Unnevehr is worth noting since it also considers the issue of price and quantity endogeneity and proceeds to develop an inverse of the ALIDS. Independent related work has been done by Moschini and Vissa [1991, 1993]. Coyle [1993b] has integrated the issue of endogeneity into an economic model of production and estimated a system of conditional crop acreage demands. These studies all point to the importance of treating the endogeneity question more systematically and earnestly.

Thus if the assumption of exogeneity of m^h is no longer valid, then m^h will be contemporaneously correlated with the error term. This means that OLS estimation is asymptotically biased since OLS, in explaining variation in the dependent variable (w_i) caused by a particular exogenous variable, does in fact attribute some of the variation in the dependent variable caused purely by the stochastic error term to the regressor with which the stochastic error is contemporaneously correlated. Hence, part of our task in this study is to account for this endogeneity problem in the estimation.

In order to formalize the problem, let us rewrite the N-1 conditional demands given by (4.20) (and ignoring demographic variables) as

$$w_i^h = \alpha_0 + \sum_j \gamma_{ij} \log p_i + \beta_i \left[\log(\sum_i p_i^h x_i^h) - \log \sum_i w_i^h p_i \right] \qquad 4.21$$

where $\sum_i w_i^h \log p_i$ is the price index and $[\log(\sum_i p_i^h x_i^h) - \log \sum_i w_i^h p_i]$ is the log of total real food at home expenditure, i.e. the sum of food expenditure on individual commodities. We observed however that the expenditures on individual commodities are endogenous as is clear from equations (2.9, and 2.13-2.17 Chapter 2). Let us again examine stage two intersectoral allocation in which the household decides to allocate aggregate expenditures $M^* = M_a^* + M_b^*$ +...+ M_s^* in an optimal way among the commodities within each group by solving the following maximization problem:

$$Max\ U^a(X_a^1,...,X_a^{Na}) \ \ ... \ \ Max\ U^s(X_s^1,...,X_s^{Ns}) \qquad 4.22$$

subject to

$$\sum_{i}^{N_a} P_a^i X_a^i = M_a \qquad \sum_{i}^{N_s} P_s^i X_s^i = M_s \qquad 4.23$$

where each U^i (i=1,...,s) in a subutility function for each food category. Clearly, the consumer has a subutility function for the food she purchases: it is defined over all individual commodities in that group, i.e. $X_a^1,...,X_a^{Na}$ with individual prices $P_a^1,...,P_a^{Na}$ in that group. $M_a,...,M_s$ are second stage allocations of group (FAH) expenditure M_{FAH} to commodities $X_a = (X_a^1,...,X_a^{Na})$, ..., $X_s = (X_s^1,...,X_s^{Ns})$ respectively. Based on weak separability of the household's group A indirect utility function $V_a(P_a, M_a, D)$, the Marshallian demands corresponding to the above maximization problem can be written as

$$X_a = X_a(P_a, M_a, D) \qquad 4.24$$

and

$$M_a = M_a\ (P_a,...,P_s, M) \qquad 4.25$$

the conditional expenditure variable for commodity group A and it is obviously not exogenous to the household. As such, estimators of structural parameters will be biased and inconsistent. One might argue that the household's Stage II decisions occur at two separate points in time, in which case the exogeneity assumption seems appealing and hence FAH is a predetermined variable. However, the usual assumption in the literature is that the two stages occur simultaneously. Unless households breakdown this decision in time, it is not reasonable to assume exogeneity. Hence, although modelling Stage II independently of Stage I as has been done in other studies appears conceptually valid and consistent with the sub-utility function approach, the assumption regarding the exogeneity of M is not persuasive and is at best misleading, if not 'hazardous' altogether.

In order to account for endogenous regressors as well as the linear dependence between the error terms on the right hand side of (4.20), we shall employ three stage least squares (3SLS)

[Zellner and Theil, 1962] to estimate our N-1 system of conditional demands appropriately augmented with a regression of FAH on a set of instruments. 3SLS is a full information method in that it takes into account complete information on all the structural equations in the estimation of any structural equations as opposed to limited information methods such as ILS, 2SLS, LIVE, and LIML. Essentially, 3SLS generalizes the 2SLS method to incorporate correlation between equations in the same way that SURE generalizes OLS.

To formalize the estimation procedure, we can rewrite our N-1 conditional demands as

$$W_i^h = \Gamma X_i + \pi M_i^h + e_i^h \qquad 4.26$$

or more compactly as

$$\mathbf{W} = \mathbf{Z\Theta} + e \qquad 4.27$$

where

$\mathbf{W}$ = $[w_1, w_2, ..., w_{12}]^T$ is an $(N$-1)x(Hx1) matrix of budget share equations;

$\mathbf{Z}$ = an (N-1)x(HxK) full rank matrix of predetermined and endogenous variables X and M respectively on the right hand side; $K = \sum_i^{N-1}$ and k_i is the number of right hand side variables in the i^{th} equation.

$\mathbf{\Theta}$ = a Kx1 vector of structural parameters $\mathbf{\Gamma}$ and $\boldsymbol{\pi}$.

e = an (N-1)x(Hx1) matrix of stochastic error terms.

Since M is endogenous, it follows that $E(Me) = \sigma_{Me} \neq 0$ and hence estimation of structural parameters $\mathbf{\Gamma}$ and $\boldsymbol{\pi}$ will be biased and inefficient. Observe that we only estimate N-1 equations to avoid singularity of the covariance matrix due to summability. The omitted equation is the 'OTHER' category whose parameters are recovered residually from the summability restriction. Thus, 3SLS proceeds as follows: in stage I, a regression of W on Z is run to get predicted values of $\mathbf{\Theta}$ for the endogenous regressors in $\mathbf{Z}$; in stage II, a residual covariance matrix $\hat{\Sigma}$ is computed using 2SLS; in stage III, $\hat{\Sigma}$ is used to derive the 3SLS estimator given by

$$\hat{\Theta}^{*} = \left[Z^{T}[\hat{\Sigma}^{-1} \otimes X(X^{T}X)]Z\right]^{-1} Z^{T}[\hat{\Sigma}^{-1} \otimes X(X^{T}X)^{-1}X(X^{T}X)^{-1}]W \qquad 4.28$$

where the inverse of the term in braces is the covariance matrix of coefficients.

The next question is what do we choose as an instrument. An overriding consideration for choice is that the instrument be exogenous to the second stage of the budgeting procedure, i.e. one that is not contemporaneously correlated with the error term. It is however desirable that such an instrument be highly correlated with the variable for which it is to serve as the instrument. For our purpose, we shall income before taxes as the instrument. Gallant [1977] has observed that there is no set limit to the number of instruments, especially for demand systems, and the results are not invariant to the particular choice of instrument. Such variability in results may occur even with the same model and data.

Finally, note that in terms of testing endogeneity, one can use homogeneity restrictions as proposed by Attfield [1985, 1991] in which he demonstrates the equivalence of the exogeneity and homogeneity tests. However, as Blundell [1988] has shown, the obvious advantage in adopting a 3SLS procedure is that it permits us to assess endogeneity and homogeneity separately.

Both the restricted and unrestricted versions of (4.20) are estimated. Under the restricted model, certain parameter estimates are constrained to assume the value zero, thereby removing the corresponding variable from the model. The model was first estimated in its unconstrained form. In addition, since at this stage the estimation is on an equation-by-equation basis, homogeneity it tested since it is a within-equation restriction. Notice that the summability restrictions are embodied in the unrestricted model and hence they are not testable.[12]

Next, each model was re-estimated subject to homogeneity and symmetry. Since this involves cross-equation restrictions, the restricted model can no longer be estimated equation-by-

[12] Recall that the summability restrictions are automatically imposed in the estimation because we treat one of the n^{th} equation as a residual. And in spite of estimating each equation separately, summability restrictions together with invariance, are automatically preserved.

equation and hence requires maximum likelihood estimation using 3SLS as stated above. Notice too that total food at home expenditure has been deflated by Stone's price index. By definition, this index depends on estimated parameters and is common across all equations. One can therefore say that this leads to an additional set of within and cross-equation restrictions.

4.7 Analysis and Discussion of Empirical Results

In this section , results from the disaggregated stage two household ALIDS model are presented along with goodness of fit statistics, tests of linear restrictions, and model validation. Important elasticities (Marshallian, Hicksian, Allen-Uzawa, and Morishima elasticities of substitution) are derived and presented. A comparison of these results with other studies is also provided.

4.7.1 Parameter Estimates from, Unrestricted ALIDS.

Tables 4.1 - 4.3 present estimated parameters of the unrestricted household ALIDS for each of the three survey years individually in which the regressand (i.e. budget share) is a function of an intercept, α_i, unit prices, p_j, food-at-home expenditures, and a set of binary variables representing household size, age of head of household, and region. The latter enter the ALIDS via translating the intercept term. We first consider the intercept term, α_i, which represents average budget shares when all explanatory variables are held constant and which is important for income elasticity calculations. All intercept terms are highly significant and with the correct sign and size.

The effect of a change in prices on budget shares is represented by γ_{ij} - the price coefficients which measure the change in the i^{th} price, *ceteris paribus*. In evaluating the sensitivity of budget shares to price changes, it is of course important to distinguish between the own-price and cross-price effect. The own price estimates, γ_{ii}, are highly significant and their

Table 4.1 Unrestricted Household ALIDS: 3SLS Parameter Estimates and Budget Shares Evaluated at the Sample Mean: 1984.

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
W_i	0.11427	0.03915	0.05585	0.07957	0.04136	0.13160	0.17090	0.01171	0.15288	0.02501	0.11139	0.09885
α_i	0.05767	0.07368	0.08257	0.07900	0.04714	0.13415	0.15460	0.01613	0.08606	0.05016	0.13448	0.08437
	*7.47**	*19.55*	*19.42*	*15.50*	*11.11*	*21.73*	*22.07*	*7.82*	*10.65*	*20.45*	*20.50*	
γ_{i1}	0.01496	0.00067	-0.00061	-0.00104	-0.00037	-0.00230	-0.00270	-0.00011	-0.00443	-0.00039	-0.00197	-0.00171
	49.08	*4.49*	*-3.62*	*-5.15*	*-2.22*	*-9.43*	*-9.86*	*-1.39*	*-13.90*	*-3.97*	*-7.58*	
γ_{i2}	-0.00380	0.00758	-0.00062	-0.00030	-0.00048	-0.00030	-0.00097	-0.00013	-0.00020	-0.00016	-0.00052	-0.00011
	-15.71	*64.23*	*-4.63*	*-1.90*	*-3.59*	*-1.70*	*-4.34*	*-2.11*	*-0.90*	*-2.02*	*-2.50*	
γ_{i3}	-0.00118	-0.00062	0.00924	-0.00085	-0.00051	-0.00139	-0.00098	-0.00013	-0.00180	-0.00034	-0.00066	-0.00078
	-5.04	*-5.40*	*71.61*	*-5.51*	*-3.98*	*-7.42*	*-4.61*	*-2.09*	*-7.34*	*-4.56*	*-3.29*	
γ_{i4}	-0.00098	-0.00043	-0.00085	0.00960	-0.00066	-0.00090	-0.00177	-0.00020	-0.00270	-0.00037	-0.00049	-0.00025
	-3.29	*-2.93*	*-5.17*	*48.73*	*-4.06*	*-3.78*	*-6.63*	*-2.50*	*-8.63*	*-3.93*	*-1.96*	
γ_{i5}	-0.00071	-0.00055	-0.00057	-0.00099	0.00610	-0.00053	-0.00003	-0.00013	-0.00071	-0.00029	-0.00100	-0.00059
	-3.31	*-5.28*	*-4.79*	*-7.05*	*51.64*	*-3.08*	*-0.33*	*-2.19*	*-3.16*	*-4.30*	*-5.53*	
γ_{i6}	-0.00163	-0.00017	-0.00025	0.00010	-0.00079	0.01750	-0.00330	-0.00033	-0.00685	-0.00061	-0.00320	-0.00047
	-2.82	*-0.59*	*-0.78*	*0.26*	*-2.49*	*37.81*	*-6.32*	*-2.14*	*-11.30*	*-3.31*	*-6.50*	
γ_{i7}	-0.00091	0.00008	0.00083	-0.00070	0.00010	-0.00550	0.02270	0.00010	-0.01080	-0.00010	-0.00450	-0.00130
	-1.63	*0.31*	*2.69*	*-1.97*	*0.27*	*-12.32*	*45.03*	*0.53*	*-18.55*	*-0.43*	*-9.44*	
γ_{i8}	-0.00097	-0.00017	-0.00010	-0.00049	-0.00030	0.00067	0.00007	0.00140	-0.00036	-0.00014	0.00041	-0.00001
	-4.13	*-1.47*	*-0.79*	*-3.24*	*-2.34*	*3.55*	*0.31*	*22.31*	*-1.49*	*-1.70*	*2.05*	
γ_{i9}	-0.00203	0.00020	-0.00158	-0.00120	-0.00170	-0.00600	-0.00410	0.00017	0.02480	-0.00013	-0.00670	-0.00173
	-2.45	*0.49*	*-3.47*	*-2.21*	*-3.78*	*-9.13*	*-5.39*	*0.77*	*28.56*	*-0.50*	*-9.56*	
$\gamma_{i,10}$	-0.00072	-0.00032	-0.00063	-0.00050	-0.00047	0.00030	-0.00090	0.00024	-0.00020	0.00456	-0.00096	-0.00041
	-2.97	*-2.72*	*-4.73*	*-3.22*	*-3.52*	*1.55*	*-4.10*	*3.73*	*-0.80*	*59.66*	*-4.69*	
$\gamma_{i,11}$	-0.00172	-0.00090	-0.00041	-0.00125	-0.00045	-0.00220	-0.00260	-0.00023	-0.00390	-0.00037	0.01506	-0.00103
	-4.62	*-4.96*	*-2.00*	*-5.03*	*-2.21*	*-7.22*	*-7.96*	*-2.25*	*-10.00*	*-3.15*	*47.53*	
$\gamma_{i,12}$	-0.00126	-0.00042	-0.00026	-0.00067	-0.00037	-0.00071	-0.00119	0.00004	-0.00210	-0.00010	-0.00110	0.00814
	-3.58	*-2.42*	*-1.33*	*-2.79*	*-1.90*	*-2.58*	*-3.72*	*0.41*	*-5.70*	*-0.66*	*-3.64*	
β_i	0.00721	0.00201	0.00535	-0.00190	0.00742	-0.01153	-0.00857	0.00110	0.02079	-0.00227	-0.01380	-0.00580
	3.09	*1.77*	*4.17*	*-1.17*	*5.79*	*-6.20*	*-4.06*	*1.78*	*8.53*	*-3.07*	*-6.96*	

Table 4.1 (continued)

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
δiH2	0.00056	-0.00082	-0.00434	0.00044	-0.00231	-0.00030	0.00896	-0.00130	0.01094	-0.00019	-0.00230	-0.00934
	0.14	*-0.43*	*-2.00*	*0.17*	*-1.06*	*-0.10*	*2.50*	*-1.24*	*2.65*	*-0.15*	*-0.68*	
δiH3	0.00110	-0.00265	-0.01118	-0.00947	-0.00840	0.01222	0.00682	-0.00140	0.02715	-0.00082	-0.00890	-0.00448
	0.23	*-1.13*	*-4.24*	*-2.99*	*-3.19*	*3.19*	*1.56*	*1.06*	*5.42*	*-0.54*	*-2.21*	
δiH4	0.00251	-0.00232	-0.00877	-0.00680	-0.01290	0.02023	0.00445	-0.00349	0.02373	-0.00512	-0.00630	-0.00523
	0.50	*-0.94*	*-3.16*	*-2.03*	*-4.66*	*5.02*	*0.97*	*-2.59*	*4.50*	*-3.20*	*-1.46*	
δiH5	-0.00226	-0.00159	-0.00500	-0.00610	-0.01372	0.02538	0.00350	-0.00130	0.02353	-0.00619	-0.00620	-0.01005
	-0.36	*-0.51*	*-1.44*	*-1.47*	*-3.94*	*5.02*	*0.61*	*-0.77*	*3.55*	*-3.08*	*-1.15*	
δiH6	-0.00020	-0.00638	-0.01866	0.00970	-0.00644	0.03201	0.01575	0.00109	0.00779	-0.00077	-0.01630	-0.01760
	-0.02	*-1.23*	*-3.20*	*1.39*	*-1.11*	*3.78*	*1.64*	*0.38*	*0.70*	*-0.23*	*-1.81*	
δiH7	-0.00422	-0.00349	-0.01351	-0.01309	-0.00770	0.03640	0.00239	0.00227	0.03928	-0.01018	-0.01356	-0.01460
	-0.31	*-0.53*	*-1.83*	*-1.48*	*-1.05*	*3.40*	*0.20*	*0.64*	*2.80*	*2.39*	*-1.18*	
δiA35	0.00753	-0.00230	0.00032	-0.00440	0.00191	-0.00220	0.00477	0.00043	-0.00655	-0.00108	0.00490	-0.00332
	1.87	*-1.17*	*0.14*	*-1.67*	*0.86*	*-0.69*	*1.31*	*0.40*	*-1.55*	*-0.84*	*1.44*	
δiA45	0.01182	-0.00467	-0.00009	0.00268	0.00022	-0.00260	0.00421	-0.00012	-0.01108	-0.00053	0.00798	-0.00784
	2.63	*-2.12*	*-0.04*	*0.90*	*0.09*	*-0.71*	*1.03*	*-0.10*	*-2.35*	*-0.37*	*2.09*	
δiA55	0.00171	0.00021	0.00566	0.00540	0.00198	-0.00724	0.00405	0.00236	-0.00913	-0.00087	0.00140	-0.00553
	0.37	*0.09*	*2.23*	*1.76*	*0.78*	*-1.97*	*0.97*	*1.92*	*-1.89*	*-0.59*	*0.35*	
δiA65	-0.00357	-0.00139	-0.00034	0.00132	0.00420	0.00919	-0.00949	0.00446	-0.00136	0.00119	0.00190	-0.00612
	-0.85	*-0.68*	*-0.15*	*0.47*	*1.83*	*2.73*	*-2.49*	*3.98*	*-0.31*	*0.89*	*0.54*	
δiR2	0.02878	0.00115	-0.00049	-0.00170	-0.00122	-0.00926	0.00833	-0.00204	-0.00982	0.00167	-0.00710	-0.00830
	6.12	*0.50*	*-0.19*	*-0.56*	*-0.47*	*-2.46*	*1.95*	*-1.62*	*-2.00*	*1.12*	*-1.77*	
δiR3	0.00549	0.00103	-0.00274	-0.00210	-0.00092	-0.00869	0.00393	-0.00068	0.00970	0.00361	-0.00670	-0.00193
	1.25	*0.48*	*-1.14*	*-0.72*	*-0.38*	*-2.48*	*0.99*	*-0.58*	*2.12*	*2.59*	*-1.78*	
δiR4	0.00555	0.00012	-0.00150	-0.00180	-0.00061	-0.00256	0.01031	-0.00255	-0.00455	0.00046	-0.00200	-0.00087
	1.34	0.06	-0.66	-0.65	-0.26	-0.77	2.74	-2.31	-1.05	0.35	-0.57	
δiR5	-0.00251	0.00146	0.00318	-0.01110	-0.00023	0.00713	-0.00384	-0.00118	0.01003	0.00454	-0.00523	-0.00224
	-0.49	*0.58*	*1.13*	*-3.32*	*-0.08*	*1.75*	*-0.83*	*-0.87*	*1.89*	*2.81*	*-1.21*	
δiQ2	0.00597	-0.00049	-0.00077	0.00530	0.00416	-0.00501	-0.00254	-0.00018	-0.00520	-0.00206	0.00227	-0.00145
	1.57	*-0.26*	*-0.37*	*2.10*	*1.99*	*-1.64*	*-0.74*	*-0.18*	*-1.31*	*-1.70*	*0.70*	
δiQ3	0.01464	0.00472	-0.00030	0.00516	0.00236	-0.00767	-0.00383	-0.00222	-0.00940	0.00085	0.00271	-0.00702
	3.81	*2.52*	*-0.14*	*2.03*	*1.12*	*-2.50*	*-1.10*	*-2.17*	*-2.34*	*0.70*	*0.83*	
δiQ4	0.00312	0.00461	0.00850	0.00795	-0.00211	0.00058	-0.02238	-0.00052	-0.00128	-0.00125	0.00162	0.00115
	0.82	*2.48*	*4.05*	*3.15*	*-1.01*	*0.09*	*-6.46*	*-0.51*	*-0.32*	*-1.03*	*0.50*	
s-w R2[b]	0.3558											
F (2SLS)[c]	93.79	178.81	194.70	86.51	94.38	70.97	76.22	20.36	102.10	123.12	86.71	

a. Figures in italics are ratios of parameter estimates to standard errors.
b. System-weighted R2.
c. The third stage output for 3SLS or FIML does not include the analysis of variance table. Hence, the F statistics correspond to the second stage, i.e. 2SLS.

Table 4.2 Unrestricted Household Alids: 3SLS Parameter Estimates and Budget Shares Evaluated at the Sample Mean: 1986

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
Wi	0.09212	0.03287	0.04896	0.07547	0.03507	0.18909	0.15589	0.00890	0.14478	0.02233	0.10268	0.09182
αi	0.05430	0.06994	0.07111	0.07924	0.04032	0.16648	0.13463	0.00998	0.08471	0.04066	0.13460	0.11402
	11.39'	*28.94*	*23.60*	*22.29*	*14.35*	*36.68*	*27.26*	*7.44*	*15.40*	*26.04*	*28.81*	
γi1	0.01151	0.00027	-0.00066	-0.00118	-0.00045	-0.00187	-0.00189	-0.00011	-0.00262	-0.00033	-0.00156	-0.00113
	65.13	*3.06*	*-5.94*	*-8.93*	*-4.28*	*-11.09*	*-10.30*	*-2.22*	*-12.83*	*-5.67*	*-9.01*	
γi2	-0.00237	0.00690	-0.00064	-0.00042	-0.00047	-0.00040	-0.00069	-0.00007	-0.00051	-0.00021	-0.00039	-0.00073
	-15.77	*90.53*	*-6.69*	*-3.74*	*-5.31*	*-2.81*	*-4.44*	*-1.56*	*-2.96*	*-4.26*	*-2.66*	
γi3	-0.00096	-0.00055	0.00838	-0.00095	-0.00029	-0.00068	-0.00100	-0.00008	-0.00151	-0.00043	-0.00086	-0.00108
	-6.52	*-7.34*	*89.86*	*-8.66*	*-3.28*	*-4.86*	*-6.51*	*-1.82*	*-8.85*	*-8.98*	*-5.95*	
γi4	-0.00082	-0.00032	-0.00069	0.00939	-0.00093	-0.00107	-0.00213	-0.00012	-0.00203	-0.00026	-0.00044	-0.00057
	-4.38	*-3.42*	*-5.86*	*67.64*	*-8.51*	*-6.05*	*-11.05*	*-2.30*	*-9.43*	*-4.31*	*-2.40*	
γi5	-0.00071	-0.00037	-0.00048	-0.00077	0.00548	-0.00075	-0.00026	-0.00008	-0.00067	-0.00029	-0.00085	-0.00026
	-5.27	*-5.49*	*-5.62*	*-7.64*	*69.19*	*-5.88*	*-1.87*	*-1.98*	*-4.34*	*-6.52*	*-6.42*	
γi6	-0.00147	-0.00118	-0.00097	-0.00245	-0.00013	0.02459	-0.00547	-0.00011	-0.00328	-0.00057	-0.00539	-0.00359
	-6.56	*-10.43*	*-6.83*	*14.69*	*-0.95*	*115.44*	*23.58*	*-1.74*	*-12.68*	*-7.83*	*-24.58*	
γi7	0.00034	0.00004	0.00039	-0.00108	0.00051	-0.00577	0.02106	-0.00012	-0.00995	-0.00011	-0.00355	-0.00176
	0.98	*0.20*	*1.78*	*-4.19*	*2.51*	*-17.54*	*58.88*	*-1.22*	*-24.96*	*0.97*	*-10.49*	
γi8	-0.00052	-0.00020	-0.00011	-0.00037	-0.00016	0.00053	0.00024	0.00120	-0.00043	-0.00003	0.00060	-0.00074
	-3.40	*-2.58*	*1.12*	*-3.28*	*-1.79*	*3.66*	*1.48*	*27.89*	*-2.42*	*-0.69*	*0.40*	
γi9	-0.00155	-0.00048	-0.00184	-0.00035	-0.00094	-0.00606	-0.00207	-0.00049	0.02285	0.00006	-0.00523	-0.00392
	-2.80	*-1.70*	*-5.26*	*-0.84*	*-2.87*	*-11.55*	*3.63*	*-3.13*	*35.90*	*0.31*	*-9.66*	
γi,10	-0.00053	-0.00022	-0.00045	-0.00024	-0.00056	0.00039	-0.00086	0.00015	-0.00097	0.00399	-0.00069	-0.00002
	-3.54	*-2.89*	*-4.70*	*-2.11*	*-6.29*	*2.71*	*-5.56*	*3.55*	*-5.61*	*81.35*	*-4.69*	
γi,11	-0.00135	-0.00019	-0.00062	-0.00117	-0.00049	-0.00238	-0.00247	-0.00014	-0.00436	-0.00020	0.01416	-0.00081
	-5.97	*-1.68*	*-4.32*	*-6.91*	*-3.66*	*-11.05*	*-10.55*	*-2.15*	*-16.70*	*-2.64*	*63.97*	
γi,12	-0.00130	-0.00003	-0.00029	-0.00057	-0.00040	-0.00149	-0.00187	-0.00006	-0.00365	-0.00004	-0.00151	0.01122
	-5.86	*-0.27*	*-2.06*	*-3.47*	*-3.08*	*-7.02*	*-8.12*	*-0.96*	*-14.25*	*-0.58*	*-6.94*	
βi	0.01038	0.00221	0.00714	0.00140	0.00895	-0.02998	0.00142	0.00150	0.01168	0.00060	-0.00119	-0.01410
	8.22	*3.45*	*8.94*	*1.48*	*12.03*	*-24.94*	*1.09*	*4.22*	*8.02*	*1.44*	*-9.65*	

Table 4.2 (continued)

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
δiH2	0.00382	-0.00133	-0.00148	-0.00540	-0.00554	0.01273	-0.00808	-0.00055	0.01715	-0.00112	-0.00045	-0.00975
	1.49	*-1.02*	*-0.91*	*-2.82*	*-3.66*	*5.21*	*-3.04*	*-0.76*	*5.80*	*-1.33*	*-0.18*	
δiH3	-0.00248	-0.00344	-0.00663	-0.00692	-0.01257	0.01914	-0.00786	-0.00024	0.03304	-0.00095	-0.00418	-0.00690
	-0.81	*-2.23*	*-3.45*	*-3.05*	*-7.01*	*6.61*	*-2.49*	*-0.28*	*9.42*	*-0.95*	*-1.40*	
δiH4	-0.00545	-0.00356	-0.01052	-0.00931	-0.01625	0.03446	-0.01164	-0.00183	0.03976	-0.00517	-0.00346	-0.00703
	-1.70	*-2.18*	*-5.18*	*-3.89*	*-8.59*	*11.28*	*-3.50*	*-2.03*	*10.74*	*-4.93*	*-1.00*	
δiH5	-0.01025	-0.00414	-0.01142	-0.00864	-0.01371	0.04705	-0.01314	-0.00184	0.03793	-0.00565	-0.00558	-0.01062
	-2.56	*-2.05*	*-4.52*	*-2.90*	*-7.80*	*12.37*	*-3.17*	*-1.64*	*8.23*	*-4.32*	*-1.42*	
δiH6	-0.00796	-0.00520	-0.00972	-0.00819	-0.02596	0.06207	-0.01487	0.00065	0.04098	-0.00659	-0.00838	-0.01685
	-1.19	*-1.53*	*-2.30*	*-1.64*	*-6.61*	*9.78*	*-2.15*	*0.34*	*5.33*	*-3.02*	*-1.28*	
δiH7	0.00300	-0.00024	-0.01589	-0.01222	-0.01058	0.06011	-0.00987	-0.00067	0.02328	-0.00263	-0.01699	-0.01728
	0.31	*-0.05*	*-2.62*	*-1.70*	*-3.19*	*6.58*	*-0.99*	*-0.25*	*2.10*	*-0.84*	*-1.80*	
δiA35	0.00198	-0.00089	0.00122	-0.00071	0.00516	0.00255	-0.00251	0.00034	0.00130	-0.00108	0.00047	-0.00782
	0.78	*-0.70*	*0.76*	*-0.37*	*3.47*	*1.06*	*-0.96*	*0.48*	*0.45*	*-1.30*	*0.19*	
δiA45	0.00585	-0.00243	0.00179	0.00353	0.00066	0.00422	0.00289	0.00217	-0.00576	-0.00138	0.00071	-0.01226
	0.21	*-1.69*	*1.00*	*1.67*	*0.40*	*1.56*	*0.98*	*2.70*	*-1.76*	*-1.48*	*0.25*	
δiA55	0.00374	0.00098	0.00291	0.00116	0.00067	0.00540	-0.00227	0.00381	-0.00488	0.00109	0.00167	-0.01427
	1.29	*0.67*	*1.58*	*0.53*	*0.39*	*1.95*	*-0.75*	*4.66*	*-1.45*	*-1.14*	*0.58*	
δiA65	-0.00558	-0.00141	0.00044	-0.00264	0.00178	0.01130	-0.00185	0.00482	0.00517	0.00280	-0.00201	-0.01282
	-2.14	*-1.06*	*0.26*	*-1.35*	*1.16*	*4.54*	*-0.68*	*6.55*	*1.71*	*3.26*	*-0.78*	
δiR2	0.02084	-0.00035	-0.00171	-0.00229	0.00108	-0.00444	0.01094	0.00018	-0.00932	-0.00032	-0.00709	-0.00753
	7.85	*-0.26*	*-1.02*	*-1.15*	*0.69*	*-1.75*	*3.98*	*0.24*	*-3.04*	*-0.36*	*-2.72*	
δiR3	0.01030	0.00243	-0.00020	-0.00302	-0.00165	-0.00173	0.00559	-0.00241	0.00094	0.00106	-0.00344	-0.00787
	3.68	*1.72*	*-0.11*	*-1.44*	*-1.00*	*-0.65*	*1.93*	*-3.06*	*0.29*	*1.15*	*-1.25*	
δiR4	-0.00125	0.00356	-0.00133	0.00082	-0.00834	0.00180	0.00846	0.00002	-0.00130	0.00025	-0.00276	0.00008
	-0.45	*2.52*	*-0.75*	*0.39*	*-5.07*	*0.67*	*2.93*	*0.02*	*-0.40*	*0.27*	*-1.10*	
δiR5	-0.00064	0.00062	0.00143	-0.00741	-0.00294	0.00202	0.00242	0.00027	0.00314	0.00360	-0.00656	0.00405
	-0.21	*0.42*	*0.76*	*-3.35*	*-1.68*	*0.71*	*0.79*	*0.31*	*0.92*	*3.70*	*-2.26*	
δiQ2	0.00263	-0.00053	-0.00332	0.00013	0.00486	-0.00314	0.00591	0.00088	-0.00228	-0.00129	-0.00181	-0.00203
	1.10	*-0.43*	*-2.20*	*0.08*	*3.44*	*-1.38*	*2.38*	*1.30*	*-0.82*	*-1.64*	*-0.77*	
δiQ3	0.00387	0.00028	-0.00289	0.00152	0.00487	-0.00635	0.00967	0.00105	-0.00431	-0.00329	-0.00019	-0.00423
	1.60	*0.23*	*-1.89*	*0.84*	*3.41*	*-2.75*	*3.86*	*1.53*	*-1.54*	*-4.15*	*-0.08*	
δiQ4	-0.00266	0.00367	0.00926	0.00278	0.00221	-0.00256	-0.00558	0.00033	0.00058	-0.00251	-0.00274	-0.00276
	-1.11	*3.01*	*6.08*	*1.54*	*1.55*	*-1.12*	*-2.24*	*0.49*	*0.20*	*-3.18*	*-1.16*	
s-w R2	0.5297											
F (2SLS)	195.59	339.26	320.47	185.79	186.54	2209.63	193.45	40.15	213.03	247.60	183.65	

a. Figures in italics are ratios of parameter estimates to standard errors.
b. System-weighted R2.
c. The third stage output for 3SLS or FIML does not include the analysis of variance table. Hence, the F statistics correspond to the second stage, i.e. 2SLS.

Table 4.3 Unrestricted Household ALIDS: 3SLS Parameter Estimates and Budget Shares Evaluated at the Sample Mean: 1990

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
W_i	0.73126	0.02325	0.04530	0.07556	0.03603	0.16076	0.16723	0.00848	0.19021	0.01639	0.09624	0.10742
α_i	0.13874	0.09891	0.11077	0.14207	0.33586	0.21772	0.13892	0.01217	0.12201	0.05694	0.13184	-0.50596
	16.09[a]	*22.38*	*16.62*	*17.58*	*51.38*	*18.31*	*11.22*	*3.77*	*8.70*	*17.94*	*12.12*	
γ_{i1}	0.01243	-0.00032	-0.00100	-0.00094	-0.00033	-0.00148	-0.02631	-0.00019	-0.00262	-0.00034	-0.00149	0.02260
	87.14	*-4.42*	*-9.06*	*-7.01*	*-3.09*	*-7.54*	*-12.84*	*3.53*	*-11.27*	*-6.54*	*-8.27*	
γ_{i2}	-0.00100	0.00830	-0.00092	-0.00050	-0.00036	-0.00103	-0.00128	-0.00005	-0.00164	-0.00023	-0.00068	-0.00063
	-6.23	*101.22*	*-7.42*	*-3.32*	*-2.96*	*-4.66*	*-5.59*	*-0.79*	*-6.31*	*-3.82*	*-3.34*	
γ_{i3}	-0.00129	-0.00049	0.01054	-0.00113	-0.00039	-0.00082	-0.00109	-0.00019	-0.00247	-0.00025	-0.00134	-0.00108
	-8.78	*-6.46*	*92.57*	*-8.15*	*-3.53*	*-4.02*	*-5.15*	*-3.53*	*-10.31*	*-4.52*	*-7.23*	
γ_{i4}	-0.00102	-0.00021	-0.00063	0.01091	-0.00053	-0.00107	-0.00232	-0.00014	-0.00252	-0.00032	-0.00115	-0.00101
	-6.85	*-2.70*	*-5.47*	*78.58*	*-4.71*	*-5.24*	*-10.92*	*-2.57*	*-10.45*	*-5.84*	*-6.15*	
γ_{i5}	-0.02025	-0.00658	-0.01104	-0.01307	0.00809	-0.01760	-0.01356	-0.00230	-0.02453	-0.00361	-0.02038	0.12482
	-7.87	*-4.98*	*-5.54*	*-6.76*	*75.59*	*-4.96*	*-3.66*	*-2.38*	*-5.85*	*-3.80*	*-6.27*	
γ_{i6}	-0.00092	-0.00019	-0.00081	-0.00022	-0.00029	0.02180	-0.00464	-0.00013	-0.00911	-0.00001	-0.00369	-0.00179
	-3.80	*-1.55*	*-4.36*	*-0.95*	*-1.59*	*65.54*	*-13.39*	*-1.43*	*-23.21*	*-0.14*	*-12.13*	
γ_{i7}	0.00026	0.00047	0.00034	-0.00082	0.00090	-0.00543	0.02240	-0.00016	-0.01174	-0.00002	-0.00430	-0.00190
	1.08	*3.87*	*1.82*	*-3.68*	*498.00*	*-16.55*	*65.51*	*-1.75*	*-30.31*	*-0.22*	*-14.30*	
γ_{i8}	-0.00036	-0.00021	-0.00046	-0.00028	-0.00026	0.00060	-0.00030	0.00139	-0.00029	-0.00014	0.00029	0.00002
	-2.62	*-2.96*	*-4.31*	*-2.18*	*-2.49*	*3.16*	*-1.52*	*27.00*	*-1.28*	*-2.82*	*1.69*	
γ_{i9}	-0.00102	-0.00049	-0.00042	-0.00174	-0.00052	-0.00684	-0.00520	-0.00044	0.02571	-0.00011	-0.00574	-0.00319
	-3.39	*-3.20*	*-1.83*	*-6.20*	*-2.29*	*-16.52*	*-12.07*	*-3.88*	*52.65*	*-1.01*	*-15.15*	
$\gamma_{i,10}$	-0.00051	-0.00031	-0.00041	-0.00306	-0.00038	0.00016	-0.00810	0.00009	-0.00996	0.00471	-0.00095	0.01872
	-3.28	*-3.94*	*-3.46*	*-2.11*	*-3.20*	*0.76*	*-3.64*	*1.63*	*-3.94*	*82.46*	*-4.86*	
$\gamma_{i,11}$	-0.00098	-0.00037	-0.00046	-0.00120	-0.00039	-0.00207	-0.00269	-0.00015	-0.00425	-0.00024	0.01359	-0.00080
	-5.50	*-4.04*	*-3.31*	*-7.18*	*-2.90*	*-8.43*	*-10.52*	*-2.18*	*-14.65*	*-3.72*	*60.46*	
$\gamma_{i,12}$	-0.00118	-0.00023	-0.00058	-0.00104	-0.00056	-0.00181	-0.00246	0.00010	-0.00453	-0.00012	-0.00157	0.01397
	-7.04	*-2.71*	*-4.44*	*-6.60*	*-4.38*	*-7.81*	*-10.21*	*1.66*	*-16.61*	*-1.99*	*-7.40*	
β_i	0.00416	-0.00016	0.00560	-0.00589	-0.00705	-0.02908	0.00738	0.00342	0.03044	-0.00148	0.00581	-0.01315
	2.84	*-0.21*	*4.94*	*-4.29*	*-6.34*	*-14.40*	*3.51*	*6.22*	*12.77*	*-2.75*	*3.14*	

Table 4.3 (continued)

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
δiH2	0.00239	0.00000	-0.00178	-0.00303	0.00129	0.01272	-0.00760	-0.00125	0.00285	-0.00095	-0.00523	0.00059
	0.97	*0.00*	*-0.93*	*-1.31*	*0.69*	*3.74*	*-0.21*	*-1.35*	*0.71*	*-1.04*	*-1.68*	
δiH3	-0.00525	0.00093	-0.00503	-0.00423	-0.00008	0.02418	-0.00916	-0.00221	0.01867	-0.00229	-0.01146	-0.00405
	1.79	*0.62*	*-2.21*	*-1.54*	*0.00*	*5.97*	*-2.17*	*-2.00*	*3.91*	*-2.11*	*-3.09*	
δiH4	-0.00305	0.00054	-0.00779	-0.00669	-0.00195	0.03673	-0.01254	-0.00475	0.02591	-0.00266	-0.01610	-0.00765
	-0.97	*0.34*	*-3.22*	*-2.28*	*-0.82*	*8.52*	*-2.79*	*-4.05*	*5.09*	*-2.31*	*-4.08*	
δiH5	-0.00999	-0.00089	-0.00969	-0.00352	0.00255	0.03571	-0.01564	-0.00431	0.02751	-0.00520	-0.01396	-0.00257
	-2.41	*-0.41*	*-3.03*	*-0.91*	*0.81*	*6.27*	*-2.63*	*-2.78*	*4.09*	*-3.42*	*-2.67*	
δiH6	-0.00661	0.00020	-0.00661	-0.01767	0.00769	0.04117	-0.00316	-0.00439	0.01390	-0.00388	-0.01282	-0.00780
	-1.02	*0.06*	*-1.32*	*-2.91*	*1.57*	*4.61*	*-0.34*	*-1.81*	*1.32*	*-1.63*	*-1.57*	
δiH7	-0.00711	0.00146	-0.01439	-0.00695	0.00592	0.04468	0.01794	-0.00628	0.00647	-0.00290	-0.02217	-0.01668
	-0.77	*0.31*	*-2.02*	*-0.80*	*0.85*	*3.51*	*1.35*	*-1.81*	*0.43*	*-0.85*	*-1.90*	
δiA35	0.00669	0.00023	-0.00079	-0.00064	0.00345	0.00058	-0.00505	-0.00027	-0.00417	0.00071	0.00400	-0.00474
	2.88	*0.19*	*-0.43*	*-0.29*	*1.95*	*0.18*	*-1.51*	*-0.31*	*-1.10*	*0.82*	*1.36*	
δiA45	0.00822	0.00006	0.00173	-0.00005	0.00226	-0.00192	0.00746	-0.00097	-0.00589	-0.00047	0.00337	-0.01379
	3.01	*0.04*	*0.82*	*-0.02*	*1.09*	*-0.50*	*1.90*	*-0.95*	*-1.32*	*-0.47*	*0.98*	
δiA55	0.00238	0.00307	0.00466	0.00541	0.00626	0.00033	0.00304	0.00270	-0.00134	0.00424	-0.00894	-0.02181
	0.80	*2.01*	*2.03*	*1.95*	*2.78*	*0.08*	*0.71*	*2.42*	*-0.28*	*3.88*	*-2.38*	
δiA65	-0.00094	0.0013	0.0012	0.0000	0.0061	0.0131	0.0011	0.0041	0.0013	0.0044	-0.0161	-0.0157
	-0.35	*0.99*	*0.61*	*0.02*	*3.04*	*3.60*	*0.28*	*4.18*	*0.31*	*4.58*	*-4.85*	
δiR2	0.00265	-0.00034	0.00242	-0.00482	-0.00227	0.00250	0.01313	0.00128	-0.01077	0.00239	-0.00511	-0.00106
	0.90	*-0.22*	*1.07*	*-1.75*	*-1.02*	*0.62*	*3.11*	*1.16*	*-2.25*	*2.21*	*-1.38*	
δiR3	-0.00254	0.00179	-0.00058	-0.00627	-0.00507	-0.00906	0.02464	-0.00137	-0.00810	-0.00009	-0.00418	0.01083
	-0.95	*1.30*	*-0.27*	*-2.50*	*-2.49*	*-2.45*	*6.40*	*-1.36*	*-1.85*	*-0.09*	*-1.23*	
δiR4	0.00056	0.00232	0.00376	0.00108	-0.00440	-0.00114	0.00081	-0.00042	-0.01325	0.00155	-0.00424	0.01336
	0.22	*1.77*	*1.90*	*0.45*	*-2.26*	*-0.32*	*0.22*	*-0.44*	*-3.17*	*1.64*	*-1.31*	
δiR5	0.00033	0.00067	0.00429	-0.00682	-0.00803	0.00322	-0.00181	0.00173	-0.00321	0.00117	-0.00412	0.01257
	0.11	*0.44*	*1.88*	*-2.46*	*-3.58*	*0.79*	*-0.42*	*1.56*	*-0.66*	*1.08*	*-1.10*	
δiQ2	0.01224	0.00144	-0.00067	0.00040	0.00175	-0.00693	-0.00089	0.00111	-0.01114	0.00043	0.00540	-0.00313
	5.17	*1.18*	*-0.37*	*0.18*	*0.97*	*-2.12*	*-0.26*	*1.25*	*-2.89*	*0.49*	*1.81*	
δiQ3	0.00864	-0.00031	0.00058	0.00293	-0.00139	-0.00107	-0.00331	0.00185	-0.00519	0.00016	0.00095	-0.00383
	3.71	*-0.26*	*0.32*	*1.34*	*-0.78*	*-0.33*	*-0.98*	*2.12*	*-1.37*	*0.18*	*0.32*	
δiQ4	0.00434	0.00198	0.00708	0.00647	-0.00149	-0.00130	-0.01965	0.00279	-0.00157	-0.00025	-0.00010	0.00170
	1.86	*1.66*	*3.93*	*2.96*	*-0.84*	*-0.41*	*-5.87*	*3.19*	*-0.41*	*-0.29*	*-0.04*	
s-w R2	0.4381											
F (2SLS)	284.71	360.98	316.25	214.67	202.94	182.10	166.32	30.39	245.41	238.35	149.39	

a. Figures in italics are ratios of parameter estimates to standard errors.
b. System-weighted R2.
c. The third stage output for 3SLS or FIML does not include the analysis of variance table. Hence, the F statistics correspond to the second stage, i.e. 2SLS.

(positive) signs conform to our *a priori* expectations, suggesting inelastic price, i.e. the percentage change in the quantity consumed of a food commodity as a result of a change in its price is less than the percentage change in the price. This is shown later in the discussion and evaluation of various elasticities. The significance levels for a majority of cross-price estimates, γ_{ij}, are quite high, indicating once again evidence of cross price effects on budget shares and hence leading us to conclude that the data have a significant degree of price sensitivity (see asymptotic values). We must qualify this statement by noting that the degree of cross-price sensitivity largely depends on the nature of substitutability or complementarity among commodities. This has to do with elasticities, an issue that is considered below. In passing, we note that we are encouraged by the fact that notwithstanding the large number of demographic variables that enter each equation (14 per equation), all price parameters have highly significant effects on budget shares.

The effect of a proportional change in the i^{th} budget share with respect to a change in food at home expenditure, *ceteris paribus*, is delineated by the parameter β_i. This parameter is quite significant in almost all cases, and this, together with the highly significant intercept, shows that expenditure effects are a quantitatively important determinant of budget allocation and implies that a change in real food-at-home expenditure, *ceteris paribus*, will decrease/increase food budget shares of a given commodity. Statements regarding signs of β should be based on whether or not a commodity can be classified as a necessity (for $\beta_i < 0$ in which case the expenditure elasticity $\epsilon_{iM} < 1$) or a luxury (for $\beta_i > 0$). The results show that meats in general have positive estimates, suggesting that expenditure shares for these commodities will increase with total FAH expenditure.

Next, we consider demographic variables whose effect on budget shares is represented by δ_{in} where n is the n^{th} demographic variable defined in Table 3.5 (Chapter 3). Recall that this is equivalent to estimating the effect of H, A, R, and QT on the intercept term α_i. As noted earlier, we represented all demographic variables by binary values as opposed to integer values equal to the size of household or age of head of household as is typical in most studies. If we were to use actual household size or age, we would be implicitly imposing a restriction on the effect of different household sizes and we would not capture the exact pattern of, say, how different household sizes affect food expenditure allocation. Also note that we have dropped the first row from each submatrix formed by the dummy variables in order to eschew the problem of complete multicollinearity and hence ensure that the matrix of dummy variables is nonsingular. Hence, in view of this, the parameter estimates attached to dummy variables should be interpreted with reference to the combined set of excluded categorical conditions. In other words, the reference for interpreting these coefficients is a household head aged 25-35, having one member household, and living in the Atlantic province. That we have 6 binary variables representing household size indicates our *a priori* belief that we consider household to be the most important socioeconomic variable. This bias may be justified in view of the fact that we are trying to assess the impact of expenditure on choice. There is obviously no limit to the number of socioeconomic variables as illustrated by Guilkey, Haines, and Popkin (1988,1990).

The parameter estimates for these demographic variables are interesting. First, most of them are appreciably significant. Let us first examine household size (H) whose impact is delineated by δ_{iH2}-δ_{iH7}. In general, increasing household size gives rise to sharp increases in the share of total food-at-home expenditure allocated to most food categories. Observe in particular that the increase is sharpest whenever household size increases from 1 to 2, and this may be explained by the fact that the second member of the household is often an adult. The increase tapers off as household size reaches 5 or more. This trend is not entirely unexpected and demonstrates the existence of children in the household. When we tested for presence of children under 5 and those aged between 5 and 17, we found that the increase in the proportion of food-at-home expenditure allocated to meats and other foods increases less dramatically. In general, our results indicate that as family size increases, there are significant alterations in its food expenditure patterns and possibly a switch from some other food commodities. This aspect clearly needs more work. The number of parameters already included in this analysis precludes this exercise.

The next set of demographic variables relate to age of head of household and are given by δ_{iA35}-δ_{iA65}. These coefficients delineate the effect of the stage of family cycle on budget share allocation. Although the levels of significance are low for some of the estimated parameters of age, the joint F-test shows that these variables are jointly significant and cause dramatic increases in the proportion of food-at-home expenditure allocated to the other category as head of household increases.[13] Notice again that the most significant increases occur when the household enters the child rearing years. However, as the offsprings grow up, their preference patterns closely resemble those of adults in the home, thereby shifting the food budget toward that of a larger family, clearly illustrating that changes in demographic composition of a household are important. Regional differences in budget share allocation are represented by δ_{iR2}-δ_{iR52}. There are distinct differences in food budget shares of the 12 food commodities relative to the Atlantic provinces. In 1984, households in all provinces, except the Pacific, spent more on beef than they did on other food categories. The highest share on beef is recorded for Quebec. By contrast, the Pacific region had the highest share of pork and fish. Regional parameters are important for Canada in so far as they reflect differences in "cultural" practices among provinces. The Microdata tapes mask records identified as rural/urban such that it is no possible to discern from the parameters whether or not the degree of urbanization or population density has any significant impact.

Finally, we examine seasonal factors which are represented by δ_{iQT} and relate to spring (second quarter) , summer (third quarter) and fall (fourth quarter). The parameter estimates once again suggest that qualitative effects of season are important and have an interesting pattern and

[13] Most applied work has a tendency of excluding dummy variables with low t-values. We have avoided this practice. As Judge *et. al.* [1988] point out, this practice should not be encouraged. If dummy variables with insignificant t-values are dropped, two parameterizations of the same problem can lead to different dummy variables being excluded. Hence, a joint F-test is preferred.

magnitude. The parameters for most of seasonal dummies reflect the importance of seasonal supply and storage factors and events related to festivities.

Overall, the results show that demographic variables play a significant role in explaining household food-at-home expenditure patterns. To validate this claim, we have devised a simple F-test based on simple exclusion restrictions. The test results are presented in Tables 4.3a-4.3b and all F-values are greater than their critical values at the 1 percent and 5 percent levels of significance.

4.7.2 Parameter estimates from Restricted Model

Next, in Tables 4.4 - 4.6, we present parameter estimates from the homogeneity and symmetry restricted household ALIDS. Although the signs and orders of magnitude are not substantially changed, more parameters come out significant in the restricted model relative to the unrestricted model, which may suggest that the restricted model is more price sensitive. This conclusion must be made with caution since it is also known that imposing restrictions lowers true standard errors of coefficients even when restrictions are false. Nevertheless, in general we cannot discern any major differentiation of parameters between the restricted and unrestricted models. (See elasticity estimates below).

4.7.3 Estimated Elasticities

The preceding discussion has provided insights into parameter estimates from the household ALIDS. However, a direct interpretation of these parameter estimates in a flexible functional form such as the ALIDS has no economic meaning. Any economic implications must be expressed in terms of elasticities which are themselves functions of these parameter estimates. Hence, in this section, we present uncompensated (Marshallian) and compensated (Hicksian) price and expenditure elasticity matrices. These elasticities are presented for both the restricted and

Table 4.3a F-test Values for Joint Significance of Demographic Variables: Unrestricted Model.

	1984		1986		1990	
Equation	F-test	prob>F[a]	F-test	prob>F	F-test	prob>F
BEEF	5.0249	0.0001	8.1184	0.0001	3.5140	0.0001
PORK	1.4029	0.1236	2.3682	0.0012	0.9880	0.4683
CHICKEN	3.9216	0.0001	8.5831	0.0001	3.7810	0.0001
OMEAT	3.4146	0.0001	2.3879	0.0011	2.7442	0.0001
FISH	3.3005	0.0001	10.8711	0.0001	2.3969	0.0001
CEREAL	6.4842	0.0001	16.6687	0.0001	6.7210	0.0001
VEGES	5.4233	0.0001	4.8000	0.0001	8.9426	0.0001
SUGAR	2.9236	0.0001	5.7395	0.0001	5.7984	0.0001
DAIRY	4.7376	0.0001	10.7265	0.0001	4.2400	0.0001
FATS	3.3778	0.0001	7.7506	0.0001	4.4550	0.0001
NALCO	1.0242	0.4269	1.0658	0.3814	2.7790	0.0001

a. Prob>F is the exact significance level for the F-ratio test of the hypothesis that all nonintercept parameters are zero.

Table 4.3b F-test Values for Joint Significance of Demographic Variables: Restricted Model

	1984		1986		1990	
Equation	F-test	prob>F	F-test	prob>F	F-test	prob>F
BEEF	5.4963	0.0001	9.4086	0.0001	4.3826	0.0001
PORK	1.5246	0.0760	1.4082	0.1211	1.2074	0.2483
CHICKEN	3.8608	0.0001	7.9225	0.0001	5.1015	0.0001
OMEAT	3.5340	0.0001	4.7523	0.0011	3.0397	0.0001
FISH	3.2526	0.0001	10.5939	0.0001	6.1587	0.0001
CEREAL	7.7694	0.0001	30.3847	0.0001	7.4288	0.0001
VEGES	5.3622	0.0001	5.1323	0.0001	9.0257	0.0001
SUGAR	3.0134	0.0001	6.1724	0.0001	5.8200	0.0001
DAIRY	4.9059	0.0001	16.7728	0.0001	7.1126	0.0001
FATS	3.7617	0.0001	8.4082	0.0001	5.6020	0.0001
NALCO	1.0800	0.3665	4.5773	0.0001	3.1186	0.0001

a. Prob>F is the exact significance level for the F-ratio test of the hypothesis that all nonintercept parameters are zero.

Table 4.4 Homogeneity and Symmetry Restricted ALIDS: 3SLS Parameter Estimates and Mean Budget Shares: 1984

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
W_i	0.11427	0.03915	0.05585	0.07957	0.04136	0.13160	0.17090	0.01171	0.15288	0.02501	0.11139	0.09885
α_i	0.09620	0.05914	0.07241	0.07920	0.04481	0.12404	0.15657	0.01167	0.08296	0.04440	0.14206	0.08656
	14.16	*16.98*	*18.76*	*17.35*	*11.93*	*21.55*	*24.49*	*6.02*	*10.99*	*19.23*	*24.27*	
γ_{i1}	0.01365											
	45.76											
γ_{i2}	-0.00052	0.00765										
	-4.00	*64.67*										
γ_{i3}	-0.00085	-0.00074	0.00910									
	-6.28	*-8.52*	*70.67*									
γ_{i4}	-0.00097	-0.00046	-0.00087	0.00958								
	-5.88	*-4.28*	*-7.74*	*48.79*								
γ_{i5}	-0.00046	-0.00055	-0.00057	-0.00088	0.00608							
	-3.51	*-6.71*	*-6.55*	*-8.25*	*51.82*							
γ_{i6}	-0.00180	-0.00093	-0.00133	-0.00058	-0.00066	0.01800						
	-8.19	*-6.04*	*-8.50*	*-2.96*	*-4.50*	*41.79*						
γ_{i7}	-0.00228	-0.00120	-0.00072	-0.00142	-0.00015	-0.00435	0.02276					
	-9.32	*-7.14*	*-4.19*	*-6.56*	*-0.94*	*-13.20*	*46.30*					
γ_{i8}	-0.00017	-0.00020	-0.00015	-0.00028	-0.00016	-0.00001	-0.00002	0.00138				
	-2.20	*-3.55*	*-2.62*	*-3.95*	*-3.03*	*-0.05*	*-0.17*	*22.08*				
γ_{i9}	-0.00294	-0.00161	-0.00236	-0.00236	-0.00106	-0.00532	-0.00767	-0.00038	0.03010			
	-10.72	*-8.67*	*-12.36*	*-9.91*	*-5.85*	*-14.41*	*-19.45*	*-2.88*	*51.69*			
$\gamma_{i,10}$	-0.00042	-0.00028	-0.00046	-0.00045	-0.00034	-0.00042	-0.00066	0.00005	-0.00083	0.00452		
	-4.68	*-4.41*	*-7.16*	*-5.51*	*-5.53*	*-3.29*	*-4.90*	*1.04*	*-5.63*	*59.46*		
$\gamma_{i,11}$	-0.00175	-0.00080	-0.00048	-0.00090	-0.00075	-0.00209	-0.00312	-0.00010	-0.00363	-0.00050	0.01517	
	-8.30	*-5.89*	*-3.35*	*-5.09*	*-5.53*	*-8.37*	*-11.33*	*-1.15*	*-12.02*	*-4.91*	*48.01*	
$\gamma_{i,12}$	-0.00150	-0.00034	-0.00056	-0.00040	-0.00051	-0.00051	-0.00115	0.00002	-0.00194	-0.00020	-0.00103	0.00811
	-8.67	*-2.92*	*-4.66*	*-2.61*	*-4.45*	*-2.31*	*-4.79*	*0.29*	*-7.44*	*-2.23*	*-5.42*	
β_i	0.00473	0.00794	0.00962	-0.00088	0.00826	-0.01247	-0.00799	0.00204	0.01398	-0.00032	-0.01823	-0.00669
	2.16	*7.38*	*7.99*	*-0.61*	*6.98*	*-7.08*	*-4.03*	*3.48*	*6.00*	*-0.46*	*-9.89*	

Table 4.4 (continued)

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
γiH2	-0.00337	0.00141	-0.00238	-0.00007	-0.00172	0.00065	0.00885	-0.00088	0.00937	0.00047	-0.00285	-0.00949
	-0.85	*0.72*	*-1.09*	*-0.03*	*-0.79*	*0.21*	*2.48*	*-0.83*	*2.24*	*0.37*	*-0.85*	
γiH3	-0.00576	-0.00074	-0.00934	-0.01037	-0.00764	-0.01419	0.00627	-0.00093	0.02804	-0.00022	-0.00895	0.02383
	-1.19	*-0.31*	*-3.54*	*-3.29*	*-2.92*	*3.71*	*1.45*	*-0.72*	*5.52*	*-0.14*	*-2.20*	
γiH4	-0.00534	-0.00088	-0.00690	-0.00803	-0.01219	0.03069	0.00369	-0.00299	0.02531	-0.00467	-0.00563	-0.01306
	-1.06	*-0.35*	*-2.50*	*-2.43*	*-4.45*	*5.75*	*0.81*	*-2.23*	*4.75*	*-2.92*	*-1.32*	
γiH5	-0.01071	-0.00092	-0.00348	-0.00748	-0.01299	0.02851	0.00253	-0.00092	0.02650	-0.00589	-0.00511	-0.01004
	-1.67	*-0.29*	*-1.00*	*-1.80*	*-3.77*	*5.64*	*0.44*	*-0.54*	*3.95*	*-2.92*	*-0.95*	
γiH6	-0.01003	-0.00579	-0.01758	0.00832	-0.00577	0.03558	0.01386	0.00156	0.01237	-0.00054	-0.01419	-0.01779
	-0.93	*-1.01*	*-2.99*	*1.19*	*-0.99*	*4.19*	*1.44*	*0.55*	*1.10*	*-0.16*	*-1.57*	
γiH7	-0.01754	-0.00424	-0.01239	-0.01491	-0.00711	0.04177	0.01276	0.00287	0.04536	-0.01005	-0.01067	-0.02585
	-1.29	*-0.63*	*-1.67*	*-1.68*	*-0.97*	*3.88*	*0.11*	*0.80*	*3.18*	*-2.34*	*-0.93*	
γiA35	0.00665	-0.00176	0.00054	-0.00427	0.00137	-0.00188	0.00519	0.00052	-0.00695	-0.00096	0.00445	-0.00289
	1.62	*-0.88*	*0.24*	*-1.60*	*0.83*	*-0.58*	*1.41*	*0.48*	*-1.62*	*-0.75*	*1.29*	
γiA45	0.01137	-0.00308	0.00075	0.00276	0.00049	-0.00270	0.00404	0.00015	-0.01256	-0.00006	0.00699	-0.00814
	2.48	*-1.37*	*0.30*	*0.92*	*0.20*	*-0.74*	*0.98*	*0.12*	*-2.63*	*-0.04*	*1.82*	
γiA55	0.00089	0.00093	0.00599	0.00533	0.00221	-0.00688	0.00352	0.00252	-0.00849	-0.00055	0.00037	-0.00586
	0.19	*0.41*	*2.34*	*1.75*	*0.87*	*-1.85*	*0.83*	*2.05*	*-1.73*	*-0.37*	*0.10*	
γiA65	-0.00387	-0.00048	0.00015	0.00129	0.00444	0.00957	-0.01013	0.00472	-0.00158	0.00152	0.00096	-0.00660
	-0.91	*-0.23*	*0.06*	*0.47*	*1.92*	*2.84*	*-2.65*	*4.20*	*-0.35*	*1.13*	*0.27*	
γiR2	0.03034	0.00237	0.00028	-0.00131	-0.00092	-0.01068	0.00835	-0.00217	-0.01263	0.00178	-0.00727	-0.00813
	6.33	*1.01*	*0.11*	*-0.42*	*-0.35*	*-2.83*	*1.95*	*-1.73*	*-2.52*	*1.18*	*-1.81*	
γiR3	0.00477	0.00129	-0.00167	-0.00125	-0.00047	-0.01053	0.00473	-0.00109	0.00791	0.00381	-0.00612	-0.00137
	1.07	*0.59*	*-0.69*	*-0.43*	*-0.19*	*-3.01*	*1.19*	*-0.93*	*1.70*	*2.72*	*-1.64*	
γiR4	0.00533	-0.00189	-0.00262	-0.00172	-0.00077	-0.00226	0.01020	-0.00278	-0.00325	-0.00007	0.00005	-0.00023
	1.27	*-19.92*	*-1.14*	*-0.63*	*-0.34*	*-0.68*	*2.71*	*-2.51*	*-0.74*	*0.05*	*0.01*	
γiR5	-0.00209	0.00287	0.00461	-0.01054	-0.00010	0.00617	-0.00272	-0.00118	0.00678	0.00498	-0.00663	-0.00216
	-0.40	*1.14*	*1.63*	*-3.14*	*-0.04*	*1.51*	*-0.58*	*-0.86*	*1.25*	*3.07*	*-1.52*	
γiQ2	0.00621	-0.00045	-0.00070	0.00534	0.00410	-0.00500	-0.00271	-0.00022	-0.00567	-0.00220	0.00274	-0.00145
	1.60	*-0.24*	*-0.33*	*2.12*	*1.95*	*-1.63*	*-0.78*	*-0.21*	*-1.40*	*-1.81*	*0.84*	
γiQ3	0.01664	0.00383	-0.00113	0.00505	0.00221	-0.00794	-0.00417	-0.00239	-0.00902	0.00048	0.00343	-0.00701
	4.25	*2.01*	*-0.26*	*1.99*	*1.05*	*-2.58*	*-1.19*	*-2.33*	*-2.21*	*0.39*	*1.04*	
γiQ4	0.00251	0.00447	0.00820	0.00791	-0.00237	0.00145	-0.02265	-0.00038	-0.00062	-0.00140	0.00186	0.00103
	0.65	*2.36*	*3.87*	*3.14*	*-1.13*	*0.47*	*-6.52*	*-0.37*	*-0.15*	*-1.15*	*0.57*	
s-w R^2[b]	0.3455											
F (2SLS)[c]	96.99	177.00	196.70	89.12	97.65	73.27	77.69	20.78	100.74	125.65	87.17	

a. Figures in italics are ratios of parameter estimates to standard errors.
b. System-weighted R2.
c. The third stage output for 3SLS or FIML does not include the analysis of variance table. Hence, the F statistics correspond to the second stage, i.e. 2SLS.

Table 4.5 Homogeneity and Symmetry Restricted ALIDS: 3SLS Parameter Estimates and Mean Budget Shares: 1986

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
W_i	0.09212	0.03287	0.04896	0.07547	0.03507	0.18909	0.15589	0.00890	0.14478	0.02233	0.10268	0.09182
α_i	0.07209	0.0618	0.0672	0.0749	0.0431	0.1475	0.1440	0.0076	0.1020	0.0360	0.1310	0.1127
	18.01[a]	*28.10*	*25.43*	*24.07*	*17.73*	*34.53*	*32.49*	*6.04*	*20.56*	*24.45*	*32.37*	
γ_{i1}	0.01082											
	63.06											
γ_{i2}	-0.00039	0.00694										
	-4.94	*91.61*										
γ_{i3}	-0.00083	-0.00061	0.00833									
	-9.40	*-10.48*	*89.99*									
γ_{i4}	-0.00112	-0.00039	-0.00084	0.00941								
	-10.57	*-5.36*	*-10.44*	*67.97*								
γ_{i5}	-0.00054	-0.00046	-0.00040	-0.00086	0.00546							
	-6.63	*-8.57*	*-6.61*	*-11.58*	*69.09*							
γ_{i6}	-0.00152	-0.00100	-0.00090	-0.00172	-0.00047	0.02455						
	-11.34	*-11.26*	*-9.01*	*-14.10*	*-5.10*	*116.02*						
γ_{i7}	-0.00140	-0.00096	-0.00079	-0.00164	-0.00018	-0.00587	0.02141					
	-8.80	*-8.45*	*-6.44*	*-10.71*	*-1.60*	*-31.25*	*62.14*					
γ_{i8}	-0.00013	-0.00012	-0.00008	-0.00016	-0.00092	-0.00017	-0.00026	0.00120				
	-2.69	*-3.23*	*-2.13*	*-3.32*	*-2.65*	*-0.29*	*-0.32*	*27.96*				
γ_{i9}	-0.00187	-0.00194	-0.00193	-0.00119	-0.00106	-0.00598	-0.00615	-0.00046	0.02756			
	-10.74	*-15.91*	*-14.49*	*-7.24*	*-8.66*	*-29.70*	*-22.57*	*-5.44*	*71.30*			
$\gamma_{i,10}$	-0.00034	-0.00031	-0.00048	-0.00027	-0.00036	-0.00037	-0.00041	0.00050	-0.00105	0.00392		
	-6.27	*-7.43*	*-11.19*	*-5.07*	*-9.09*	*-5.70*	*-4.62*	*1.54*	*-11.20*	*80.42*		
$\gamma_{i,11}$	-0.00147	-0.00034	-0.00074	-0.00073	-0.00070	-0.00402	-0.00238	-0.00009	-0.00305	-0.00032	0.01464	
	-10.79	*-3.77*	*-7.35*	*-5.92*	*-7.46*	*-26.02*	*-12.41*	*-1.56*	*-14.69*	*-4.78*	*66.38*	
$\gamma_{i,12}$	-0.00124	-0.00043	-0.00073	-0.00051	-0.00034	-0.00270	-0.00159	-0.00008	-0.00290	-0.00007	-0.00081	0.01140
	-10.10	*-5.11*	*-7.81*	*-4.46*	*-4.00*	*-19.04*	*-8.83*	*-1.37*	*-15.08*	*-1.17*	*-5.59*	
β_i	0.01064	0.00413	0.00809	0.00466	0.00779	-0.02919	-0.00080	0.00195	-0.00182	0.00194	-0.00734	-0.00006
	10.97	*7.47*	*12.38*	*5.94*	*12.91*	*-24.43*	*-0.69*	*5.86*	*1.45*	*5.08*	*-7.22*	

Table 4.5 (continued)

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
δiH2	0.00169	0.00168	0.00064	-0.00829	-0.00398	0.02093	-0.00852	-0.00050	0.01987	-0.00045	-0.00839	-0.01467
	0.67	*1.30*	*0.40*	*-4.42*	*-2.70*	*8.59*	*-3.25*	*-0.70*	*6.68*	*-0.54*	*-3.38*	
δiH3	-0.00621	0.00039	-0.00374	-0.01141	-0.01042	0.03145	-0.00854	-0.00019	0.03848	-0.00023	-0.01558	-0.01399
	-2.11	*0.25*	*-2.01*	*-5.19*	*-6.02*	*10.96*	*-2.77*	*-0.22*	*10.98*	*-0.23*	*-5.37*	
δiH4	-0.00924	0.00073	-0.00709	-0.01501	-0.01365	0.04926	-0.01279	-0.00180	0.04709	-0.00453	-0.01733	-0.01565
	-3.04	*0.46*	*-3.67*	*-6.57*	*-7.60*	*16.43*	*-3.98*	*-2.03*	*12.84*	*-4.41*	*-5.75*	
δiH5	-0.01530	-0.00012	-0.00801	-0.01520	-0.01559	0.06340	-0.01380	-0.00182	0.04828	-0.00513	-0.02111	-0.01560
	-4.00	*-0.06*	*-3.30*	*-5.31*	*-6.91*	*16.85*	*-3.42*	*-1.65*	*10.54*	*-3.99*	*-5.58*	
δiH6	-0.01326	-0.00083	-0.00602	-0.01531	-0.02303	0.07964	-0.01647	0.00070	0.05034	-0.00619	-0.02451	-0.02507
	-2.01	*-0.24*	*-1.44*	*-3.12*	*-5.95*	*12.48*	*-2.40*	*0.37*	*6.69*	*-2.84*	*-3.77*	
δiH7	-0.00071	0.00318	-0.01271	-0.01988	-0.01487	0.07551	-0.01134	-0.00083	0.03740	-0.00283	-0.03317	-0.01976
	-0.07	*0.65*	*-2.11*	*-2.79*	*-2.65*	*8.17*	*-1.14*	*-0.31*	*3.33*	*-0.90*	*-3.52*	
δiA35	0.00163	-0.00007	0.00172	-0.00113	0.00565	0.00384	-0.00240	0.00033	0.00120	-0.00079	-0.00118	-0.00880
	0.64	*-0.06*	*1.07*	*-0.60*	*3.80*	*1.58*	*-0.92*	*0.47*	*0.40*	*-0.95*	*-0.47*	
δiA45	0.00546	-0.00157	0.00225	0.00323	0.00111	0.00555	0.00269	0.00221	-0.00602	-0.00098	-0.00082	-0.01312
	1.91	*-1.08*	*1.26*	*1.53*	*0.66*	*2.03*	*0.91*	*2.77*	*-1.81*	*-1.05*	*-0.29*	
δiA55	0.00400	0.00218	0.00358	0.00060	0.00121	0.00714	-0.00314	0.00387	-0.00490	0.00145	-0.00058	-0.01541
	1.37	*1.46*	*1.95*	*0.27*	*0.71*	*2.54*	*-1.04*	*4.74*	*-1.43*	*1.52*	*-0.20*	
δiA65	-0.00504	0.00016	0.00133	-0.00272	0.00247	0.01284	-0.00274	0.00489	0.00390	0.00352	-0.00476	-0.01385
	-1.92	*0.12*	*0.80*	*-1.40*	*1.61*	*5.10*	*-1.01*	*6.66*	*1.27*	*4.10*	*-1.85*	
δiR2	0.02299	-0.00001	-0.00134	-0.00230	0.00136	-0.00526	0.01120	0.00005	-0.01144	-0.00041	-0.00725	-0.00759
	8.60	*-0.01*	*-0.79*	*-1.16*	*0.87*	*-0.21*	*4.06*	*0.06*	*-3.66*	*-0.47*	*-2.76*	
δiR3	0.01199	0.00158	-0.00012	-0.00357	-0.00034	-0.00413	0.00677	-0.00282	0.00622	0.00097	-0.00830	-0.00826
	4.46	*1.14*	*-0.07*	*-1.79*	*-0.21*	*-1.58*	*2.41*	*-3.59*	*1.97*	*1.08*	*-2.56*	
δiR4	-0.00002	0.00150	-0.00215	0.00152	-0.00916	-0.00073	0.00973	-0.00008	-0.00127	-0.00045	-0.00035	0.00145
	-0.01	*1.06*	*-1.22*	*0.73*	*-5.60*	*-0.27*	*3.37*	*-0.10*	*-0.38*	*-0.49*	*-0.12*	
δiR5	0.00154	0.00035	0.00158	-0.00692	-0.00278	0.00009	0.00360	0.00009	0.00165	0.00355	-0.00675	0.00402
	0.51	*0.22*	*0.84*	*-3.13*	*-1.59*	*0.03*	*1.17*	*0.11*	*0.47*	*3.63*	*-2.30*	
δiQ2	0.00310	-0.00074	-0.00336	0.00020	0.00489	-0.00395	0.00566	0.00084	-0.00215	-0.00143	-0.00116	-0.00189
	1.28	*-0.61*	*-2.21*	*0.11*	*3.47*	*-1.71*	*2.28*	*1.25*	*-0.76*	*-1.81*	*-0.49*	
δiQ3	0.00495	-0.00010	-0.00310	0.00177	0.00457	-0.00760	0.00923	0.00106	-0.00465	-0.00359	0.00101	-0.00354
	2.03	*-0.07*	*-2.02*	*0.98*	*3.20*	*-3.25*	*3.67*	*1.56*	*-1.63*	*-4.50*	*0.42*	
δiQ4	-0.00250	0.00346	0.00926	0.00288	0.00213	-0.00257	-0.00589	0.00035	0.00041	-0.00254	-0.00234	-0.00266
	-1.03	*2.80*	*6.06*	*1.60*	*1.50*	*-1.10*	*-2.35*	*0.52*	*0.15*	*-3.21*	*-0.98*	
s-w R2	0.5203											
F (2SLS)	202.34	340.24	329.44	192.21	192.34	2263.88	199.11	41.54	214.01	250.83	183.56	

a. Figures in italics are ratios of parameter estimates to standard errors.
b. System-weighted R2.
c. The third stage output for 3SLS or FIML does not include the analysis of variance table. Hence, the F statistics correspond to the second stage, i.e. 2SLS.

Table 4.6 Homogeneity and Symmetry Restricted ALIDS: 3SLS Parameter Estimates and Mean Budget Shares: 1990

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
Wi	0.07313	0.02325	0.04530	0.07556	0.03603	0.16076	0.16723	0.00848	0.19021	0.01639	0.09624	0.10742
αi	0.07204	0.04480	0.05679	0.09497	0.05568	0.16563	0.12567	0.03967	0.14370	0.03991	0.12160	0.03954
	16.93 *	*25.33*	*16.57*	*23.77*	*19.12*	*27.95*	*20.54*	*12.84*	*19.97*	*19.01*	*22.91*	
γi1	0.01213											
	86.56											
γi2	-0.00060	0.00796										
	-16.12	*100.04*										
γi3	-0.00140	-0.00097	0.01035									
	-11.47	*-13.96*	*91.38*									
γi4	-0.00113	-0.00038	-0.00098	0.01099								
	-11.19	*-4.97*	*-11.29*	*78.18*								
γi5	-0.00097	-0.00060	-0.00085	-0.00080	0.00806							
	-11.62	*-16.48*	*-3.19*	*-9.39*	*79.32*							
γi6	-0.00152	-0.00107	-0.00126	-0.00080	-0.00086	0.02200						
	-10.15	*-7.41*	*-9.42*	*-5.24*	*-6.70*	*67.05*						
γi7	-0.00188	-0.00056	-0.00090	-0.00197	-0.00035	-0.00526	0.02416					
	-12.19	*-3.17*	*-6.17*	*-12.45*	*-2.65*	*-20.98*	*70.16*					
γi8	-0.00020	-0.00019	-0.00026	-0.00016	-0.00019	-0.00003	-0.00012	0.00140				
	-4.14	*-3.28*	*-5.58*	*-3.2600*	*-4.36*	*-0.14*	*-1.53*	*28.50*				
γi9	-0.00219	-0.00217	-0.00190	-0.00230	-0.00168	-0.00720	-0.00760	-0.00029	0.03227			
	-12.55	*-12.11*	*-12.46*	*-13.57*	*-11.72*	*-27.19*	*-28.13*	*-3.49*	*73.22*			
γi,10	-0.00043	-0.00053	-0.00047	-0.00038	-0.00036	-0.00033	-0.00045	-0.00007	-0.00141	0.00459		
	-8.71	*-9.16*	*-8.61*	*-7.62*	*7.71*	*-4.09*	*-5.37*	*-1.91*	*-12.35*	*81.56*		
γi,11	-0.00126	-0.00058	-0.00077	-0.00120	-0.00080	-0.00223	-0.00320	-0.00007	-0.00290	-0.00040	0.01392	
	-9.99	*-5.54*	*-7.36*	*-9.78*	*-7.68*	*-11.68*	*-16.13*	*-1.09*	*-13.59*	*-6.49*	*61.88*	
γi,12	-0.00129	-0.00021	-0.00058	-0.00088	-0.00058	-0.00150	-0.00200	0.00017	-0.00310	-0.00012	-0.00080	0.01089
	-10.84	*-4.90*	*-8.75*	*-7.48*	*-5.88*	*-8.41*	*-10.79*	*2.92*	*-15.32*	*-2.04*	*-5.38*	
βi	0.01176	0.01080	0.01490	-0.00230	0.00520	-0.03039	0.00000	0.00335	-0.00145	0.00370	-0.00840	-0.00717
	9.73	*11.27*	*16.04*	*-2.23*	*6.06*	*16.83*	*0.00*	*8.00*	*-0.75*	*8.59*	*-5.79*	

Table 4.6 (continued)

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
δiH2	0.00118	-0.00003	-0.00190	-0.00297	-0.00038	0.01525	-0.00087	-0.00118	0.00578	-0.00090	-0.00545	-0.00854
	0.47	*-0.23*	*-1.25*	*-1.32*	*-0.20*	*4.43*	*-0.24*	*-1.31*	*1.39*	*-0.96*	*-1.72*	
δiH3	-0.00783	0.00063	-0.00570	-0.00497	-0.00476	0.02700	-0.00988	-0.00195	0.02436	-0.00250	-0.01068	-0.00372
	-2.64	*0.40*	*-2.48*	*-1.88*	*-2.14*	*6.10*	*-2.30*	*-1.81*	*4.91*	*-2.26*	*-2.86*	
δiH4	-0.00666	-0.00149	-0.01000	-0.00860	-0.00877	0.04070	-0.01265	-0.00448	0.03619	-0.00380	-0.01290	-0.00754
	-2.12	*-0.90*	*-4.15*	*-2.92*	*-3.72*	*8.89*	*-2.78*	*-3.94*	*6.89*	*-3.24*	*-3.27*	
δiH5	-0.01299	-0.00267	-0.01146	-0.00450	-0.00655	0.04080	-0.01460	-0.00380	0.03760	-0.00640	-0.01123	-0.00420
	-3.12	*-1.25*	*-3.53*	*-1.16*	*-2.10*	*6.62*	*-2.43*	*-2.52*	*5.40*	*-4.08*	*-2.14*	
δiH6	-0.01236	-0.00280	-0.00998	-0.01960	-0.00770	0.04750	-0.00600	-0.00360	0.03160	-0.00557	-0.00690	-0.00459
	-1.89	*-0.72*	*-1.95*	*-3.23*	*-1.57*	*4.79*	*-0.64*	*-1.54*	*2.89*	*-2.26*	*-0.83*	
δiH7	-0.01252	-0.00233	-0.01860	-0.00970	-0.00950	0.05080	0.01770	-0.00600	0.02200	-0.00500	-0.01759	-0.00926
	-1.34	*-0.39*	*-2.55*	*-1.17*	*-1.36*	*3.62*	*1.31*	*-1.79*	*1.41*	*-1.43*	*-1.49*	
δiA35	0.00676	0.00076	-0.00021	-0.00048	0.00510	0.00390	-0.00580	-0.00020	-0.00570	0.00112	0.00300	-0.00825
	2.87	*0.46*	*-0.12*	*-0.21*	*2.90*	*0.12*	*-1.71*	*-0.23*	*-1.44*	*1.26*	*1.04*	
δiA45	0.00839	0.00170	0.00306	0.00010	0.00360	-0.00175	0.00700	-0.00070	-0.00758	0.00026	0.00190	-0.01599
	3.04	*0.57*	*-1.41*	*0.04*	*1.74*	*-0.45*	*1.74*	*-0.71*	*-1.63*	*0.25*	*0.55*	
δiA55	0.00309	0.00460	0.00620	0.00600	0.00650	0.00447	0.00150	0.00290	-0.00498	0.00490	-0.01119	-0.02399
	1.29	*2.55*	*2.65*	*2.24*	*2.89*	*0.11*	*0.35*	*2.70*	*-0.98*	*4.30*	*-2.95*	
δiA65	0.00110	0.00350	0.00275	0.00115	0.00630	0.01330	-0.00420	0.00460	-0.00421	0.00536	-0.01860	-0.01105
	0.44	*1.72*	*1.32*	*0.46*	*3.16*	*3.63*	*-1.10*	*4.78*	*-0.90*	*5.36*	*-5.54*	
δiR2	0.00613	0.00650	0.00260	-0.00470	0.00290	-0.00180	0.02700	0.00110	-0.02000	0.00210	-0.00970	-0.01213
	2.08	*0.61*	*1.13*	*-1.69*	*1.33*	*-0.44*	*6.29*	*1.01*	*-4.09*	*1.89*	*-2.59*	
δiR3	-0.00099	0.00137	-0.00116	-0.00590	-0.00098	-0.00980	0.02058	-0.00144	-0.00860	-0.00057	-0.00290	0.01039
	-0.45	*1.22*	*-0.55*	*-2.33*	*-0.48*	*-2.62*	*5.24*	*-1.47*	*-1.89*	*-0.56*	*-0.86*	
δiR4	0.00186	0.00050	0.00165	0.00020	-0.00270	-0.00323	0.01210	-0.00050	-0.01530	0.00036	-0.00348	0.00854
	0.72	*1.25*	*0.81*	*0.08*	*-1.40*	*-0.90*	*3.23*	*-0.54*	*-3.54*	*0.37*	*-1.06*	
δiR5	0.02484	0.00010	0.00350	-0.00670	-0.00370	0.00038	0.01000	0.00160	-0.01008	0.00070	-0.00545	-0.01520
	0.83	*0.62*	*1.48*	*-2.40*	*-1.66*	*0.09*	*2.38*	*1.50*	*-2.01*	*0.65*	*-1.44*	
δiQ2	0.01268	0.00165	-0.00031	0.00061	0.00381	-0.00750	-0.00090	0.00101	-0.01316	0.00047	0.00460	-0.00296
	5.30	*1.34*	*-0.17*	*0.27*	*1.61*	*-2.29*	*-0.26*	*1.13*	*-3.31*	*0.53*	*1.52*	
δiQ3	0.00914	-0.0002	0.0008	0.0034	-0.0032	-0.0014	-0.0033	0.0019	-0.0049	0.0002	0.0012	-0.0036
	3.88	*-0.18*	*0.47*	*1.55*	*-1.38*	*-0.45*	*-0.98*	*2.15*	*-1.26*	*0.23*	*0.40*	
δiQ4	0.00435	0.00201	0.00712	0.00653	-0.00950	-0.00140	-0.01955	0.00283	-0.00198	-0.00022	-0.00045	0.01024
	1.85	*1.66*	*3.90*	*2.97*	*-0.40*	*-0.43*	*-5.80*	*3.23*	*-0.50*	*-0.25*	*-0.15*	
s-w R2	0.4064											
F (2SLS)	326.70	379.50	351.60	246.40	251.30	214.90	205.80	36.80	260.10	257.00	162.60	

a. Figures in italics are ratios of parameter estimates to standard errors.

b. System-weighted R2.

c. The third stage output for 3SLS or FIML does not include the analysis of variance table. Hence, the F statistics correspond to the second stage, i.e. 2SLS.

unrestricted ALIDS. For reasons explained later in this section, we also present the Allen-Uzawa and Morishima elasticities of substitution.

For the ALIDS, the estimates of demand, substitution, and expenditure elasticities can be computed by differentiating the ALIDS share equations and from the Slutsky equation. Green and Alston [1990] have suggested general matrix solutions for computing price and expenditure elasticities. Eales and Unnevehr [1988] and Chalfant [1987] have computed formulae for the linearized ALIDS as special cases of the general result of Green and Alston. In a follow up 1991 article, Green and Alston have illustrated the inappropriateness of using the general price elasticity formulae when the linear approximate ALIDS is employed. Hence, following similar applications by Eales and Unnevehr [1993] and other researchers, we shall use Chalfant's [1987] formulae to calculate our price elasticities. The elasticities are computed as follows:

1. Uncompensated price elasticity:

$$\epsilon_{ij} = \gamma_{ij}/w_i - \beta_i(w_j/w_i) - \delta_{ij} \qquad 4.25$$

2. Compensated price elasticity:

$$\epsilon^c_{ij} = \gamma_{ij}/w_i + w_j - \delta_{ij} \qquad 4.26$$

3. Expenditure elasticity:

$$\epsilon_{iM} = \beta_i w^{-1}_j + 1 \qquad i = 1,2,...,n \qquad 4.27$$

where δ_{ij} is Kronecker delta and $i,j = 1,2,3,...,12$ are the 12 food commodities that we estimated at the second stage. *A priori*, the uncompensated own-price elasticities, $\epsilon_{ii,}$ are expected to be negative at all data points if the expenditure function is globally concave. There are no *a priori* restrictions on the compensated and uncompensated price elasticity, except that $\epsilon_{ij} \neq \epsilon_{ji}$ and $\epsilon^c_{ij} \neq \epsilon^c_{ji}$. Finally, no restrictions are imposed on expenditure elasticities ϵ_{iM} since, as noted above, β_i can be positive or negative depending on whether the commodity in question is a necessity or a luxury. It is intuitively obvious that $\beta_i = 0 \ \forall \ i$ implies homothetic preferences. We tested for homotheticity and rejected the null that $\beta_i = 0$ and hence conclude that our preference structure is nonhomothetic, a desirable result as far as we are concerned since a homothetic utility function implies linear Engel curves and constant elasticities both of which are theoretically uninteresting and empirically inappropriate for modelling demand for food commodities.[14] Finally, these elasticities are functions of p and M and so they are expected to vary over the sample space. A related point that needs emphasizing at this stage is that with this extended ALIDS, the classification of food commodities as luxury or necessity is independent of the demographic variables. In other words, household size, age, and region have their influence on price only via the budget share w_i. In any case, they only affect the magnitude and not the direction of these elasticities. The fact that they affect only the degree of demand elasticity is clear from the ϵ_{ij} expression.

Before discussing the estimated elasticities in detail, it is instructive to briefly note that although the linearized ALIDS has implications for computing price elasticities, it is not necessarily a distortion of the original ALIDS as far as elasticities are concerned. Recently, Alston, Foster, and Green [1994] performed Monte Carlo simulations and showed that the linear approximate ALIDS provides quite accurate estimates of elasticities when the true data generating process is the original ALIDS. They concluded that demand analysts can have confidence when estimating the linear approximate ALIDS and using the formulae to derive estimates of the 'true' ALIDS elasticities. Linear approximations based on Stone's index have also been used by Eales and Unnevehr [1991, 1993] in their Inverse ALIDS (IALIDS). Their work shows that a linear approximation to the IALIDS provided a good approximation of the full IALIDS. The authors conclude that the adequacy of an approximation within the ALIDS context is an empirical question. In practice, it seems to us that most researchers start off by estimating the full original ALIDS and invariably end up estimating the linearized version due to immense convergence problems created by the 'less amenable' nonlinear Translog price index which, unlike the Stone

[14] From our earlier discussion, notice how this outcome automatically excludes the Rotterdam model due to the homotheticity and additivity condition implied by this functional form.

index, depends on unknown parameters. And while modern econometric software makes estimation of the nonlinear ALIDS feasible, convergence comes at a very high cost, at least in the context of the present study. Hence, one needs to weigh all the relevant factors.

Tables 4.7 - 4.12 present matrices of the estimated uncompensated price elasticities and expenditure elasticities evaluated at the sample mean budget shares and associated variables. These are calculated both for the restricted model and the unrestricted model. Ideally, one should provide confidence intervals for these elasticities so that more implications may be derived from the results. Most studies employing demand systems to estimate price and expenditure elasticities do not report confidence intervals associated with the stability of these elasticities due to the difficulty involved in calculating these confidence limits. We attempted to use the bootstrap method of Efron [1979] to calculate standard errors but ran into serious SAS data handling and programming problems because of the sheer size of model. An alternative suggested by Chalfant [1987] and based on predicted budget shares can be used. However, the predicted shares must be treated as exogenous, thus making the resulting standard errors only approximations. These qualifications must be taken into account when interpreting these elasticities.

Own price elasticities are in the diagonal while cross price elasticities are off diagonal. Based on simple inspection of standard errors using Chalfant's [1987] method, all uncompensated own price elasticities are significant and their signs and magnitude in accord with prior expectations (i.e. $\epsilon_{ii} < 0$). For instance, for beef, ϵ_{11} = -0.88 in 1984, meaning that a 1 percent own price increase would depress the demand for that food by 0.88 percent. This magnitude suggests that in terms of their absolute size, these own price elasticities are larger than those that we would expect from more aggregated commodities. This is due to the fact that as the level of aggregation increases, the possibility of substitution declines. The absence of unanticipated wrong (positive) signs signifies the existence of sufficient price variation for all categories during the sample period. One can easily assess price variation by specifying an auxiliary regression

Table 4.7 Uncompensated (Marshallian) Own Price and Cross Price Elasticities, Expenditure Elasticities, Demographic Elasticities, and Budget Shares Evaluated at the Sample Mean: 1984

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
W_i	0.11427	0.03915	0.05585	0.07957	0.04136	0.13160	0.17090	0.01171	0.15288	0.02501	0.11139	0.09885
$\varepsilon 1i$	-0.87625	0.01118	-0.02181	-0.01034	-0.02949	-0.00745	-0.01007	-0.02038	-0.04452	-0.00522	-0.00353	-0.01061
$\varepsilon 2i$	-0.03572	-0.80832	-0.01478	-0.00284	-0.01858	0.00115	-0.00371	-0.01478	-0.00663	-0.00284	0.00018	0.00119
$\varepsilon 3i$	-0.01387	-0.01862	-0.83996	-0.00935	-0.02235	-0.00567	-0.00293	-0.01634	-0.01937	-0.00853	0.00099	-0.00459
$\varepsilon 4i$	-0.01363	-0.01499	-0.02284	-0.87745	-0.03023	0.00013	-0.00637	-0.02455	-0.02848	-0.00757	0.00546	0.00215
$\varepsilon 5i$	-0.00882	-0.01625	-0.01408	-0.01145	-0.85993	-0.00040	0.00190	-0.01498	-0.01027	-0.00784	-0.00385	-0.00356
$\varepsilon 6i$	-0.02260	-0.01107	-0.01706	0.00440	-0.04270	-0.85549	-0.01271	-0.04053	-0.06270	-0.01245	-0.01242	0.00299
$\varepsilon 7i$	-0.01872	-0.00665	-0.00159	-0.00472	-0.02823	-0.02682	-0.85860	-0.00751	-0.09387	0.01151	-0.01923	-0.00314
$\varepsilon 8i$	-0.00924	-0.00492	-0.00295	-0.00588	-0.00935	0.00612	0.00097	-0.88157	-0.00395	-0.00453	0.00513	0.00057
$\varepsilon 9i$	-0.02737	-0.00276	-0.04293	-0.01143	-0.06852	-0.03220	-0.01632	0.00016	-0.85857	0.00868	-0.04121	-0.00856
$\varepsilon 10,i$	-0.00784	-0.00946	-0.01360	-0.00569	-0.01575	0.00446	-0.00399	0.01814	-0.00474	-0.81540	-0.00552	-0.00268
$\varepsilon 11,i$	-0.02209	-0.02870	-0.01801	-0.01305	-0.03086	-0.00696	-0.00963	-0.03010	-0.04066	-0.00468	-0.85100	-0.00386
$\varepsilon 12,i$	-0.01729	-0.01572	-0.01410	-0.00606	-0.02663	0.00327	-0.00201	-0.00587	-0.02718	0.00497	0.00237	-0.91188
$\varepsilon i,M$	1.06306	1.05129	1.09574	0.97612	1.17935	0.91239	0.94985	1.09391	1.13599	0.90924	0.87611	0.94134
$\varepsilon iH2$	0.00147	-0.00632	-0.02335	0.00166	-0.01676	-0.00068	0.01575	-0.03334	0.02150	-0.00222	-0.00620	-0.02839
$\varepsilon iH3$	0.00165	-0.01161	-0.03439	-0.02045	-0.03489	0.01596	0.00686	-0.02053	0.03051	-0.00563	-0.01373	-0.00779
$\varepsilon iH4$	0.00398	-0.01070	-0.02842	-0.01547	-0.05645	0.02782	0.00472	-0.05388	0.02809	-0.03705	-0.01024	-0.00958
$\varepsilon iH5$	-0.00155	-0.00317	-0.00700	-0.00599	-0.02592	0.01507	0.00160	-0.00867	0.01203	-0.01934	-0.00435	-0.00794
$\varepsilon iH6$	-0.00003	-0.00312	-0.00639	0.00233	-0.00298	0.00465	0.00176	0.00178	0.00097	-0.00059	-0.00280	-0.00341
$\varepsilon iH7$	-0.00042	-0.00101	-0.00275	-0.00187	-0.00212	0.00314	0.00016	0.00220	0.00292	-0.00463	-0.00138	-0.00168
$\varepsilon iA35$	0.01106	-0.00985	0.00095	-0.00929	0.00775	-0.00281	0.00469	0.00615	-0.00720	-0.00723	0.00739	-0.00565
$\varepsilon iA45$	0.01230	-0.01417	-0.00019	0.00400	0.00062	-0.00235	0.00293	-0.00118	-0.00861	-0.00251	0.00852	-0.00943
$\varepsilon iA55$	0.00166	0.00060	0.01125	0.00753	0.00531	-0.00611	0.00263	0.02239	-0.00663	-0.00385	0.00139	-0.00621
$\varepsilon iA65$	-0.00478	-0.00543	-0.00093	0.00253	0.01554	0.01068	-0.00850	0.05831	-0.00136	0.00729	0.00261	-0.00947
$\varepsilon iR2$	0.04121	0.00482	-0.00142	-0.00350	-0.00483	-0.01152	0.00798	-0.02847	-0.01051	0.01090	-0.01043	-0.01375
$\varepsilon iR3$	0.01112	0.00611	-0.01136	-0.00611	-0.00512	-0.01529	0.00532	-0.01344	0.01469	0.03338	-0.01392	-0.00453
$\varepsilon iR4$	0.01510	0.00096	-0.00833	-0.00704	-0.00459	-0.00605	0.01876	-0.06772	-0.00925	0.00572	-0.00559	-0.00275
$\varepsilon iR5$	-0.00277	0.00469	0.00718	-0.01759	-0.00070	0.00683	-0.00283	-0.01270	0.00827	0.02289	-0.00592	-0.00286
$\varepsilon iQ2$	0.01316	-0.00314	-0.00347	0.01676	0.02532	-0.00959	-0.00374	-0.00387	-0.00856	-0.02073	0.00513	-0.00368
$\varepsilon iQ3$	0.03180	0.02992	-0.00131	0.01608	0.01416	-0.01447	-0.00557	-0.04704	-0.01526	0.00844	0.00603	-0.01762
$\varepsilon iQ4$	0.00678	0.02924	0.03777	0.02480	-0.01269	0.00109	-0.03250	-0.01093	-0.00208	-0.01237	0.00361	0.00289

Table 4.8 Uncompensated (Marshallian) Own Price and Cross Price Elasticities, Expenditure Elasticities, Demographic Elasticities, and Budget Shares Evaluated at the Sample Mean: 1986

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
W_i	0.0949	0.0339	0.0504	0.0780	0.0362	0.1934	0.1612	0.0092	0.1492	0.0231	0.1059	0.0971
ε_{1i}	-0.88545	0.00202	-0.02700	-0.01730	-0.03623	0.00474	-0.01294	-0.02799	-0.02550	-0.01715	-0.01413	0.00189
ε_{2i}	-0.02944	-0.79217	-0.01778	-0.00617	-0.02182	0.00310	-0.00473	-0.01295	-0.00619	-0.01028	-0.00345	-0.00293
ε_{3i}	-0.01597	-0.01999	-0.83596	-0.01350	-0.02062	0.00417	-0.00683	-0.01678	-0.01436	-0.02074	-0.00781	-0.00425
ε_{4i}	-0.01735	-0.01490	-0.02508	-0.87703	-0.04586	0.00629	-0.01436	-0.02631	-0.02008	-0.01379	-0.00339	0.00533
ε_{5i}	-0.01166	-0.01374	-0.01488	-0.01080	-0.85260	0.00158	-0.00199	-0.01434	-0.00748	-0.01379	-0.00783	0.00255
ε_{6i}	-0.03724	-0.04873	-0.04733	-0.03598	-0.05182	-0.83996	-0.03678	-0.04422	-0.03787	-0.03076	-0.05029	-0.01001
ε_{7i}	-0.01387	-0.00938	-0.01479	-0.01720	-0.02522	-0.00578	-0.86631	-0.03964	-0.08130	-0.00909	-0.03277	0.00474
ε_{8i}	-0.00665	-0.00668	-0.00350	-0.00512	-0.00689	0.00422	0.00143	-0.86680	-0.00367	-0.00179	0.00596	-0.00670
ε_{9i}	-0.03313	-0.02424	-0.05864	-0.00727	-0.06361	-0.00911	-0.01462	-0.07900	-0.85384	-0.00135	-0.04921	-0.02041
$\varepsilon_{10,i}$	-0.00828	-0.00819	-0.01235	-0.00354	-0.02155	0.00559	-0.00574	0.01309	-0.00850	-0.82189	-0.00645	0.00323
$\varepsilon_{11,i}$	-0.02622	-0.01277	-0.02758	-0.01734	-0.04012	0.00371	-0.01677	-0.03269	-0.03837	-0.01152	-0.86091	0.00691
$\varepsilon_{12,i}$	-0.02447	-0.00711	-0.01931	-0.00931	-0.03495	0.00671	-0.01282	-0.02225	-0.03262	-0.00436	-0.01364	-0.86375
$\varepsilon_{i,M}$	1.11269	1.06721	1.14584	1.01854	1.25520	0.84144	1.00910	1.16851	1.08066	1.02673	0.98838	0.84648
ε_{iH2}	0.01281	-0.01254	-0.00935	-0.02209	-0.04882	0.02080	-0.01601	-0.01902	0.03660	-0.01544	-0.00135	-0.03282
ε_{iH3}	-0.00493	-0.01915	-0.02479	-0.01678	-0.06558	0.01853	-0.00923	-0.00493	0.04176	-0.00781	-0.00745	-0.01376
ε_{iH4}	-0.01117	-0.02042	-0.04056	-0.02329	-0.08749	0.03441	-0.01410	-0.03888	0.05185	-0.04373	-0.00635	-0.01446
ε_{iH5}	-0.00920	-0.01042	-0.01928	-0.00947	-0.03232	0.02057	-0.00697	-0.01707	0.02166	-0.02091	-0.00449	-0.00957
ε_{iH6}	-0.00165	-0.00302	-0.00380	-0.00208	-0.01416	0.00628	-0.00182	0.00140	0.00541	-0.00564	-0.00156	-0.00351
ε_{iH7}	0.00027	-0.00006	-0.00269	-0.00134	-0.00250	0.00264	-0.00053	-0.00063	0.00133	-0.00098	-0.00137	-0.00156
ε_{iA35}	0.00376	-0.00475	0.00437	-0.00165	0.02581	0.00236	-0.00283	0.00670	0.00157	-0.00847	0.00081	-0.01494
ε_{iA45}	0.00758	-0.00883	0.00437	0.00559	0.00225	0.00266	0.00221	0.02908	-0.00475	-0.00736	0.00083	-0.01594
ε_{iA55}	0.00455	0.00334	0.00665	0.00171	0.00214	0.00320	-0.00163	0.04788	-0.00377	0.00546	0.00182	-0.01740
ε_{iA65}	-0.00963	-0.00682	0.00142	-0.00557	0.00809	0.00950	-0.00188	0.08610	0.00567	0.01991	-0.00311	-0.02219
ε_{iR2}	0.04318	-0.00203	-0.00667	-0.00579	0.00588	-0.00448	0.01340	0.00386	-0.01229	-0.00269	-0.01317	-0.01566
ε_{iR3}	0.02691	0.01783	-0.00098	-0.00963	-0.01132	-0.00220	0.00863	-0.06511	0.00156	0.01140	-0.00806	-0.02065
ε_{iR4}	-0.00322	0.02567	-0.00645	0.00259	-0.05633	0.00225	0.01286	0.00053	-0.00213	0.00264	-0.00637	0.00019
ε_{iR5}	-0.00089	0.00245	0.00378	-0.01266	-0.01080	0.00138	0.00200	0.00384	0.00280	0.02077	-0.00824	0.00568
ε_{iQ2}	0.00710	-0.00401	-0.01686	0.00044	0.03441	-0.00413	0.00942	0.02442	-0.00391	-0.01433	-0.00439	-0.00550
ε_{iQ3}	0.01032	0.00211	-0.01448	0.00494	0.03407	-0.00824	0.01521	0.02889	-0.00731	-0.03611	-0.00045	-0.01130
ε_{iQ4}	-0.00718	0.02772	0.04697	0.00914	0.01562	-0.00336	-0.00890	0.00927	0.00099	-0.02789	-0.00663	-0.00748

Table 4.9 Uncompensated Own Price and Cross Price Elasticities, Expenditure Elasticities, Demographic Elasticities, and Budget Shares Evaluated at the Sample Mean: 1990

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
W_i	0.0731	0.0232	0.0453	0.0756	0.0360	0.1608	0.1672	0.0085	0.1902	0.0164	0.0962	0.1074
ε1i	-0.98717	-0.00887	-0.11236	0.04457	0.13372	0.12307	-0.18959	-0.31712	-0.13078	0.04509	-0.05960	0.29984
ε2i	-0.00150	-0.64302	-0.02311	-0.00477	-0.00539	-0.00218	-0.00870	-0.01498	-0.01235	-0.01163	-0.00842	-0.00301
ε3i	-0.00203	-0.02068	-0.77292	-0.01137	-0.00208	0.00312	-0.00852	-0.04066	-0.02024	-0.01085	-0.01670	-0.00455
ε4i	-0.00182	-0.00830	-0.02317	-0.84974	0.00009	0.00701	-0.01723	-0.04732	-0.02533	-0.01257	-0.01651	-0.00015
ε5i	-0.02790	-0.28258	-0.24809	-0.17017	-0.76846	-0.10299	-0.08265	-0.28572	-0.13471	-0.21670	-0.21395	1.16637
ε6i	-0.00217	-0.00715	-0.03782	0.00968	0.02336	-0.83533	-0.03483	-0.08014	-0.07361	0.01379	-0.04805	0.00302
ε7i	-0.00060	0.02150	-0.01321	0.00215	0.05768	-0.00354	-0.87344	-0.08593	-0.08849	0.01392	-0.05472	0.00277
ε8i	-0.00054	-0.00893	-0.01118	-0.00304	-0.00556	0.00525	-0.00217	-0.83936	-0.00287	-0.00796	0.00253	0.00118
ε9i	-0.00247	-0.01989	-0.03285	-0.00826	0.02271	-0.00811	-0.03949	-0.12820	-0.89529	0.01035	-0.07107	-0.00640
ε10,i	-0.00079	-0.01335	-0.01116	-0.03922	-0.00726	0.00398	-0.04916	0.00458	-0.05499	-0.71115	-0.01087	0.17623
ε11,i	-0.00189	-0.01521	-0.02195	-0.00836	0.00799	0.00453	-0.02034	-0.05590	-0.03773	-0.00619	-0.86465	0.00438
ε12,i	-0.00223	-0.00932	-0.02600	-0.00535	0.00555	0.00821	-0.01945	-0.03106	-0.04102	0.00220	-0.02276	-0.85681
εi,M	1.00569	0.99307	1.12350	0.92208	0.80446	0.81908	1.04412	1.40320	1.16004	0.90964	1.06034	0.87762
εiH2	0.00107	-0.00005	-0.01280	-0.01307	0.01168	0.02579	-0.01481	-0.04812	0.00488	-0.01889	-0.01772	0.00179
εiH3	-0.00138	0.00764	-0.02131	-0.01075	-0.00045	0.02884	-0.01050	-0.04989	0.01882	-0.02676	-0.02283	-0.00724
εiH4	-0.00076	0.00425	-0.03128	-0.01609	-0.00987	0.04155	-0.01364	-0.10187	0.02478	-0.02950	-0.03043	-0.01295
εiH5	-0.00089	-0.00249	-0.01397	-0.00305	0.00462	0.01451	-0.00611	-0.03317	0.00945	-0.02075	-0.00948	-0.00157
εiH6	-0.00017	0.00016	-0.00282	-0.00452	0.00413	0.00495	-0.00037	-0.01002	0.00141	-0.00458	-0.00258	-0.00140
εiH7	-0.00008	0.00054	-0.00275	-0.00080	0.00142	0.00241	0.00093	-0.00641	0.00029	-0.00153	-0.00199	-0.00134
εiA35	0.00183	0.00196	-0.00346	-0.00168	0.01909	0.00072	-0.00603	-0.00630	-0.00438	0.00864	0.00828	-0.00880
εiA45	0.00136	0.00029	0.00463	-0.00009	0.00762	-0.00145	0.00541	-0.01388	-0.00376	-0.00348	0.00424	-0.01558
εiA55	0.00032	0.01314	0.01025	0.00714	0.01732	0.00020	0.00181	0.03170	-0.00070	0.02581	-0.00926	-0.02024
εiA65	-0.00020	0.00889	0.00420	0.00008	0.02603	0.01257	0.00098	0.07521	0.00108	0.04186	-0.02581	-0.02258
εiR2	0.00056	-0.00227	0.00832	-0.00993	-0.00979	0.00242	0.01223	0.02348	-0.00882	0.02270	-0.00828	-0.00154
εiR3	-0.00078	0.01731	-0.00286	-0.01871	-0.03169	-0.01271	0.03321	-0.03640	-0.00960	-0.00122	-0.00979	0.02272
εiR4	0.00023	0.02918	0.02424	0.00417	-0.03571	-0.00207	0.00142	-0.01440	-0.02036	0.02763	-0.01288	0.03636
εiR5	0.00007	0.00437	0.01436	-0.01367	-0.03380	0.00304	-0.00164	0.03084	-0.00256	0.01085	-0.00649	0.01774
εiQ2	0.00397	0.01466	-0.00351	0.00127	0.01152	-0.01023	-0.00126	0.03090	-0.01389	0.00621	0.01330	-0.00692
εiQ3	0.00299	-0.00333	0.00323	0.00978	-0.00977	-0.00168	-0.00500	0.05517	-0.00690	0.00241	0.00248	-0.00901
εiQ4	0.00148	0.02130	0.03900	0.02136	-0.01033	-0.00202	-0.02934	0.08214	-0.00206	-0.00378	-0.00027	0.00395

Table 4.10 Homogeneity and Symmetry Restricted ALIDS: Uncompensated Own- and Cross-Price Elasticities, Expenditure Elasticities, Demographic Elasticities, and Mean Budget Shares: 1984

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
Wi	0.11427	0.03915	0.05585	0.07957	0.04136	0.13160	0.17090	0.01171	0.15288	0.02501	0.11139	0.09885
ε1i	-0.88529	-0.03653	-0.03490	-0.01096	-0.03386	-0.00282	-0.00800	-0.03420	-0.02971	-0.01520	0.00304	-0.00743
ε2i	-0.00620	-0.81249	-0.02001	-0.00536	-0.02119	-0.00338	-0.00521	-0.02382	-0.01411	-0.01081	-0.00081	-0.00080
ε3i	-0.00975	-0.03025	-0.84670	-0.01032	-0.02491	-0.00484	-0.00163	-0.02230	-0.02054	-0.01779	0.00484	-0.00192
ε4i	-0.01180	-0.02791	-0.02928	-0.87870	-0.03721	0.00310	0.00289	-0.03779	-0.02273	-0.01693	0.00492	-0.01159
ε5i	-0.00571	-0.02251	-0.01731	-0.01063	-0.86118	-0.00111	0.00103	-0.02071	-0.01068	-0.01286	0.00002	-0.00232
ε6i	-0.02116	-0.05052	-0.04653	-0.00589	-0.04227	-0.85077	-0.01930	-0.02340	-0.04592	-0.01513	0.00277	0.00239
ε7i	-0.02704	-0.06541	-0.04240	-0.01594	-0.03784	-0.01687	-0.85885	-0.03151	-0.06580	-0.02434	-0.00004	-0.00009
ε8i	-0.00195	-0.00746	-0.00465	-0.00339	-0.00616	0.00107	0.00043	-0.88431	-0.00352	0.00217	0.00099	0.00104
ε9i	-0.03210	-0.07213	-0.06859	-0.02800	-0.05602	-0.02593	-0.03774	-0.05869	-0.81711	-0.03121	-0.00760	-0.00926
ε10,i	-0.00469	-0.01230	-0.01254	-0.00537	-0.01309	-0.00083	-0.00272	-0.00005	-0.00772	-0.81903	-0.00043	-0.00039
ε11,i	-0.01989	-0.04313	-0.02776	-0.01011	-0.04042	-0.00534	-0.01305	-0.02823	-0.03396	-0.01871	-0.84561	-0.00290
ε12,i	-0.01719	-0.02876	-0.02705	-0.00398	-0.03199	0.00552	-0.00213	-0.01527	-0.02171	-0.00684	0.00691	-0.91122
εi,M	1.04142	1.20281	1.17223	0.98898	1.19961	0.90528	0.95325	1.17451	1.09144	0.98709	0.83634	0.93234
εiH2	-0.00887	0.01083	-0.01279	-0.00025	-0.01246	0.00149	0.01555	-0.02262	0.01841	0.00565	-0.00769	-0.02883
εiH3	-0.00866	-0.00326	-0.02872	-0.02238	-0.03172	-0.01852	0.00630	-0.01364	0.03151	-0.00152	-0.01380	0.04141
εiH4	-0.00846	-0.00405	-0.02236	-0.01827	-0.05334	0.04221	0.00391	-0.04625	0.02996	-0.03376	-0.00915	-0.02391
εiH5	-0.00732	-0.00184	-0.00487	-0.00734	-0.02454	0.01693	0.00116	-0.00610	0.01354	-0.01840	-0.00358	-0.00793
εiH6	-0.00168	-0.00283	-0.00602	0.00200	-0.00267	0.00517	0.00155	0.00255	0.00155	-0.00042	-0.00244	-0.00344
εiH7	-0.00175	-0.00123	-0.00252	-0.00213	-0.00195	0.00361	0.00085	0.00278	0.00337	-0.00457	-0.00109	-0.00297
εiA35	0.00978	-0.00757	0.00162	-0.00902	0.00556	-0.00240	0.00510	0.00742	-0.00764	-0.00646	0.00670	-0.00491
εiA45	0.01184	-0.00934	0.00160	0.00412	0.00141	-0.00244	0.00281	0.00147	-0.00977	-0.00030	0.00747	-0.00979
εiA55	0.00086	0.00264	0.01190	0.00744	0.00594	-0.00580	0.00229	0.02391	-0.00617	-0.00243	0.00037	-0.00657
εiA65	-0.00519	-0.00186	0.00041	0.00248	0.01644	0.01112	-0.00907	0.06167	-0.00158	0.00930	0.00131	-0.01021
εiR2	0.04346	0.00990	0.00083	-0.00270	-0.00365	-0.01328	0.00799	-0.03036	-0.01352	0.01162	-0.01068	-0.01346
εiR3	0.00966	0.00760	-0.00690	-0.00364	-0.00265	-0.01853	0.00640	-0.02150	0.01198	0.03525	-0.01273	-0.00320
εiR4	0.01451	-0.01498	-0.01462	-0.00674	-0.00579	-0.00534	0.01856	-0.07373	-0.00661	-0.00082	0.00014	-0.00071
εiR5	-0.00230	0.00923	0.01041	-0.01670	-0.00031	0.00591	-0.00200	-0.01266	0.00559	0.02510	-0.00750	-0.00275
εiQ2	0.01369	-0.00289	-0.00315	0.01689	0.02495	-0.00955	-0.00399	-0.00471	-0.00934	-0.02216	0.00619	-0.00369
εiQ3	0.03595	0.02416	-0.00499	0.01567	0.01321	-0.01489	-0.00602	-0.05030	-0.01456	0.00474	0.00759	-0.01750
εiQ4	0.00541	0.02820	0.03625	0.02455	-0.01416	0.00272	-0.03271	-0.00809	-0.00100	-0.01385	0.00412	0.00256

Table 4.11 Homogeneity and Symmetry Restricted ALIDS: Uncompensated Own- and Cross-Price Elasticities, Expenditure Elasticities, Demographic Elasticities, and Mean Budget Shares: 1986

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
W_i	0.09212	0.03287	0.04896	0.07547	0.03507	0.18909	0.15589	0.00890	0.14478	0.02233	0.10268	0.09182
ε_{1i}	-0.89314	-0.02330	-0.03211	-0.02057	-0.03581	0.00620	-0.00851	-0.03430	-0.01173	0.00705	-0.00769	-0.02079
ε_{2i}	-0.00797	-0.79297	-0.01797	-0.00714	-0.02048	-0.00019	-0.00602	-0.02056	-0.01298	-0.01651	-0.00096	-0.00467
ε_{3i}	-0.01463	-0.02484	-0.83803	-0.01409	-0.02228	0.00282	-0.00484	-0.01980	-0.01270	-0.02574	-0.00375	-0.00790
ε_{4i}	-0.02090	-0.02123	-0.02953	-0.87992	-0.04118	0.00256	-0.01011	-0.03426	-0.00726	-0.01868	-0.00174	-0.00551
ε_{5i}	-0.00989	-0.01847	-0.01397	-0.01351	-0.85201	0.00294	-0.00099	-0.01804	-0.00691	-0.01907	-0.00430	-0.00374
ε_{6i}	-0.03829	-0.05405	-0.04955	-0.03445	-0.05533	-0.84101	-0.03671	-0.04321	-0.03890	-0.03298	-0.02562	-0.02928
ε_{7i}	-0.03320	-0.04894	-0.04196	-0.03130	-0.03983	-0.00700	-0.86188	-0.03705	-0.04053	-0.03202	-0.01200	-0.01723
ε_{8i}	-0.00240	-0.00474	-0.00312	-0.00264	-0.02829	0.00050	-0.00164	-0.86770	-0.00304	0.00145	-0.00025	0.01240
ε_{9i}	-0.03697	-0.07720	-0.06330	-0.02468	-0.06251	-0.00926	-0.03873	-0.08301	-0.80780	-0.05949	-0.01933	-0.03145
$\varepsilon_{10,i}$	-0.00623	-0.01209	-0.01349	-0.00497	-0.01517	0.00149	-0.00254	0.05085	-0.00696	-0.82633	-0.00148	-0.00566
$\varepsilon_{11,i}$	-0.02776	-0.02326	-0.03216	-0.01604	-0.04275	-0.00540	-0.01472	-0.03263	-0.01975	-0.02306	-0.85011	-0.00877
$\varepsilon_{12,i}$	-0.02410	-0.02466	-0.03004	-0.01243	-0.03021	-0.00010	-0.00974	-0.02875	-0.01884	-0.01127	-0.00133	-0.87577
$\varepsilon_{i,M}$	1.11547	1.12575	1.16524	1.06172	1.22222	0.84565	0.99489	1.21873	0.98741	1.08678	0.92857	0.99940
ε_{iH2}	0.00567	0.01579	0.00402	-0.03394	-0.03509	0.03420	-0.01688	-0.01750	0.04240	-0.00627	-0.02523	-0.04936
ε_{iH3}	-0.01234	0.00218	-0.01399	-0.02767	-0.05436	0.03043	-0.01003	-0.00384	0.04863	-0.00188	-0.02776	-0.02789
ε_{iH4}	-0.01894	0.00421	-0.02735	-0.03754	-0.07347	0.04918	-0.01549	-0.03816	0.06141	-0.03829	-0.03185	-0.03218
ε_{iH5}	-0.01373	-0.00030	-0.01353	-0.01665	-0.03675	0.02772	-0.00732	-0.01694	0.02757	-0.01898	-0.01700	-0.01404
ε_{iH6}	-0.00275	-0.00048	-0.00235	-0.00388	-0.01256	0.00806	-0.00202	0.00149	0.00665	-0.00530	-0.00457	-0.00522
ε_{iH7}	-0.00006	0.00080	-0.00215	-0.00219	-0.00352	0.00331	-0.00060	-0.00077	0.00214	-0.00105	-0.00268	-0.00179
ε_{iA35}	0.00310	-0.00039	0.00617	-0.00263	0.02823	0.00356	-0.00270	0.00650	0.00145	-0.00616	-0.00202	-0.01681
ε_{iA45}	0.00708	-0.00570	0.00550	0.00511	0.00378	0.00351	0.00206	0.02962	-0.00496	-0.00525	-0.00095	-0.01706
ε_{iA55}	0.00486	0.00743	0.00819	0.00089	0.00386	0.00423	-0.00226	0.04866	-0.00379	0.00729	-0.00063	-0.01879
ε_{iA65}	-0.00870	0.00076	0.00433	-0.00573	0.01119	0.01080	-0.00280	0.08735	0.00428	0.02504	-0.00737	-0.02397
ε_{iR2}	0.04765	-0.00009	-0.00521	-0.00582	0.00742	-0.00531	0.01371	0.00101	-0.01508	-0.00350	-0.01347	-0.01578
ε_{iR3}	0.03134	0.01157	-0.00059	-0.01140	-0.00231	-0.00526	0.01046	-0.07615	0.01035	0.01046	-0.01946	-0.02166
ε_{iR4}	-0.00006	0.01085	-0.01039	0.00476	-0.06190	-0.00092	0.01480	-0.00218	-0.00208	-0.00475	-0.00080	0.00375
ε_{iR5}	0.00215	0.00136	0.00416	-0.01183	-0.01023	0.00006	0.00298	0.00137	0.00147	0.02048	-0.00848	0.00564
ε_{iQ2}	0.00835	-0.00562	-0.01707	0.00065	0.03466	-0.00519	0.00901	0.02345	-0.00369	-0.01591	-0.00281	-0.00510
ε_{iQ3}	0.01319	-0.00073	-0.01555	0.00574	0.03194	-0.00985	0.01452	0.02916	-0.00788	-0.03940	0.00240	-0.00947
ε_{iQ4}	-0.00675	0.02621	0.04705	0.00949	0.01511	-0.00338	-0.00939	0.00978	0.00071	-0.02829	-0.00567	-0.00720

Table 4.12 Homogeneity and Symmetry Restricted ALIDS: Uncompensated Own- and Cross-Price Elasticities, Expenditure Elasticities, Demographic Elasticities, and Mean Budget Shares: 1990

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
W_i	0.07313	0.02325	0.04530	0.07556	0.03603	0.16076	0.16723	0.00848	0.19021	0.01639	0.09624	0.10742
ε1i	-0.84583	-0.06322	-0.05495	-0.01233	-0.03748	0.00435	-0.01064	-0.05186	-0.01093	-0.04518	-0.00593	-0.00114
ε2i	-0.01196	-0.66839	-0.02906	-0.00432	-0.02001	-0.00226	-0.00335	-0.03122	-0.01123	-0.03789	-0.00400	-0.00131
ε3i	-0.02643	-0.06277	-0.78644	-0.01168	-0.03013	0.00076	-0.00506	-0.04853	-0.00985	-0.03890	-0.00405	-0.00258
ε4i	-0.02760	-0.05136	-0.04648	-0.85225	-0.03283	0.00931	-0.01178	-0.04846	-0.01152	-0.04024	-0.00587	-0.00338
ε5i	-0.01904	-0.04255	-0.03050	-0.00944	-0.78148	0.00146	-0.00209	-0.03662	-0.00851	-0.03010	-0.00517	-0.00337
ε6i	-0.04668	-0.12071	-0.08057	-0.00569	-0.04707	-0.83276	-0.03145	-0.06724	-0.03663	-0.05643	-0.00914	-0.00268
ε7i	-0.05260	-0.10178	-0.07487	-0.02098	-0.03385	-0.00111	-0.85553	-0.08017	-0.03852	-0.06490	-0.01865	-0.00658
ε8i	-0.00403	-0.01199	-0.00853	-0.00183	-0.00650	0.00141	-0.00072	-0.83835	-0.00146	-0.00631	0.00005	0.00214
ε9i	-0.06046	-0.18171	-0.10450	-0.02465	-0.07408	-0.00883	-0.04544	-0.10928	-0.82889	-0.10395	-0.01353	-0.01566
ε10,i	-0.00853	-0.03041	-0.01574	-0.00453	-0.01236	0.00105	-0.00269	-0.01493	-0.00729	-0.72365	-0.00273	0.00334
ε11,i	-0.03268	-0.06966	-0.04865	-0.01295	-0.03610	0.00432	-0.01913	-0.04578	-0.01451	-0.04613	-0.84694	0.00159
ε12,i	-0.03491	-0.05894	-0.04813	-0.00838	-0.03160	0.01098	-0.01196	-0.02273	-0.01548	-0.03157	0.00106	-0.89143
εi,M	1.16079	1.46458	1.32889	0.96956	1.14433	0.81096	0.99998	1.39483	0.99238	1.22575	0.91272	0.93330
εiH2	0.00526	-0.00036	-0.01367	-0.01281	-0.00344	0.03091	-0.00170	-0.04532	0.00990	-0.01789	-0.01844	-0.02591
εiH3	-0.02053	0.00520	-0.02413	-0.01261	-0.02534	0.03221	-0.01133	-0.04405	0.02456	-0.02925	-0.02128	-0.00665
εiH4	-0.01657	-0.01162	-0.04015	-0.02070	-0.04427	0.04605	-0.01376	-0.09604	0.03461	-0.04217	-0.02438	-0.01277
εiH5	-0.01161	-0.00751	-0.01653	-0.00389	-0.01188	0.01659	-0.00571	-0.02927	0.01292	-0.02552	-0.00763	-0.00256
εiH6	-0.00327	-0.00233	-0.00426	-0.00502	-0.00413	0.00572	-0.00069	-0.00821	0.00321	-0.00657	-0.00139	-0.00083
εiH7	-0.00148	-0.00087	-0.00356	-0.00111	-0.00228	0.00274	0.00092	-0.00612	0.00100	-0.00264	-0.00158	-0.00075
εiA35	0.01843	0.00652	-0.00092	-0.00126	0.02823	0.00484	-0.00692	-0.00470	-0.00598	0.01362	0.00622	-0.01531
εiA45	0.01393	0.00888	0.00820	0.00016	0.01213	-0.00132	0.00508	-0.01001	-0.00484	0.00193	0.00240	-0.01806
εiA55	0.00422	0.01973	0.01364	0.00792	0.01799	0.00277	0.00089	0.03408	-0.00261	0.02981	-0.01159	-0.02227
εiA65	0.00232	0.02327	0.00938	0.00235	0.02703	0.01279	-0.00388	0.08379	-0.00342	0.05051	-0.02987	-0.01589
εiR2	0.01307	0.04356	0.00894	-0.00969	0.01254	-0.00174	0.02515	0.02020	-0.01638	0.01996	-0.01570	-0.01760
εiR3	-0.00304	0.01328	-0.00577	-0.01760	-0.00613	-0.01374	0.02774	-0.03825	-0.01019	-0.00784	-0.00679	0.02179
εiR4	0.00744	0.00626	0.01065	0.00076	-0.02191	-0.00587	0.02115	-0.01723	-0.02352	0.00642	-0.01056	0.02325
εiR5	0.05150	0.00065	0.01171	-0.01343	-0.01557	0.00035	0.00907	0.02859	-0.00803	0.00647	-0.00858	-0.02144
εiQ2	0.04114	0.01684	-0.00163	0.00191	0.02511	-0.01106	-0.00128	0.02830	-0.01641	0.00680	0.01133	-0.00654
εiQ3	0.03160	-0.00237	0.00474	0.01141	-0.02253	-0.00228	-0.00497	0.05598	-0.00658	0.00305	0.00317	-0.00840
εiQ4	0.01486	0.02162	0.03925	0.02156	-0.06582	-0.00217	-0.02917	0.08320	-0.00259	-0.00337	-0.00116	0.02379

of one explanatory variable (price in this case) on all other prices and deriving an appropriately defined correlation coefficient for that regression. If the explanatory variable is highly correlated with the artificial variable, then that particular explanatroy variable exhibits very little variation and the total sum of squares will be small or close to zero. This lack of variation in a data series has the same effect on parameter estimates as multicollinearity: parameter estimates exhibit considerable instability, including unanticipated wrong signs.

Uncompensated cross-price elasticities allow us to show interdependencies among commodities in the system. A majority of these uncompensated cross-price elasticities presented here have negative signs which indicates the foods are complements. This may seem implausible *prima facia* since it seems logical that beef and pork, for instance, are substitutes and should therefore have opposite signs.[15] However, the fact that the signs of cross-price elasticities are negative is not theoretically incorrect. Theoretically, the sign of the uncompensated cross-price elasticity indicates the grouping of commodities as substitutes or complements. Hence, there are no expected signs except commodities *i* and *j* are considered substitutes (complements) if the estimated uncompensated price elasticity (ϵ_{ij}) is positive (negative). Recall that this definition as provided by Houthakker [1960] and elaborated by Varian [1992] and Henderson and Quandt [1980] is based on the elements of the inverse of the Hessian matrix of the indirect utility function, i.e. the sign of the second partial derivative of the indirect utility function and relate to the nature of interaction among commodities in the utility function. Therefore, we need to examine the cross substitution term of the Slutsky equation and distinguish between gross substitution (complementarity) and net substitution (complementarity) in detail in order to rationalize the occurrence of negative Marshallian cross elasticities. Thus, commodity *i* and *j* are gross (uncompensated) complements depending on whether the total effect in the Slutsky equation

[15] If commodities x_1 and x_2 are substitutes and if compensating variations in a household's income keep that household on the same indifference curve, an increase in the price of x_1 will induce the household to substitute x_2 for x_1. Then $\partial x_2/\partial p_1|_{\bar{u}} > 0$.

is positive or negative. It is also important to distinguish between the notion of gross substitute (which is a Marshallian definition) and net or compensated substitution (which is a Hicksian definition) and refers to an increase in the Hicksian demand for other commodities when the price of one good increases. The term "uncompensated" is used to differentiate these gross substitutes from Hicks-Allen income compensated complements or substitutes. Commodity *i* and *j* are considered gross complements if they have negative uncompensated cross-price elasticities even though they are net substitutes in the sense of having positive compensated cross-price elasticities. In this view, we must interpret the uncompensated cross-price elasticities in Tables 4.7 - 4.12 as gross relationships incorporating both the substitution effect and the income effect since they reflect how Canadian households adjust their food-at-home budgets in response to price changes when money income is not adjusted or compensated to neutralize the change in price.

In view of this, a more appropriate interpretation of substitution or complementarity should be based on compensated price elasticities and elasticities of substitution. Hence, we also provide compensated (Hicksian) price elasticities in Tables 4.13 - 4.18 and these, by definition incorporate only the substitution effect caused by a change in price. These compensated price elasticities have all been derived from the uncompensated price and expenditure elasticities, and the sample mean budget shares. The compensated own price elasticities are significant and they have the correct sign ($\epsilon^c_{ii} < 0$), implying that the negativity condition is at least not violated.[16] As expected, the compensated own-price elasticities are smaller than the uncompensated.

The compensated cross price elasticities reported in Tables 4.13 - 4.18 are all positive, (i.e. $\epsilon^c_{ij} \succ 0$), so we can conclude that the commodities are really net substitutes and the negative sign of the uncompensated cross-price elasticity results from the substitution effect being outweighed by the income effect. In short, the preponderance of positive cross price elasticities suggests that

[16] This result is in keeping with the theory. In particular, we know that the compensated own price effect is nonpositive since the substitution matrix - the Slutsky matrix - is negative semi definite and thus has no nonpositive diagonal elements. In other words, $[\partial x^c_i(p,u)/\partial p_i] = [\partial^2 e(p,u)/\partial p^T \partial p] \leq 0 \ \forall \ i$.

Table 4.13 Unrestricted ALIDS: Compensated (Hicksian) Price Elasticities: 1984

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
W_i	0.11427	0.03915	0.05585	0.07957	0.04136	0.13160	0.17090	0.01171	0.15288	0.02501	0.11139	0.09885
ε^c_{1i}	-0.75478	0.13131	0.10340	0.10120	0.10528	0.09681	0.09847	0.10462	0.08529	0.09868	0.09658	0.09696
ε^c_{2i}	0.00590	-0.76716	0.02812	0.03538	0.02759	0.03687	0.03347	0.02805	0.03784	0.03275	0.03448	0.03805
ε^c_{3i}	0.04551	0.04009	-0.77876	0.04517	0.04352	0.04529	0.05012	0.04475	0.04408	0.04226	0.04992	0.04798
ε^c_{4i}	0.07096	0.06866	0.06435	-0.79978	0.06361	0.07273	0.06921	0.06249	0.06191	0.06478	0.07517	0.07705
ε^c_{5i}	0.03515	0.02723	0.03124	0.02892	-0.81115	0.03733	0.04118	0.03026	0.03672	0.02976	0.03238	0.03537
ε^c_{6i}	0.11730	0.12728	0.12714	0.13286	0.11250	-0.73542	0.11229	0.10343	0.08679	0.10721	0.10287	0.12687
ε_{7i}	0.16295	0.17302	0.18567	0.16210	0.17332	0.12911	-0.69627	0.17944	0.10027	0.16690	0.13050	0.15773
ε^c_{8i}	0.00321	0.00740	0.00989	0.00555	0.00446	0.01680	0.01209	-0.86876	0.00936	0.00612	0.01539	0.01159
ε^c_{9i}	0.13515	0.15796	0.12459	0.13780	0.11178	0.10729	0.12889	0.16739	-0.68490	0.14768	0.09273	0.13535
$\varepsilon^c_{10,i}$	0.01874	0.01684	0.01380	0.01873	0.01374	0.02728	0.01976	0.04550	0.02368	-0.79266	0.01639	0.02086
$\varepsilon^c_{11,i}$	0.09632	0.08840	0.10405	0.09568	0.10051	0.09467	0.09618	0.09175	0.08588	0.09660	-0.75341	0.10099
$\varepsilon^c_{12,i}$	0.08780	0.08820	0.09421	0.09043	0.08995	0.09345	0.09189	0.10227	0.08511	0.09485	0.08897	-0.81883

Table 4.14 Unrestricted ALIDS: Compensated (Hicksian) Price Elasticities: 1986

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
Wi	0.0949	0.0339	0.0504	0.0780	0.0362	0.1934	0.1612	0.0092	0.1492	0.0231	0.1059	0.0971
$\varepsilon^{c}1i$	-0.78295	0.10034	0.07856	0.07652	0.07940	0.08226	0.08002	0.07965	0.07405	0.07743	0.07692	0.07987
$\varepsilon^{c}2i$	0.00713	-0.75710	0.01988	0.02730	0.01944	0.03075	0.02843	0.02545	0.02932	0.02346	0.02904	0.02489
$\varepsilon^{c}3i$	0.03851	0.03225	-0.77986	0.03637	0.04083	0.04536	0.04257	0.04043	0.03854	0.02953	0.04058	0.03720
$\varepsilon^{c}4i$	0.06662	0.06564	0.06139	-0.80016	0.04887	0.06979	0.06180	0.06187	0.06147	0.06369	0.07120	0.06922
$\varepsilon^{c}5i$	0.02737	0.02369	0.02531	0.02492	-0.80857	0.03109	0.03340	0.02665	0.03042	0.02222	0.02684	0.03224
$\varepsilon^{c}6i$	0.17316	0.15307	0.16934	0.15662	0.18553	-0.68084	0.15404	0.17674	0.16648	0.16339	0.13660	0.15005
$\varepsilon^{c}7i$	0.15959	0.15699	0.16384	0.14158	0.17046	0.12540	-0.70900	0.14252	0.08717	0.15097	0.12131	0.13670
$\varepsilon^{c}8i$	0.00326	0.00282	0.00670	0.00395	0.00428	0.01171	0.01041	-0.85640	0.00595	0.00735	0.01476	0.00083
$\varepsilon^{c}9i$	0.12797	0.13027	0.10726	0.14020	0.11813	0.11272	0.13148	0.09019	-0.69737	0.14730	0.09389	0.10215
$\varepsilon^{c}10,i$	0.01657	0.01564	0.01324	0.01921	0.00648	0.02438	0.01680	0.03918	0.01563	-0.79896	0.01562	0.02214
$\varepsilon^{c}11,i$	0.08804	0.09681	0.09008	0.08725	0.08877	0.09011	0.08685	0.08729	0.07260	0.09391	-0.75942	0.09383
$\varepsilon^{c}12,i$	0.07770	0.09088	0.08590	0.08422	0.08030	0.08397	0.07984	0.08504	0.06661	0.08991	0.07712	-0.78603

Table 4.15 Unrestricted ALIDS: Compensated (Hicksian) Price Elasticities: 1990

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
Wi	0.0731	0.0232	0.0453	0.0756	0.0360	0.1608	0.1672	0.0085	0.1902	0.0164	0.0962	0.1074
$\varepsilon^{c}1i$	-0.75689	0.05919	0.05108	0.06071	0.06386	0.06390	-0.08420	0.05085	0.05938	0.05214	0.05764	0.28347
$\varepsilon^{c}2i$	0.00961	-0.61993	0.00301	0.01667	0.01331	0.01686	0.01557	0.01764	0.01462	0.00952	0.01623	0.01740
$\varepsilon^{c}3i$	0.02762	0.02431	-0.72202	0.03040	0.03437	0.04023	0.03879	0.02291	0.03231	0.03036	0.03134	0.03521
$\varepsilon^{c}4i$	0.06168	0.06674	0.06172	-0.78007	0.06088	0.06890	0.06166	0.05871	0.06232	0.05616	0.06361	0.06617
$\varepsilon^{c}5i$	-0.24090	-0.24680	-0.20762	-0.13695	-0.73948	-0.07348	-0.04503	-0.23517	-0.09292	-0.18392	-0.17575	1.19799
$\varepsilon^{c}6i$	0.14823	0.15250	0.14279	0.15791	0.15268	-0.70366	0.13302	0.14544	0.11288	0.16002	0.12241	0.14410
$\varepsilon^{c}7i$	0.17076	0.18758	0.17467	0.15635	0.19221	0.13344	-0.69883	0.14873	0.10551	0.16603	0.12260	0.14954
$\varepsilon^{c}8i$	0.00356	-0.00051	-0.00165	0.00478	0.00127	0.01220	0.00669	-0.82745	0.00698	-0.00024	0.01153	0.00862
$\varepsilon^{c}9i$	0.17631	0.16900	0.18085	0.16713	0.17572	0.14768	0.15911	0.13870	-0.67464	0.18337	0.13062	0.16053
$\varepsilon^{c}10,i$	0.00944	0.00293	0.00725	-0.02411	0.00593	0.01740	-0.03205	0.02758	-0.03597	-0.69624	0.00651	0.19061
$\varepsilon^{c}11,i$	0.08284	0.08037	0.08618	0.08039	0.08542	0.08336	0.08015	0.07915	0.07392	0.08136	-0.76260	0.08884
$\varepsilon^{c}12,i$	0.09127	0.09736	0.09469	0.09370	0.09196	0.09619	0.09271	0.11968	0.08359	0.09992	0.09114	-0.76253

Table 4.16 Homogeneity and Symmetry Restricted ALIDS: Compensated (Hicksian) Price Elasticities: 1984

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
Wi	0.11427	0.03915	0.05585	0.07957	0.04136	0.13160	0.17090	0.01171	0.15288	0.02501	0.11139	0.09885
ε^c1i	-0.76628	0.10091	0.09905	0.10205	0.10322	0.10063	0.10093	0.10001	0.09501	0.09760	0.09860	0.09911
ε^c2i	0.03457	-0.76540	0.02588	0.03336	0.02578	0.03206	0.03210	0.02216	0.02862	0.02783	0.03193	0.03570
ε^c3i	0.04841	0.03692	-0.78123	0.04492	0.04209	0.04572	0.05161	0.04330	0.04041	0.03734	0.05155	0.05015
ε^c4i	0.07106	0.06779	0.06399	-0.80001	0.05825	0.07513	0.07874	0.05566	0.06412	0.06162	0.07147	0.06259
ε^c5i	0.03736	0.02723	0.03117	0.03028	-0.81157	0.03633	0.04046	0.02787	0.03446	0.02797	0.03461	0.03624
ε^c6i	0.11589	0.10777	0.10773	0.12426	0.11559	-0.73164	0.10615	0.13116	0.09772	0.11477	0.11283	0.12509
ε^c7i	0.15094	0.14015	0.15794	0.15308	0.16718	0.13785	-0.69593	0.16921	0.12072	0.14435	0.14289	0.15924
ε^c8i	0.01025	0.00663	0.00908	0.00819	0.00789	0.01167	0.01160	-0.87055	0.00926	0.01373	0.01079	0.01196
ε^c9i	0.12712	0.11176	0.11062	0.12320	0.12737	0.11247	0.10799	0.12086	-0.65025	0.11969	0.12026	0.13327
ε^c10,i	0.02136	0.01778	0.01677	0.01937	0.01691	0.02181	0.02112	0.02933	0.01958	-0.79434	0.02049	0.02293
ε^c11,i	0.09611	0.09085	0.10281	0.10005	0.09321	0.09550	0.09313	0.10260	0.08762	0.09124	-0.75245	0.10095
ε^c12,i	0.08576	0.09014	0.08882	0.09379	0.08659	0.09501	0.09210	0.10083	0.08618	0.09073	0.08959	-0.81906

Table 4.17 Homogeneity and Symmetry Restricted ALIDS: Compensated (Hicksian) Price Elasticities: 1986

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
W_i	0.09212	0.03287	0.04896	0.07547	0.03507	0.18909	0.15589	0.00890	0.14478	0.02233	0.10268	0.09182
ε^{c}_{1i}	-0.79038	0.08041	0.07523	0.07724	0.07678	0.08410	0.08314	0.07796	0.07923	0.10716	0.07785	0.07128
ε^{c}_{2i}	0.02869	-0.75597	0.02032	0.02775	0.01969	0.02760	0.02668	0.01950	0.01947	0.01921	0.02955	0.02817
ε^{c}_{3i}	0.03998	0.03028	-0.78098	0.03789	0.03755	0.04422	0.04387	0.03987	0.03564	0.02747	0.04171	0.04103
ε^{c}_{4i}	0.06328	0.06372	0.05841	-0.79979	0.05106	0.06638	0.06497	0.05772	0.06726	0.06333	0.06834	0.06991
ε^{c}_{5i}	0.02923	0.02102	0.02690	0.02373	-0.80914	0.03260	0.03391	0.02470	0.02773	0.01904	0.02827	0.03131
ε^{c}_{6i}	0.17264	0.15882	0.17079	0.16632	0.17578	-0.68110	0.15142	0.18724	0.14781	0.17253	0.14997	0.15971
ε^{c}_{7i}	0.14070	0.12656	0.13970	0.13422	0.15070	0.12483	-0.70679	0.15294	0.11340	0.13740	0.13275	0.13857
ε^{c}_{8i}	0.00753	0.00528	0.00725	0.00681	-0.01741	0.00803	0.00721	-0.85685	0.00574	0.01112	0.00802	0.02130
ε^{c}_{9i}	0.12453	0.08579	0.10540	0.12904	0.11445	0.11318	0.10532	0.09344	-0.66484	0.09786	0.11511	0.11325
$\varepsilon^{c}_{10,i}$	0.01869	0.01305	0.01253	0.01874	0.01213	0.02038	0.01968	0.07806	0.01509	-0.80205	0.01926	0.01666
$\varepsilon^{c}_{11,i}$	0.08678	0.09234	0.08749	0.09298	0.08275	0.08144	0.08744	0.09252	0.08164	0.08853	-0.75476	0.09386
$\varepsilon^{c}_{12,i}$	0.07833	0.07871	0.07695	0.08506	0.08201	0.07755	0.08161	0.08316	0.07183	0.08852	0.08393	-0.78400

Table 4.18 Homogeneity and Symmetry Restricted ALIDS: Compensated (Hicksian) Price Elasticities: 1990

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
W_i	0.07313	0.02325	0.04530	0.07556	0.03603	0.16076	0.16723	0.00848	0.19021	0.01639	0.09624	0.10742
ε^{c}_{1i}	-0.76094	0.04388	0.04222	0.05857	0.04620	0.06365	0.06248	0.05014	0.06164	0.04445	0.06081	0.06711
ε^{c}_{2i}	0.01503	-0.63434	0.00184	0.01822	0.00659	0.01659	0.01990	0.00121	0.01184	-0.00940	0.01722	0.02039
ε^{c}_{3i}	0.02616	0.00358	-0.72624	0.03224	0.02171	0.03750	0.04024	0.01466	0.03511	0.01663	0.03730	0.03970
ε^{c}_{4i}	0.06011	0.05930	0.05393	-0.77899	0.05363	0.07058	0.06378	0.05694	0.06347	0.05238	0.06309	0.06715
ε^{c}_{5i}	0.02278	0.01022	0.01738	0.02549	-0.74026	0.03068	0.03393	0.01363	0.02725	0.01406	0.02772	0.03026
ε^{c}_{6i}	0.13993	0.11473	0.13306	0.15017	0.13689	-0.70239	0.12930	0.15699	0.12290	0.14062	0.13759	0.14735
ε^{c}_{7i}	0.14152	0.14314	0.14736	0.14116	0.15752	0.13451	-0.68830	0.15309	0.12743	0.14008	0.13398	0.14950
ε^{c}_{8i}	0.00582	0.00044	0.00275	0.00639	0.00321	0.00829	0.00777	-0.82651	0.00696	0.00409	0.00780	0.01006
ε^{c}_{9i}	0.16033	0.09686	0.14827	0.15977	0.14358	0.14542	0.14476	0.15603	-0.64014	0.12919	0.16008	0.16186
$\varepsilon^{c}_{10,i}$	0.01050	-0.00641	0.00604	0.01136	0.00640	0.01434	0.01370	0.00793	0.00898	-0.70356	0.01223	0.01864
$\varepsilon^{c}_{11,i}$	0.07904	0.07129	0.07925	0.08036	0.07404	0.08237	0.07711	0.08846	0.08100	0.07184	-0.75909	0.09141
$\varepsilon^{c}_{12,i}$	0.08978	0.09839	0.09462	0.09578	0.09132	0.09809	0.09546	0.12711	0.09112	0.10010	0.09911	-0.79117

for food at home commodity groups across Canada, the degree of substitutability is stronger than the degree of complementarity. Notice too that these compensated cross price elasticities are quite small in absolute size. In general, these cross-price elasticity estimates suggest that all commodities do not exhibit a significant interdependent relationship. The cross-price effects are weak - based on the fact that both compensated and uncompensated cross-price elasticities are less than unity.

Demographic elasticities have already been presented in Table 4.7 - 4.12. These are based on the expression $\epsilon_{ij}D_j[w_i]^{-1}$. Again, the results are plausible: except for cereal, vegetable, and dairy, household size has a negative effect on budget shares. This result is rather interesting, especially as it relates to dairy products which has fluid milk accounting for a substantial proportion in this sub-group. The seemingly positive impact of larger households on dairy may have to do with economies of size in purchasing and in household production and consumption. Since we are using unit prices, there is a possibility that such prices may vary systematically as households consume different amounts such that on average, a larger household might end up paying lower prices due to economies and lower search costs. In the case of dairy products like fluid milk, the price per unit volume is expected to decline with increased volume. This may not be the case for beef, chicken, or fish whose price per kilogram may not necessarily decrease with increased volume.

The argument of economies of size ought not to be taken at face value since it raises the important question regarding the extent to which changes in budget shares can be explained by associated changes in household composition. Observe in particular that as the number of household members increases, the number of children also often increases (and adults become older), so that *a priori*, this life cycle factor is likely more important than possible economies of size in purchasing. Let us examine the household size elasticities (delineated by E_iH_i) in more detail. In general, these household size elasticities suggest that the addition of one member of the household has a diminishing effect on all food commodities except cereals and dairy for which the elasticity is positive. Observe in particular what happens to the absolute size of the elasticity as household size changes. In almost all cases, the absolute value increases sharply whenever household size is 2 and then tapers off as household size reaches 4 or 5, a trend that is not entirely unusual and reflects the fact that the second member of the household is often an adult. Furthermore, this trend may demonstrate the existence of children in the household since additions to a household are usually children. In fact, it is conceivable that as children become older, they acquire preferences close to those of adults in the home, so that we can expect to see such a household's budget to shift toward that of a bigger family. This point also highlights our earlier observation regarding the significance of the life-cycle argument relative to possible economies of size in purchasing. A combination of negative and positive household size effects that as household size increases, households are induced to reallocate their budgets among foods depending on the expenditure sensitivity of those commodities. Theoretically, changes in household size will have a negative effect for expenditure elastic foods while this effect is generally positive for foods that are expenditure inelastic.

Next, we look at elasticities associated with age of household head and which represent the effect of stage of family cycle in budget share allocation. The most significant observation here is that the sharpest changes in the absolute value of these demographic elasticities occur when the household enters the child bearing years. For the age of household head between 25 and 45, there is a strong positive effect on beef consumption for all years under study. For the age category over 65, this effect is negative. A strong positive effect is also observed for fish consumption for all age categories. The effect on pork consumption is mixed. It is mostly negative for the years 1984-1986 and strongly positive for 1990. The effect on chicken, cereal, sugar and non alcoholic beverages is predominantly positive except for 1984 in which this effect is negative for the age category A45 and A65. For dairy and 'other', the effect is negative. It is worth noting that in almost all cases, the age category A65 suggests a vastly distinct effect on consumption as the household head ages.

Although it is not possible to provide precise interpretations of each variable, the general pattern exhibited by these demographic variables suggests that their impact on household food-at-home budget shares and expenditure patterns is generally consistent with our expectations.

We have also calculated the Allen-Uzawa partial elasticities of substitution (AES) in order to determine whether or not pairwise substitutability between pairs of commodities prevails. These are presented in Tables 4.19 - 4.24. The AES is a generalization of Hicks' two-variable elasticity of substitution and is computed from the compensated price elasticities and the sample mean budget shares using standard duality theory. The AES between commodities i and j are given by:

$$\sigma_{ij} = \gamma_{ij}/w_i w_j + 1 - \delta_{ij}/w_j \qquad 4.28$$

where δ_{ij} is Kronecker product. *A priori,* σ_{ii} is expected to be negative, implying that the postulates of neoclassical consumer theory are satisfied. Notice that the ALIDS does not impose any restrictions on σ_{ij} except that $\sigma_{ij} = \sigma_{ji}$. Thus, although the AES contain the same information as Hicksian price elasticities, the AES are symmetric as is clear from the Tables. Normalization with respect to budget shares accounts for this symmetry (see AES formula above). However, since the budget share is positive, both the AES and the Hicksian elasticities will have the same sign. Although the AES is typically used to analyze the degree of pairwise substitutability, this concept has been criticized by Blackorby and Russell [1989], and Chambers [1990], *inter alia.* They point out that while the AES is a generalization of the two-variable elasticity of substitution by Allen and Hicks [1934], it fails to preserve the salient properties of the Hicksian notion. First, the AES is not a measure of 'ease' of substitution or curvature of the indifference curve. Second, it fails to provide information regarding budget shares. Third, it is not a sufficient statistic for assessing the effects of price changes on

Table 4.19 Unrestricted ALIDS: Allen-Uzawa Elasticities of Substitution, 1984

Equation	1	2	3	4	5	6	7	8	9	10	11	12
Wi	0.11427	0.03915	0.05585	0.07957	0.04136	0.13160	0.17090	0.01171	0.15288	0.02501	0.11139	0.09885
$\sigma 1i$	-6.605	1.002	0.999	0.999	0.999	0.998	0.998	0.999	0.997	0.998	0.998	0.998
$\sigma 2i$	0.999	-19.595	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
$\sigma 3i$	0.999	0.999	-13.944	0.999	0.999	0.999	1.000	0.999	0.999	0.999	1.000	1.000
$\sigma 4i$	0.999	0.999	0.999	-10.051	0.999	0.999	0.999	0.999	0.999	0.999	1.000	1.000
$\sigma 5i$	1.000	0.999	1.000	0.999	-19.612	1.000	1.000	1.000	1.000	1.000	1.000	1.000
$\sigma 6i$	0.998	0.999	0.999	1.000	0.997	-5.588	0.997	-0.873	-7.789	-1.317	-3.134	1.000
$\sigma 7i$	0.999	1.000	1.003	0.998	1.000	0.993	-4.074	1.001	0.988	0.999	0.993	0.998
$\sigma 8i$	1.000	1.000	1.000	1.000	1.000	1.000	1.000	-74.171	1.000	1.000	1.000	1.000
$\sigma 9i$	0.997	1.001	0.996	0.998	0.994	0.993	0.996	1.002	-4.480	0.999	0.991	0.997
$\sigma 10,i$	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.001	1.000	-31.694	1.000	1.000
$\sigma 11,i$	0.998	0.997	0.999	0.998	0.999	0.998	0.998	0.998	0.997	0.998	-6.764	0.999
$\sigma 12,i$	0.999	0.999	1.000	0.999	0.999	0.999	0.999	1.000	0.999	1.000	0.999	-8.284

Table 4.20 Allen-Uzawa Elasticities of Substitution: Unrestricted Model: 1986

Equation	1	2	3	4	5	6	7	8	9	10	11	12
W_i	0.0949	0.0339	0.0504	0.0780	0.0362	0.1934	0.1612	0.0092	0.1492	0.0231	0.1059	0.0971
$\sigma 1i$	-8.499	1.001	0.999	0.999	0.999	0.999	0.999	0.999	0.998	0.999	0.999	0.999
$\sigma 2i$	0.999	-23.036	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
$\sigma 3i$	0.999	0.999	-15.929	0.999	1.000	1.000	1.000	1.000	0.999	0.999	1.000	0.999
$\sigma 4i$	0.999	0.999	0.999	-10.603	0.998	1.000	0.999	0.999	0.999	0.999	1.000	0.999
$\sigma 5i$	1.000	1.000	1.000	1.000	-23.053	1.000	1.000	1.000	1.000	1.000	1.000	1.000
$\sigma 6i$	0.997	0.993	0.996	0.994	0.999	-3.601	0.993	0.998	0.995	0.995	0.990	0.996
$\sigma 7i$	1.001	1.000	1.001	0.998	1.002	0.995	-4.548	0.998	0.989	0.999	0.995	0.997
$\sigma 8i$	1.000	1.000	1.000	1.000	1.000	1.000	1.000	-96.211	1.000	1.000	1.000	1.000
$\sigma 9i$	0.998	0.998	0.995	0.999	0.996	0.995	0.998	0.992	-4.817	1.000	0.993	0.994
$\sigma 10,i$	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	-35.775	1.000	1.000
$\sigma 11,i$	0.998	0.999	0.999	0.998	0.999	0.999	0.998	0.998	0.997	0.999	-7.396	0.999
$\sigma 12,i$	0.999	1.000	0.999	0.999	0.999	0.999	0.999	0.999	0.998	1.000	0.999	-8.560

Table 4.21 Allen-Uzawa Elasticities of Substitution: Unrestricted ALIDS: 1990

Equation	1	2	3	4	5	6	7	8	9	10	11	12
W_i	0.0731	0.0232	0.0453	0.0756	0.0360	0.1608	0.1672	0.0085	0.1902	0.0164	0.0962	0.1074
$\sigma 1i$	-0.344	0.990	0.984	0.991	0.993	0.993	0.885	0.984	0.990	0.985	0.989	0.997
$\sigma 2i$	1.000	-26.667	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
$\sigma 3i$	1.000	0.999	-15.937	0.999	1.000	1.000	1.000	0.999	0.999	0.999	0.999	1.000
$\sigma 4i$	1.000	0.999	0.999	-10.324	0.999	0.999	0.999	0.999	0.999	0.998	0.999	0.999
$\sigma 5i$	0.999	0.990	0.991	0.994	-20.525	0.996	0.997	0.999	1.000	1.000	1.000	1.000
$\sigma 6i$	1.000	0.999	0.997	1.000	0.999	-4.377	0.996	0.998	0.992	1.000	0.994	0.997
$\sigma 7i$	1.000	1.003	1.001	0.998	1.004	0.994	-4.179	0.997	0.990	1.000	0.993	0.997
$\sigma 8i$	1.000	1.000	1.000	1.000	1.000	1.000	1.000	-97.524	1.000	1.000	1.000	1.000
$\sigma 9i$	1.000	0.996	0.998	0.996	0.997	0.992	0.994	0.990	-3.547	0.999	0.989	0.994
$\sigma 10,i$	1.000	1.000	1.000	0.999	1.000	1.000	0.999	1.000	0.999	-42.480	1.000	1.003
$\sigma 11,i$	1.000	0.998	0.999	0.998	0.999	0.999	0.998	0.998	0.998	0.999	-7.924	0.999
$\sigma 12,i$	1.000	0.999	0.999	0.999	0.998	0.999	0.998	1.001	0.997	0.999	0.998	-7.098

Table 4.22 Allen-Uzawa Elasticities of Substitution: Homogeneity and Symmetry Restricted ALIDS: 1984

Equation	1	2	3	4	5	6	7	8	9	10	11	12
Wi	0.11427	0.03915	0.05585	0.07957	0.04136	0.13160	0.17090	0.01171	0.15288	0.02501	0.11139	0.09885
σ1i	-6.706	0.998	0.998	0.999	0.999	0.998	0.998	0.998	0.998	0.998	0.998	0.998
σ2i	1.000	-19.550	0.999	1.000	0.999	1.000	1.000	0.999	1.000	1.000	1.000	1.000
σ3i	1.000	0.999	-13.988	0.999	0.999	0.999	1.000	0.999	0.999	0.999	1.000	1.000
σ4i	0.999	0.999	0.999	-10.054	0.998	1.000	1.000	0.998	0.999	0.999	0.999	1.000
σ5i	1.000	0.999	1.000	1.000	-19.622	1.000	1.000	0.999	1.000	0.998	1.000	1.000
σ6i	0.998	0.997	0.997	0.999	0.998	-5.560	0.997	0.965	0.995	0.998	0.998	0.999
σ7i	0.997	0.995	0.998	0.997	0.999	0.994	-4.072	1.000	0.991	0.995	0.995	0.998
σ8i	1.000	1.000	1.000	1.000	1.000	1.000	1.000	-74.324	1.000	1.000	1.000	1.000
σ9i	0.996	0.994	0.994	0.995	0.996	0.994	0.993	0.995	-4.253	0.995	0.995	0.997
σ10,i	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	-31.761	1.000	1.000
σ11,i	0.998	0.998	0.999	0.999	0.998	0.998	0.998	0.999	0.997	0.998	-6.755	0.999
σ12,i	0.999	0.999	0.999	0.999	0.999	1.000	0.999	1.000	0.999	0.999	0.999	-8.286

Table 4.23 Allen-Uzawa Elasticities of Substitution: Homogeneity and Symmetry Restricted ALIDS: 1986.

Equation	1	2	3	4	5	6	7	8	9	10	11	12
Wi	0.09212	0.03287	0.04896	0.07547	0.03507	0.18909	0.15589	0.00890	0.14478	0.02233	0.10268	0.09182
σ1i	-8.580	0.999	0.998	0.999	0.999	0.999	0.999	0.999	0.999	1.001	0.999	0.998
σ2i	1.000	-23.002	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
σ3i	1.000	0.999	-15.952	0.999	0.999	1.000	1.000	1.000	0.999	0.999	1.000	1.000
σ4i	0.999	0.999	0.999	-10.598	0.998	0.999	0.999	0.999	0.999	0.999	0.999	1.000
σ5i	1.000	1.000	1.000	1.000	-23.070	1.000	1.000	1.000	1.000	0.999	1.000	1.000
σ6i	0.997	0.994	0.997	0.996	0.997	-3.602	0.993	0.755	0.994	0.997	0.993	0.996
σ7i	0.998	0.995	0.997	0.997	0.999	0.995	-4.534	1.000	0.993	0.997	0.996	0.997
σ8i	1.000	1.000	1.000	1.000	1.000	1.000	1.000	-96.261	1.000	1.000	1.000	1.000
σ9i	0.997	0.991	0.994	0.998	0.996	0.995	0.994	0.993	-4.592	0.993	0.996	0.995
σ10,i	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	-35.913	1.000	1.000
σ11,i	0.998	0.999	0.998	0.999	0.998	0.998	0.998	0.999	0.998	0.999	-7.350	0.999
σ12,i	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.998	1.000	0.999	-8.538

Table 4.24 Allen-Uzawa Elasticities of Substitution: Homogeneity and Symmetry Restricted ALIDS, 1990

Equation	1	2	3	4	5	6	7	8	9	10	11	12
Wi	0.07313	0.02325	0.04530	0.07556	0.03603	0.16076	0.16723	0.00848	0.19021	0.01639	0.09624	0.10742
σ1i	-10.406	0.998	0.998	0.999	0.998	0.999	0.999	0.998	0.999	0.998	0.999	1.000
σ2i	1.000	-27.287	1.000	1.000	1.000	1.000	1.000	0.999	1.000	0.999	1.000	1.000
σ3i	0.999	0.998	-16.030	0.999	0.999	1.000	1.000	0.999	1.000	0.999	1.000	1.000
σ4i	0.999	0.999	0.998	-10.309	0.998	1.000	0.999	0.999	0.999	0.998	0.999	0.999
σ5i	1.000	0.999	0.999	1.000	-20.547	1.000	1.000	0.999	1.000	0.999	1.000	1.000
σ6i	0.997	0.993	0.996	0.998	0.996	-4.369	0.995	0.650	0.994	0.997	0.998	0.998
σ7i	0.996	0.996	0.997	0.996	0.998	0.995	-4.116	0.998	0.993	0.995	0.994	0.997
σ8i	1.000	1.000	1.000	1.000	1.000	1.000	1.000	-97.413	1.000	1.000	1.000	1.000
σ9i	0.994	0.982	0.992	0.994	0.991	0.991	0.991	0.993	-3.365	0.988	0.994	0.995
σ10,i	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	-42.926	1.000	1.000
σ11,i	0.998	0.998	0.998	0.998	0.998	0.999	0.998	0.999	0.999	0.998	-7.887	1.000
σ12,i	0.998	0.999	0.999	0.999	0.998	0.999	0.999	1.002	0.998	0.999	0.999	-7.365

expenditure shares. In a terse attack on the concept, Blackorby and Russell conclude that the AES is completely uninformative. For this reason, we have also calculated the Morishima elasticity of substitution (MES) [Morishima 1967; Blackorby and Russell 1989] which as proved by the authors preserves the salient features of the original Hicksian concept in that the MES concentrates on price and quantity ratios and hence reflects the curvature of indifference curves. Thus, the MES, μ_{ij} can be derived as:

$$\mu_{ij}(p,m) = \varepsilon_{ij}(p,m) - \varepsilon_{ii} \qquad 4.29$$

The results of are presented in Tables 4.25 - 4.30. Once again, like the conditional elasticities, all off-diagonal elements are positive, suggesting again that the degree of substitutability is stronger than the degree of complementarity among food commodity groups in Canada. In general, these results are quite plausible and their ranking and magnitudes fall within ranges found by other researchers such as Moschini and Moro [1993], as will be shown later in Section 4.7.4 when we compare results from other studies.

Next, we examine expenditure elasticities (reported in Tables 4.7 - 4.15 above). First, note that all expenditure elasticities are large, positive, and significant with most of them falling in the range 0.8 to 1.3, which means all food commodities are normal (i.e. $\epsilon_{iM} > 0$). Relatively speaking, the entire meat category (other than 'OTHER MEAT') tends to be more expenditure elastic. For instance, for the three years, the expenditure elasticity for fish is around 1.2 which indicates that if group expenditure for fish increased by 1 percent, the quantity of fish demanded by households would increase by 1.2 percent. Some of the expenditure elasticities are close to one (simple inspection). Clearly, if one had estimated a system in which all the expenditure elasticities for all commodity groups in the system were unity, we would conclude that the utility function was likely homothetic, implying that doubling quantities would double utility - a situation that corresponds to $\beta_i = 0 \ \forall \ i$. In other words, the commodities have an insignificant real expenditure effect. Our initial test of $\beta_i = 0$ indicated that there is no *a priori* reason to believe

Table 4.25 Morishima Elasticities of Substitution : Unrestricted ALIDS, 1984

Equation	1	2	3	4	5	6	7	8	9	10	11	12
W_i	0.11427	0.03915	0.05585	0.07957	0.04136	0.13160	0.17090	0.01171	0.15288	0.02501	0.11139	0.09885
μ_{1i}	-	0.77305	0.82427	0.87074	0.84630	0.85272	0.85923	0.87197	0.82005	0.81141	0.84973	0.90663
μ_{2i}	0.88608	-	0.81885	0.86844	0.83839	0.86270	0.86929	0.87616	0.84286	0.80950	0.84181	0.90703
μ_{3i}	0.85818	0.79528	-	0.86413	0.84240	0.86256	0.88195	0.87865	0.80949	0.80646	0.85746	0.91305
μ_{4i}	0.85598	0.80254	0.82393	-	084007	0.86828	0.85838	0.87432	0.82270	0.81139	0.84909	0.90926
μ_{5i}	0.86005	0.79475	0.82228	0.86339	-	0.84792	0.86959	0.87322	0.79668	0.80641	0.85392	0.90879
μ_{6i}	0.85158	0.80403	0.82405	0.87251	0.84849	-	0.82538	0.88557	0.79219	0.81994	0.84808	0.91229
μ_{7i}	0.85325	0.80063	0.82888	0.86899	0.85234	0.84771	-	0.88086	0.81379	0.81242	0.84959	0.91072
μ_{8i}	0.85940	0.79521	0.82351	0.86228	0.84142	0.83885	0.87571	-	0.85230	0.83816	0.84516	0.92110
μ_{9i}	0.84007	0.80500	0.82284	0.86169	0.84787	0.82221	0.79654	0.87488	-	-1.00693	0.83929	0.90395
$\mu_{10,i}$	0.85345	0.79991	0.82102	0.86456	0.84092	0.84263	0.86318	0.87488	0.83258	-	0.85001	0.91368
$\mu_{11,i}$	0.85136	0.80164	0.82869	0.87495	0.84354	0.83829	0.82678	0.88416	0.77763	0.80905	-	0.90781
$\mu_{12,i}$	0.85174	0.80521	0.82674	0.87683	0.84653	0.86229	0.85400	0.88035	0.82025	0.81353	0.85440	-

Table 4.26 Morishima Elasticities of Substitution: Unrestricted ALIDS: 1986

Equation	1	2	3	4	5	6	7	8	9	10	11	12
W_i	0.0949	0.0339	0.0504	0.0780	0.0362	0.1934	0.1612	0.0092	0.1492	0.0231	0.1059	0.0971
μ_{1i}		0.76423	0.81836	0.86678	0.83594	0.85400	0.86860	0.85966	0.82534	0.81553	0.84746	0.86373
μ_{2i}	0.88328		0.81211	0.86580	0.83226	0.83391	0.86599	0.85922	0.82765	0.81460	0.85623	0.87691
μ_{3i}	0.86150	0.77698		0.86156	0.83388	0.85019	0.87284	0.86309	0.80464	0.81221	0.84950	0.87193
μ_{4i}	0.85947	0.78440	0.81623		0.83349	0.83746	0.85058	0.86034	0.83757	0.81817	0.84666	0.87025
μ_{5i}	0.86235	0.77654	0.82069	0.84903		0.86637	0.87946	0.86068	0.81550	0.80545	0.84819	0.86633
μ_{6i}	0.86520	0.78785	0.82522	0.86995	0.83966		0.83440	0.86811	0.81009	0.82334	0.84953	0.87000
μ_{7i}	0.86297	0.78553	0.82243	0.86196	0.84197	0.83488		0.86681	0.82885	0.81576	0.84627	0.86587
μ_{8i}	0.86260	0.78255	0.82029	0.86204	0.83522	0.85758	0.85153		0.78756	0.83815	0.84671	0.87107
μ_{9i}	0.85700	0.78642	0.81840	0.86164	0.83899	0.84732	0.79617	0.86375		-0.82726	0.83202	0.85264
$\mu_{10,i}$	0.86038	0.78056	0.80938	0.86385	0.83079	0.84424	0.85997	0.86375	0.84467		0.85333	0.87594
$\mu_{11,i}$	0.85986	0.78614	0.82044	0.87136	0.83541	0.81745	0.83031	0.87116	0.79126	0.81459		0.86315
$\mu_{12,i}$	0.86281	0.78199	0.81705	0.86938	0.84081	0.83090	0.84571	0.85723	0.79952	0.82110	0.85325	

Table 4.27 Morishima Elasticities of Substitution: Unrestricted ALIDS, 1990

Equation	1	2	3	4	5	6	7	8	9	10	11	12
W_i	0.0731	0.0232	0.0453	0.0756	0.0360	0.1608	0.1672	0.0085	0.1902	0.0164	0.0962	0.1074
μ_{1i}		0.64182	0.76556	0.85424	0.74781	0.86316	0.86642	0.83545	0.86346	0.71193	0.85751	0.86834
μ_{2i}	0.96906		0.74634	0.84681	0.49267	0.85616	0.88641	0.82695	0.84364	0.69916	0.84297	0.85989
μ_{3i}	0.96095	0.62294		0.84179	0.53186	0.84645	0.87350	0.82581	0.85549	0.70349	0.84878	0.85722
μ_{4i}	0.97059	0.63660	0.75243		0.60253	0.86157	0.85519	0.83223	0.84177	0.67213	0.84299	0.85623
μ_{5i}	0.97373	0.63324	0.75639	0.84094		0.85634	0.89105	0.82872	0.85036	0.70216	0.84802	0.85449
μ_{6i}	0.97378	0.63680	0.76225	0.84896	0.66600		0.83227	0.83966	0.82232	0.71364	0.84596	0.85872
μ_{7i}	0.82567	0.63551	0.76081	0.84173	0.69444	0.83668		0.83414	0.83375	0.66419	0.84276	0.85524
μ_{8i}	0.96073	0.63758	0.74493	0.83877	0.50431	0.84909	0.84756		0.81334	0.72381	0.84176	0.88221
μ_{9i}	0.96925	0.63455	0.75434	0.84239	0.64656	0.81654	0.80434	0.82721		-2.52633	0.83652	0.84612
$\mu_{10,i}$	0.96201	0.62945	0.75238	0.83622	0.55555	0.86368	0.86487	0.82721	0.85801		0.84396	0.86245
$\mu_{11,i}$	0.96752	0.63617	0.75336	0.84368	0.56373	0.82607	0.82144	0.83898	0.80526	0.70275		0.85367
$\mu_{12,i}$	1.19335	0.63733	0.75724	0.84623	1.93747	0.84776	0.84837	0.83608	0.83517	0.88685	0.85145	

Table 4.28 Morishima Elasticities of Substitution: Homogeneity and Symmetry Restricted ALIDS, 1984

Equation	1	2	3	4	5	6	7	8	9	10	11	12
W_i	0.11427	0.03915	0.05585	0.07957	0.04136	0.13160	0.17090	0.01171	0.15288	0.02501	0.11139	0.09885
μ_{1i}	-	0.79997	0.82964	0.87107	0.84893	0.84753	0.84687	0.88081	0.77737	0.81570	0.84856	0.90482
μ_{2i}	0.86720	-	0.81815	0.86780	0.83880	0.83941	0.83608	0.87718	0.76201	0.81212	0.84330	0.90920
μ_{3i}	0.86534	0.79128	-	0.86400	0.84274	0.83937	0.85387	0.87964	0.76088	0.81112	0.85526	0.90788
μ_{4i}	0.86834	0.79875	0.82615	-	0.84184	0.85590	0.84901	0.87875	0.77345	0.81371	0.85250	0.91284
μ_{5i}	0.86951	0.79118	0.82332	0.85825	-	0.84723	0.86311	0.87845	0.77763	0.81125	0.84566	0.90565
μ_{6i}	0.86692	0.79746	0.82695	0.87514	0.84790	-	0.83378	0.88223	0.76272	0.81615	0.84795	0.91406
μ_{7i}	0.86721	0.79750	0.83285	0.87875	0.85202	0.83778	-	0.88215	0.75825	0.81547	0.84558	0.91116
μ_{8i}	0.86630	0.78756	0.82453	0.85567	0.83944	0.86280	0.86514	-	0.77112	0.82367	0.85505	0.91989
μ_{9i}	0.86130	0.79402	0.82164	0.86413	0.84602	0.82935	0.81666	0.88429	-	-0.78056	0.84007	0.90524
$\mu_{10,i}$	0.86388	0.79323	0.81857	0.86162	0.83953	0.84640	0.84029	0.88429	0.76995	-	0.84369	0.90979
$\mu_{11,i}$	0.86489	0.79733	0.83278	0.87148	0.84617	0.84447	0.83882	0.88134	0.77051	0.81483	-	0.90864
$\mu_{12,i}$	0.86539	0.80110	0.83139	0.86260	0.84781	0.85672	0.85518	0.88251	0.78353	0.81727	0.85340	-

Table 4.29 Morishima Elasticities of Substitution: Homogeneity and Symmetry Restricted ALIDS: 1986

Equation	1	2	3	4	5	6	7	8	9	10	11	12
Wi	0.09212	0.03287	0.04896	0.07547	0.03507	0.18909	0.15589	0.00890	0.14478	0.02233	0.10268	0.09182
μ_{1i}		0.78466	0.82096	0.86307	0.83837	0.85374	0.84748	0.86438	0.78937	0.82074	0.84154	0.86233
μ_{2i}	0.87079		0.81126	0.86351	0.83016	0.83992	0.83335	0.86213	0.75063	0.81511	0.84710	0.86271
μ_{3i}	0.86561	0.77630		0.85820	0.83604	0.85189	0.84648	0.86410	0.77025	0.81458	0.84225	0.86096
μ_{4i}	0.86762	0.78373	0.81887		0.83287	0.84741	0.84100	0.86366	0.79389	0.82080	0.84775	0.86907
μ_{5i}	0.86716	0.77567	0.81853	0.85085		0.85688	0.85749	0.83943	0.77929	0.81418	0.83752	0.86602
μ_{6i}	0.87448	0.78358	0.82520	0.86617	0.84174		0.83162	0.86488	0.77802	0.82243	0.83620	0.86156
μ_{7i}	0.87352	0.78266	0.82485	0.86476	0.84305	0.83252		0.86406	0.77016	0.82174	0.84220	0.86561
μ_{8i}	0.86835	0.77547	0.82085	0.85751	0.83384	0.86834	0.85973		0.75829	0.88012	0.84728	0.86716
μ_{9i}	0.86961	0.77545	0.81662	0.86705	0.83687	0.82891	0.82018	0.86797		-0.62008	0.83640	0.85583
$\mu_{10,i}$	0.89755	0.77518	0.80845	0.86312	0.82818	0.85362	0.84419	0.86797	0.76270		0.84330	0.87252
$\mu_{11,i}$	0.86823	0.78553	0.82269	0.86813	0.83741	0.83106	0.83954	0.86487	0.77995	0.82131		0.86794
$\mu_{12,i}$	0.86166	0.78415	0.82201	0.86970	0.84045	0.84080	0.84536	0.87814	0.77809	0.81871	0.84862	

Table 4.30 Morishima Elasticities of Substitution: Homogeneity and Symmetry Restricted ALIDS: 1990

Equation	1	2	3	4	5	6	7	8	9	10	11	12
Wi	0.07313	0.02325	0.04530	0.07556	0.03603	0.16076	0.16723	0.00848	0.19021	0.01639	0.09624	0.10742
μ1i		0.64937	0.75240	0.83910	0.76303	0.84232	0.82982	0.83233	0.80046	0.71406	0.83813	0.88096
μ2i	0.80482		0.72982	0.83829	0.75047	0.81712	0.83144	0.82695	0.73700	0.69715	0.83039	0.88956
μ3i	0.80317	0.63618		0.83292	0.75763	0.83545	0.83566	0.82926	0.78840	0.70960	0.83834	0.88579
μ4i	0.81951	0.65256	0.75848		0.76575	0.85256	0.82946	0.83290	0.79990	0.71492	0.83945	0.88695
μ5i	0.80714	0.64094	0.74795	0.83263		0.83928	0.84581	0.82972	0.78371	0.70996	0.83313	0.88250
μ6i	0.82459	0.65093	0.76374	0.84958	0.77093		0.82281	0.83480	0.78555	0.71790	0.84146	0.88927
μ7i	0.82342	0.65424	0.76648	0.84277	0.77419	0.83169		0.83428	0.78490	0.71726	0.83620	0.88664
μ8i	0.81109	0.63555	0.74090	0.83593	0.75389	0.85938	0.84138		0.79616	0.71149	0.84756	0.91828
μ9i	0.82258	0.64618	0.76135	0.84246	0.76750	0.82529	0.81573	0.83060		-1.44233	0.84009	0.88230
μ10,i	0.80539	0.62495	0.74287	0.83137	0.75432	0.84301	0.82838	0.83060	0.76933		0.83093	0.89128
μ11,i	0.82176	0.65156	0.76354	0.84209	0.76797	0.83998	0.82228	0.83431	0.80021	0.71579		0.89028
μ12,i	0.82805	0.65473	0.76594	0.84614	0.77051	0.84974	0.83779	0.83657	0.80200	0.72220	0.85050	

that the composition of a Canadian household's food-at-home budget is independent of utility or total expenditure, hence there is no reason why this restriction must be imposed *a priori.*

In Table 4.31, we have presented a comparison of own-price and expenditure related elasticities for the three years. The trends in the magnitudes of elasticities for the meat categories (beef, pork, chicken, and fish) and fat is interesting. Although all these own-price elasticities still exhibit inelastic demands, it is worth noting that within the meat category, chicken, fish, and pork have recorded relative declines in own price elasticity between 1984 and 1990, which implies that these meats have acquired a very salient position in the Canadian diet. The exception is fish whose change in expenditure elasticity is ambiguous. Overall, these results may not be entirely surprising when one considers the issues of structural change in demand as they relate to health issues associated with red meats such as beef. Notice too that fat has acquired a very important position. Is this ironic? We believe not. The fat category includes both polysaturates and monosaturates. A significant proportion of the increase in fats and oils has been attributed to increased vegetable oil consumption. Again, caution is required in drawing conclusions about the structure of preferences. However, this observation seems to corroborate anecdotal and empirical evidence showing major changes in consumer preferences in favour of certain commodities.

These own-price effects on food-at-home budget shares are indeed very significant from a policy vantage point as they suggest that price policy will continue to be an important agricultural policy instrument, especially in relation to supply management programs. Obviously, one needs to add a caveat here in view of the limited substitution possibilities indicated by the very small cross-price elasticities. Notice too that expenditure elasticities are generally high for pork, chicken, fish, and fat, implying that we would anticipate further increases in meat consumption in future provided of course household incomes rise. Table 4.31 also suggests that the relationship between our own price and expenditure elasticities is not fixed. For instance, observe that for 1984, the highest Marshallian own-price elasticities are ranked as beef, other

Table 4.31 Comparing Own-price and Expenditure Elasticities for 1984, 1986, and 1990

	1984		1986		1990	
Commodity	Marshallian Own-Price	Expenditure Elasticity	Marshallian Own-Price	Expenditure Elasticity	Marshallian Own-Price	Expenditure Elasticity
BEEF	-0.88529	1.04142	-0.89314	1.11547	-0.85583	1.16079
PORK	-0.81249	1.20281	-0.79297	1.12575	-0.66839	1.46458
CHICKEN	-0.84670	1.11722	-0.83803	1.16524	-0.78644	1.32889
OMEAT	-0.88787	0.98898	-0.87992	1.05172	-0.85225	0.96956
FISH	-0.86118	1.19961	-0.85201	1.21222	-0.78148	1.14433
CEREAL	-0.85077	0.90528	-0.84101	0.84565	-0.83276	0.81096
VEGES	-0.85885	0.95325	-0.86188	0.99489	-0.85553	0.99983
SUGAR	-0.88431	1.17451	-0.86770	1.20873	-0.83835	1.39483
DAIRY	-0.81711	1.09144	-0.80780	0.98741	-0.82889	0.99238
FATS	-0.81903	0.98709	-0.82633	1.08678	-0.72365	1.22575
NALCO	-0.84561	0.83634	-0.85011	0.92857	-0.84694	0.91272
OTHER	-0.91122	0.93231	-0.87577	0.99940	-0.89143	0.93330

meat, sugar, and other. But the rank for the highest expenditure elasticity corresponds to pork, fish, chicken, and sugar. For 1990, the ranking is other, vegetables, beef, and non alcoholic beverages and the expenditure elasticities are pork, sugar, chicken, and fat. In demand systems such as the Rotterdam and the Linear Expenditure System (LES) which assume strong separability, we would expect to find a fixed relationship between the own-price elasticities and expenditure elasticities. Deaton [1974] refers to this restrictive approximate proportionality between price and expenditure elasticities as Pigou's law. For a fairly disaggregated commodity system like ours, it is easy to see how additive demand systems such as the LES which assumes strong separability can severely distort measurement since one can generally expect variations in total expenditure to outweigh those in relative prices. Assuming homothetic preferences hinders this analysis.

4.7.4 Comparing Elasticities from other Studies.

In Table 4.32, we present a summary of price and expenditure related elasticities from other studies that have investigated issues similar to ones addressed in this study. There are many such studies and it is impossible to reference all of them. Hence, we only pick those that closely match the level of aggregation employed in this study. Since Canadian studies in this vein are quite few, we also present U.S. studies. However, comparing studies from Canada and the U.S. may not be wholly warranted if the countries constitute two distinct economic mosaics although it is not too far fetched to talk about North American preferences. It is also instructive to caution against making unqualified direct comparisons of elasticities especially since we know that such estimates can vary considerably depending on empirical model specification, level of commodity aggregation, theoretical restrictions in force, as well as types of data employed and period covered. Our study employs Public Use Micro Data Tapes for 1984, 1986, 1990 - the first time to our knowledge that this data has been employed in this manner.

As can be seen from Table 4.32, a number of our own- price and expenditure elasticities fall within the range reported in these other studies, especially for beef, chicken, pork, and fish.

Table 4.32. A Comparison of Elasticities from other Demand Studies

Study	Model	Data	Commodity	Elasticities	
				Own-Price	Expenditure
Reynolds and Goddard [1991]	Gradual-Switching ALIDS	TS 1975-84	Beef	-0.76	1.13
			Pork	-0.67	1.14
			Chicken	-0.19	-0.02
Chen and Veeman [1991]	Dynamic ALIDS	TS 1967-87	Beef	-0.77	0.93
			Pork	-0.82	1.01
			Chicken	-0.95	1.04
			Turkey	-0.09	0.99
Atkins, Kerr, and McGivern [1989]	Log-Linear	TS 1968-74	Beef	0.58	-0.07
			Pork	-0.78	-0.20
			Chicken	-0.51	-1.25
Hassan and Johnson [1979]	Box-Cox Transformatio n	TS 1965-76	Beef	-0.45	0.36
			Pork	-0.84	0.44
			Chicken	-0.73	0.62
			Veal	-3.19	0.86
Moschini and Moro [1993]	Static and Dynamic ALIDS	TS 1961-88	Beef	-0.50	0.93
			Pork	-0.62	1.00
			Poultry	-0.72	1.51
			Fish	-0.61	1.92
			Milk	-0.36	0.47
			Butter	-0.92	0.49
			Fats & Oils	-0.12	-0.51
			Fresh Vege	-0.49	3.89
			Bread, Bakery	-0.45	0.88
			Sugars	-0.14	0.72
			Beverages	-0.28	1.08
			Other Food	-0.24	0.71
Blanciforti and Green [1984]	ALIDS	Pooled CS TS Sample Mean 1948-78	Meats	-0.57	0.78
			Fruit, Vege	-0.60	0.67
			Cereal,	-0.55	0.36
			Bakery	-1.01	1.62
Moschini and Meilke [1989]	Gradual-Switching ALIDS	TS 1967-87	Beef	-1.05	1.39
			Pork	-0.84	0.85
			Chicken	-0.10	0.21
			Fish	-0.43	0.31

Table 4.32 (continued)

Study	Model	Data	Commodity	Elasticities	
				Own-Price	Expenditure
Lee, Brown, and Seale [1992]	Rotterdam	TS 1960-87	Oranges	-0.27	1.37
			Grapefruit	-0.50	0.03
			Apples	-0.28	1.11
			Bananas	-0.27	0.18
			Orange Juice	-0.04	1.30
			Apple Juice	-0.35	1.80
Eales and Unnevehr [1993][a]	ALIDS Inverse ALIDS	TS 1962-1989	Beef	-0.85	0.79
			Pork	-1.23	1.28
			Chicken	-0.23	0.69
			Nonmeat	-1.20	0.15
			Other	-1.10	1.18
Huang [1985]	Composite	Constant	Beef	-0.62	0.45
			Pork	-0.73	0.44
			Chicken	-0.53	0.36
			Other Meats	-1.37	0.06
			Fats, Oils	-0.22	0.37
			Sugar	-0.05	-0.18
Capps and Havlicek [1984]	S_1-Branch System	Sample Mean 1946-68	Ground Beef	-1.58	1.38
			Roasts	-1.83	1.66
			Steaks	-1.69	1.51
			Pork	-1.30	1.11
			Other Meats	-1.46	1.28
			Poultry	-1.25	1.10
			Seafood	-2.24	1.96
Heien and Pompelli [1988]	ALIDS	Sample Mean 1977	Steak	-0.73	1.14
			Roast	-1.11	1.37
			Ground Beef	-0.85	0.69
Christensen and Manser [1977]	Indirect Translog	CS 1971	Beef	-1.09	1.45
			Poultry	-0.71	0.93
			Fish	-0.17	0.37
			Seafood	-0.38	0.40
Blackorby, Boyce, and Russell [1978]	Generalized S-Branch System	CS 1968	Beef	-0.27	1.04
			Pork	-0.69	1.13
			Poultry	-0.63	1.01
			Fish	-0.64	0.87

[a] Eales and Unnevehr also report flexibilities based on their Inverse ALIDS. These are not presented here due to space limitations.

On the other hand, differences are quite dramatic from one study to another irrespective of econometric functional form employed. Also, the levels of aggregation vary a great deal, and there is clearly no limit to the level of commodity aggregation. As pointed out earlier in Chapter 3, levels of commodity aggregation are really driven by particular objectives of a study. Overall, these differences in the magnitude of elasticities suggest that the estimates are not likely independent of the level of commodity aggregation, as Klevmarben [1979] has shown. Large demand systems involving highly disaggregated commodities tend to generate elasticities with unanticipated signs.

4.8 Testing Theoretical Restrictions

In this section, we present results of our tests of theoretical restrictions, recalling that the ALIDS (because it is derived from an explicit expenditure function) permits us to test the validity of these neoclassical restrictions. Model validation, goodness of fit, and curvature are also considered.

4.8.1 Testing Homogeneity and Symmetry

We first estimated the full unconstrained model in order to test the homogeneity restriction $\Sigma_j \gamma_{ij}=0$. We then imposed homogeneity and symmetry and tested symmetry in that context. In order to test the validity of these linear restrictions on the disaggregated ALIDS system, we employed the extended version of the single *F-test.* The general hypothesis about the test of linear restrictions on the elements of the coefficient vector β in (4.22) has the form:

$$R\beta - r = 0 \qquad 5.24$$

where R is a known full row rank matrix (i.e. no linear dependencies between hypothesis) with dimension q x K ($q \leq K$) and r is a known vector of dimension q x 1. Assuming that stochastic errors are normally distributed, the F-test statistic for testing the general hypothesis that $R\beta$ - $r = 0$ is true is given by:

$$F(q,(N-1)(H-K)) = \frac{(R\hat{\beta}-r)^T[R(X^T\Psi^{-1}X)^{-1}R^T]^{-1}(R\hat{\beta}-r)/q}{W-X\hat{\beta})\Psi^{-1}(W-X\hat{\beta})/[(N-1)T-K]}$$

where $\Psi^{1} = \Sigma^{-1} \otimes I$

Table 4.33 presents F-tests results of homogeneity and symmetry. Looking first at the homogeneity test, we observe that F-test values for homogeneity are less than their critical values at the 1 percent and 5 percent levels of significance in all but one equation. This result is encouraging in view of the frequency with which homogeneity has been rejected in most demand studies. We find the frequent rejection of homogeneity difficult to understand given that homogeneity imposes only one restriction on each budget share equation. Such rejection may signal a violation of one or more of the classical OLS assumptions. In particular, observe that most studies have tended to assume exogeneity of expenditure and proceeded to apply SURE to their share equations. In fact, we initially estimated our model using SURE but quickly abandoned this approach and adopted 3SLS due to the fact that homogeneity was strongly rejected. Under these circumstances, the explicit assumption of exogeneity of expenditure is not the proper parametric representation of demand and hence the rejection of homogeneity may precisely be the consequence. Attfield [1985, 1991] has suggested that because a test for homogeneity (with total expenditure assumed exogenous) is equivalent to a test for exogeneity of total expenditure assuming homogeneity, rejection of homogeneity could be interpreted instead as rejecting the hypothesis of exogeneity of the expenditure variable where homogeneity is assumed as one of the maintained hypothesis. Our homogeneity results seem to validate our use of 3SLS. Ideally, a formal Hausman test may need to be conducted to justify the use of 3SLS. The fact that the statistics obtained by the 3SLS procedure do not reject the hypothesis of homogeneity may not say anything about the endogeneity of expenditure since the 3SLS estimator

Table 4.33 Results of Homogeneity and Symmetry Tests for 1984, 1986, and 1990

Commodity	1984 F-test	1984 prob>F[a]	1986 F-test	1986 prob>F	1990 F-test	1990 prob>F
a. Homogeneity:						
BEEF	1.1940	0.1592	0.6117	0.4405	1.5078	0.2195
PORK	0.5364	0.9133	1.2202	0.2693	0.0672	0.7955
CHICKEN	0.0545	0.8154	2.1092	0.1206	1.5923	0.2070
OMEAT	0.5349	0.4645	0.0139	0.9003	2.8799	0.0897
FISH	0.0122	0.1260	0.2828	0.0949	1.0644	0.3022
CEREAL	1.1594	0.2994	0.0579	0.2001	0.0020	0.0944
VEGES	1.0759	0.1301	0.1260	0.9221	0.5431	0.4502
SUGAR	0.5690	0.8911	0.0161	0.6099	2.9104	0.0712
DAIRY	1.0010	0.3150	0.0678	0.4107	3.5324	0.0601
FATS	0.1076	0.7429	0.0119	0.0601	7.3924	0.0046
NALCO	0.8766	0.6524	0.6154	0.0001	2.7392	0.1079
OTHER[b]	-	-	-	-	-	-
b. Symmetry:						
All Equations	12.7112	0.0001	14.2154	0.0001	19.7173	0.0001

a. Prob>F is the exact significance level for the F ratio test of the hypothesis that all nonintercept parameters are zero.

b. The restriction $\Sigma \gamma_{ij} = 0$ reduces the ALIDS to $w_i = \alpha_i + \sum_{j=1}^{n-1} \gamma_{ij} \ln p_j + \beta_i \ln(m/P) + \delta_{ij} D_i$, hence the category 'OTHER' is missing.

is consistent even if total expenditure is in fact exogenous. All we can say is that based on our two-stage budgteing procedure, we know *a priori* that m^h is contemporaneously correlated with the error term, so that at the very least, our use of 3SLS is more defensible than any procedure that does not accommodate this endogeneity problem.

Next, we examine symmetry test results. The situation here is very disappointing since all F-values are significantly greater than their critical values at the 1 percent and 5 percent levels, leading us to strongly reject symmetry in all cases. Within the context of other food demand studies, this result is not entirely unusual. Indeed, as illustrated in Table 4.34 virtually all existing empirical investigations of demand systems reject symmetry restrictions. Needless to say, quite a number of other studies did not bother to test the significance of theoretical restrictions. Canadian studies that have found statistical support for the neoclassical theory of consumer behaviour within the context of the present study include Chen and Veeman [1991], and Moschini and Moro [1993] although these conditions are only found acceptable for dynamic specifications of the ALIDS.

As alluded to above, a number of factors can cause rejection of a theoretical hypothesis. Winter [1984] and Blundell *et. al* [1993] argue that a common rejection of theoretical restrictions is due to dynamic misspecification. Meisner [1979] and Lin [1993] point out that the asymptotic χ^2 test based on the estimated covariance matrix of the unrestricted model tends to reject the null hypothesis of symmetry too often.

Although the analysis of household expenditures in cross-sectional demand studies is necessarily static, the above observations suggest that further work in this area be directed at incorporating dynamics in the form of some food stock adjustment mechanism, based of course on the assumption of the existence of stocks. This may involve treating, say, frozen foods, as a 'durable' good. In actual empirical work, data are usually not available on stocks, hence the difficulty in estimation. An alternative would be to incorporate price and expenditure adjustment

Table 4.34. Homogeneity, Symmetry, and Curvature Tests from other Demand Studies

Study	Model	Data	Theoretical Restriction[a]		
			Homogeneity	H + S	Curvature
Reynolds and Goddard [1991]	Gradual-Switching ALIDS	TS 1975-84	NA	NA	NA
Chen and Veeman [1991]	Dynamic ALIDS	TS 1967-87	A	A	NA
Atkins, Kerr, and McGivern [1989]	Log-Linear	TS 1968-74	NA	NA	NA
Hassan and Johnson [1979]	Box-Cox Transformation	TS 1965-76	NA	NA	NA
Moschini and Moro [1993]	Static and Dynamic ALIDS	TS 1961-88	A	A	R
Blanciforti and Green [1984]	ALIDS	Pooled CS TS Sample Mean 1948-78	R	NA	NA
Moschini and Meilke [1989]	Gradual-Switching ALIDS	TS 1967-87	NA	NA	NA
Deaton and Muellbauer [1980]	ALIDS	U.K. 1954-74	R	R	R
Christensen, Yorgenson, and Lau [1975]	Translog	U.S. 1929-72	IMPOSED	R	R
Goddard, D.[1983]	LES, ALIDS	Canada	R	R	NA
Ray [1982]	ALIDS	Pooled	R	R	NA
Rossi [1984]	ALIDS	TS	R	R	NA
Eales and Unnvehr [1988]	ALIDS	TS	R	NA	NA

[a] A= accepted; R= rejected; NA= not available .

mechanisms since these are often available. However, to do this, one needs sufficient time series of cross-sections. The present microdata set does not make this possible. Hence, short of these considerations, it is easy to see why a failure to incorporate inter temporal elements in a context which clearly warrants such inclusion will continue to cause significant problems for tests of theoretical restrictions of utility theory.

Given the strong rejection of symmetry, one might be inclined to conclude that our extended stage two household ALIDS is not the proper parametric representation of household demand in Canada. However, whether or not the rejection of salient theoretical restrictions such as symmetry must now suggest that we take the falsificationist debate more earnestly, as suggested recently by Fox and Kivanda [1994] will continue to be a contestable issue that lies beyond the scope of this study. In general, however, it is important to test implications of neoclassical theory. However, as Clark and Coyle [1994] have argued, the difficulties in formulating tests for theoretical restrictions are frequently underestimated. This is particularly true with respect to econometric specification where it is difficult to infer whether neoclassical properties have been rejected even though classical statistical tests may be available. According to Clark and Coyle, this may be explained by a number of factors. First, the normality assumptions underlying the statistical tests may not be reasonable approximations to the true empirical distribution, leading to a distortion in the power of tests. Second, there may be serious questions about the exogeneity of regressors and about consistent aggregation. Clearly, any of these imply serious misspecification. Indeed, as Antle and Capalbo [1988] have also stated, researchers must generally be aware that violations of theoretical restrictions by an econometrically estimated model may simply be caused by sampling error, data errors, model misspecification, or simultaneous equation bias. In this view, we believe it is fair to question the extent to which rejection or nonrejection of theoretical restrictions must be the sole criterion for model selection.

4.8.2 Checking Curvature Conditions.

A fourth restriction imposed by neoclassical theory is negativity and involves concavity of the expenditure function $e(p,\mathbf{u})$. Concavity or negativity of the substitution matrix has received far less attention in empirical demand studies relative to summability, homogeneity, and symmetry in spite of the fact that it is an important result in economic theory. In this section, we present results of our tests of curvature. Testing curvature is significant in that semi negative definiteness of the substitution matrix corresponds to the second order conditions for competitive utility maximization behaviour of economic agents. Symmetry and negative semidefiniteness of $\partial x(p,\mathbf{u})/\partial p$ implies that the set of Hicksian differential demand equations $x_i^c(p,\mathbf{u}) = \partial e(p,\mathbf{u})/\partial p_i$ integrate up to a macro function $e(p,\mathbf{\mathring{u}})$ that is concave in p, so that one can interpret the uncompensated demands $x_i(p,\mathbf{m})$ as being derived from competitive utility maximizing behaviour. Hence, concavity implies that the Hessian matrix of the expenditure function $e(p,\mathbf{u})$ is negative semi definite. The Hessian equals the Slutsky matrix Ş of compensated price responses defined as

$$S=[s_{ij}]=\left(\frac{\partial x^c(p,u^*)}{\partial p}\right)_{NxN}=\left(\frac{\partial^2 e(p,u)}{\partial p^T \partial p}\right)_{NxN} \qquad 4.30$$

which is simply the matrix of second order partial derivatives of the expenditure function $e(p,\mathbf{u})$ with respect to prices p.

Within our ALIDS model, this property of negativity cannot be easily maintained or tested statistically especially since, unlike homogeneity and symmetry, it involves inequality restrictions on latent roots.. Neither can it be imposed *a priori*. Rather, it can be verified separately for each data point by deriving the characteristic roots or eigenvalues of the estimated matrix of compensated substitution terms Ķ have the typical element $\{k_{ij}\}$ related to Hicksian elasticities as follows:

$$k_{ij} = p_i p_j s_{ij}/m = \epsilon^c_{ij} w_i$$

$$k_{ij} = \gamma_{ij} + \beta_i \beta_j (logM - logP) + w_i w_j - w_i \delta_{ij} \qquad 4.31$$

where all the variables and parameters are as defined above. This expression is more amenable. Rather than searching for conditions for the negative semidefiniteness of the Hessian matrix, it is much simpler to just derive the k_{ij} matrix and then establish conditions for which this matrix is negative semi definite. A necessary (but not sufficient) condition for concavity requires all diagonal elements of our Slutsky substitution matrix to be negative. Equivalently, a necessary condition for the negative semidefiniteness of the matrix K requires the computed diagonal elements to be nonpositive, i.e.

$$k_{ii} \;=\; \gamma_{ii} + \beta_i^2(logM - logP) + w_i w_i - w_i \leq 0. \qquad 4.32$$

This condition is only necessary but not suffient. In addition, we need to establish that matrix K is negative semidefinite, implying concavity of the Hessian matrix). To do this, we compute characteristic roots of matrix K. If all computed characteristic roots are nonpositive, then matrix K is negative semidefinite and our expenditure function $e(p,u)$ is concave. Since the matrix K is a function of prices and expenditure, we would expect each data point in the sample to have a different K matrix since we cannot expect concavity to hold globally for the ALIDS.

From Tables 4.35 - 4.40 , we can see that all diagonal elements of the substitution matrix are negative, thus establishing the necessary condition for concavity. In Table 4.41, we have provided characteristic roots corresponding to the compensated substitution matrices derived from both the restricted and unrestricted models for the years 1984, 1986, and 1990. All estimated characteristic roots are nonpositive, except for 1990 where the unrestricted model generates one nonnegative root. In general, however, these results may suggest that evidence from the data appears to be sufficiently strong for us to conclude that the theoretical property of negative semidefiniteness holds and hence there is no violation of the concavity of the households' expenditure functions.

Table 4.35 Compensated Substitution Effects: Unrestricted ALIDS: 1984

Equation	1	2	3	4	5	6	7	8	9	10	11	12
ki1	-0.08625	0.00514	0.00577	0.00805	0.00435	0.01274	0.01683	0.00123	0.01304	0.00247	0.01076	0.00958
ki2	0.00067	-0.03003	0.00157	0.00282	0.00114	0.00485	0.00572	0.00033	0.00579	0.00082	0.00384	0.00376
ki3	0.00520	0.00157	-0.04349	0.00359	0.00180	0.00596	0.00856	0.00052	0.00674	0.00106	0.00556	0.00474
ki4	0.00811	0.00269	0.00359	-0.06364	0.00263	0.00957	0.01183	0.00073	0.00946	0.00162	0.00837	0.00762
ki5	0.00402	0.00107	0.00174	0.00230	-0.03355	0.00491	0.00704	0.00035	0.00561	0.00074	0.00361	0.00350
ki6	0.01340	0.00498	0.00710	0.01057	0.00465	-0.09678	0.01919	0.00121	0.01327	0.00268	0.01146	0.01254
ki7	0.01862	0.00677	0.01037	0.01290	0.00717	0.01699	-0.11899	0.00210	0.01533	0.00417	0.01454	0.01559
ki8	0.00037	0.00029	0.00055	0.00044	0.00018	0.00221	0.00207	-0.01018	0.00143	0.00015	0.00171	0.00115
ki9	0.01544	0.00618	0.00696	0.01096	0.00462	0.01412	0.02203	0.00196	-0.10471	0.00369	0.01033	0.01338
ki,10	0.00214	0.00066	0.00077	0.00149	0.00057	0.00359	0.00338	0.00053	0.00362	-0.01982	0.00183	0.00206
ki,11	0.01101	0.00346	0.00581	0.00761	0.00416	0.01246	0.01644	0.00107	0.01313	0.00242	-0.08392	0.00998
ki,12	0.01003	0.00345	0.00526	0.00720	0.00372	0.01230	0.01570	0.00120	0.01301	0.00237	0.00991	-0.08094

Table 4.36 Compensated Substitution Effects: Unrestricted ALIDS: 1986

Equation	1	2	3	4	5	6	7	8	9	10	11	12
ki1	-0.07212	0.00330	0.00385	0.00578	0.00279	0.01555	0.01247	0.00071	0.01072	0.00173	0.00790	0.00733
ki2	0.00066	-0.02488	0.00097	0.00206	0.00068	0.00581	0.00443	0.00023	0.00425	0.00052	0.00298	0.00229
ki3	0.00355	0.00106	-0.03818	0.00274	0.00143	0.00858	0.00664	0.00036	0.00558	0.00066	0.00417	0.00342
ki4	0.00614	0.00216	0.00301	-0.06039	0.00171	0.01320	0.00963	0.00055	0.00890	0.00142	0.00731	0.00636
ki5	0.00252	0.00078	0.00124	0.00188	-0.02836	0.00588	0.00521	0.00024	0.00440	0.00050	0.00276	0.00296
ki6	0.01595	0.00503	0.00829	0.01182	0.00651	-0.12874	0.02401	0.00157	0.02410	0.00365	0.01403	0.01378
ki7	0.01470	0.00516	0.00802	0.01068	0.00598	0.02371	-0.11053	0.00127	0.01262	0.00337	0.01246	0.01255
ki8	0.00030	0.00009	0.00033	0.00030	0.00015	0.00222	0.00162	-0.00762	0.00086	0.00016	0.00152	0.00008
ki9	0.01179	0.00428	0.00525	0.01058	0.00414	0.02131	0.02050	0.00080	-0.10097	0.00329	0.00964	0.00938
ki,10	0.00153	0.00051	0.00065	0.00145	0.00023	0.00461	0.00262	0.00035	0.00226	-0.01784	0.00160	0.00203
ki,11	0.00811	0.00318	0.00441	0.00658	0.00311	0.01704	0.01354	0.00078	0.01051	0.00210	-0.07798	0.00862
ki,12	0.00716	0.00299	0.00421	0.00636	0.00282	0.01588	0.01245	0.00076	0.00964	0.00201	0.00792	-0.07217

Table 4.37 Compensated Substitution Effects: Unrestricted ALIDS: 1986

Equation	1	2	3	4	5	6	7	8	9	10	11	12
ki1	-0.18409	0.01668	0.03213	0.05432	0.02601	0.11607	0.09598	0.00602	0.13648	0.01164	0.06889	0.10115
ki2	0.01600	-0.01441	0.00014	0.00126	0.00048	0.00271	0.00260	0.00015	0.00278	0.00016	0.00156	0.00187
ki3	0.03184	0.00057	-0.03271	0.00230	0.00124	0.00647	0.00649	0.00019	0.00615	0.00050	0.00302	0.00378
ki4	0.05424	0.00155	0.00280	-0.05894	0.00219	0.01108	0.01031	0.00050	0.01185	0.00092	0.00612	0.00711
ki5	0.00609	-0.00574	-0.00941	-0.01035	-0.02664	-0.01181	-0.00753	-0.00200	-0.01767	-0.00301	-0.01691	0.12869
ki6	0.11664	0.00355	0.00647	0.01193	0.00550	-0.11312	0.02224	0.00123	0.02147	0.00262	0.01178	0.01548
ki7	0.12255	0.00436	0.00791	0.01181	0.00692	0.02145	-0.11687	0.00126	0.02007	0.00272	0.01180	0.01606
ki8	0.00584	-0.00001	-0.00007	0.00036	0.00005	0.00196	0.00112	-0.00702	0.00133	0.00000	0.00111	0.00093
ki9	0.13808	0.00393	0.00819	0.01263	0.00633	0.02374	0.02661	0.00118	-0.12832	0.00301	0.01257	0.01724
ki,10	0.01148	0.00007	0.00033	-0.00182	0.00021	0.00280	-0.00536	0.00023	-0.00684	-0.01141	0.00063	0.02048
ki,11	0.06940	0.00187	0.00390	0.00607	0.00308	0.01340	0.01340	0.00067	0.01406	0.00133	-0.07340	0.00954
ki,12	0.07737	0.00226	0.00429	0.00708	0.00331	0.01546	0.01550	0.00102	0.01590	0.00164	0.00877	-0.08191

Table 4.38 Compensated Substitution Effects: Homogeneity and Symmetry Restricted ALIDS: 1984

Equation	1	2	3	4	5	6	7	8	9	10	11	12
ki1	-0.08756	0.00395	0.00553	0.00812	0.00427	0.01324	0.01725	0.00117	0.01453	0.00244	0.01098	0.00980
ki2	0.00395	-0.02997	0.00145	0.00265	0.00107	0.00422	0.00549	0.00026	0.00438	0.00070	0.00356	0.00353
ki3	0.00553	0.00145	-0.04363	0.00357	0.00174	0.00602	0.00882	0.00051	0.00618	0.00093	0.00574	0.00496
ki4	0.00812	0.00265	0.00357	-0.06366	0.00241	0.00989	0.01346	0.00065	0.00980	0.00154	0.00796	0.00619
ki5	0.00427	0.00107	0.00174	0.00241	-0.03357	0.00478	0.00691	0.00033	0.00527	0.00070	0.00386	0.00358
ki6	0.01324	0.00422	0.00602	0.00989	0.00478	-0.09628	0.01814	0.00154	0.01494	0.00287	0.01257	0.01236
ki7	0.01725	0.00549	0.00882	0.01218	0.00691	0.01814	-0.11894	0.00198	0.01846	0.00361	0.01592	0.01574
ki8	0.00117	0.00026	0.00051	0.00065	0.00033	0.00154	0.00198	-0.01020	0.00142	0.00034	0.00120	0.00118
ki9	0.01453	0.00438	0.00618	0.00980	0.00527	0.01480	0.01846	0.00142	-0.09941	0.00299	0.01340	0.01317
ki,10	0.00244	0.00070	0.00094	0.00154	0.00070	0.00287	0.00361	0.00034	0.00299	-0.01987	0.00228	0.00227
ki,11	0.01098	0.00356	0.00574	0.00796	0.00386	0.01257	0.01592	0.00120	0.01340	0.00228	-0.08382	0.00998
ki,12	0.00980	0.00353	0.00496	0.00746	0.00358	0.01250	0.01574	0.00118	0.01318	0.00227	0.00998	-0.08096

Table 4.39 Compensated Substitution Effects: Homogeneity and Symmetry Restricted ALIDS: 1986

Equation	1	2	3	4	5	6	7	8	9	10	11	12
ki1	-0.07281	0.00264	0.00368	0.00583	0.00269	0.01590	0.01296	0.00069	0.01147	0.00239	0.00799	0.00654
ki2	0.00264	-0.02485	0.00100	0.00209	0.00069	0.00522	0.00416	0.00017	0.00282	0.00043	0.00303	0.00259
ki3	0.00368	0.00100	-0.03824	0.00286	0.00132	0.00836	0.00684	0.00035	0.00516	0.00061	0.00428	0.00377
ki4	0.00583	0.00209	0.00286	-0.06036	0.00179	0.01255	0.01013	0.00051	0.00974	0.00141	0.00702	0.00642
ki5	0.00269	0.00069	0.00132	0.00179	-0.02838	0.00617	0.00529	0.00022	0.00401	0.00043	0.00290	0.00287
ki6	0.01590	0.00522	0.00836	0.01255	0.00617	-0.12879	0.02361	0.00167	0.02140	0.00385	0.01540	0.01466
ki7	0.01296	0.00416	0.00684	0.01013	0.00529	0.02361	-0.11018	0.00136	0.01642	0.00307	0.01363	0.01272
ki8	0.00069	0.00017	0.00035	0.00051	-0.00061	0.00152	0.00112	-0.00763	0.00083	0.00025	0.00082	0.00196
ki9	0.01147	0.00282	0.00516	0.00974	0.00401	0.02140	0.01642	0.00083	-0.09626	0.00219	0.01182	0.01040
ki,10	0.00172	0.00043	0.00061	0.00141	0.00043	0.00385	0.00307	0.00069	0.00219	-0.01791	0.00198	0.00153
ki,11	0.00799	0.00303	0.00428	0.00702	0.00290	0.01540	0.01363	0.00082	0.01182	0.00198	-0.07750	0.00862
ki,12	0.00722	0.00259	0.00377	0.00642	0.00288	0.01467	0.01272	0.00074	0.01040	0.00198	0.00862	-0.07199

Table 4.40 Compensated Substitution Effects: Homogeneity and Symmetry Restricted ALIDS: 1990

Equation	1	2	3	4	5	6	7	8	9	10	11	12
ki1	-0.05564	0.00102	0.00191	0.00443	0.00166	0.01023	0.01045	0.00043	0.01172	0.00073	0.00585	0.00721
ki2	0.00110	-0.01475	0.00008	0.00138	0.00024	0.00267	0.00333	0.00001	0.00225	-0.00015	0.00166	0.00219
ki3	0.00191	0.00008	-0.03290	0.00244	0.00078	0.00603	0.00673	0.00012	0.00668	0.00027	0.00359	0.00426
ki4	0.00440	0.00138	0.00244	-0.05886	0.00193	0.01135	0.01067	0.00048	0.01207	0.00086	0.00607	0.00721
ki5	0.00167	0.00024	0.00079	0.00193	-0.02667	0.00493	0.00567	0.00012	0.00518	0.00023	0.00267	0.00325
ki6	0.01023	0.00267	0.00603	0.01135	0.00493	-0.11291	0.02162	0.00133	0.02338	0.00230	0.01324	0.01583
ki7	0.01035	0.00333	0.00668	0.01067	0.00567	0.02162	-0.11510	0.00130	0.02424	0.00230	0.01289	0.01606
ki8	0.00043	0.00001	0.00012	0.00048	0.00012	0.00133	0.00130	-0.00701	0.00132	0.00007	0.00075	0.00108
ki9	0.01172	0.00225	0.00672	0.01207	0.00517	0.02338	0.02421	0.00132	-0.12176	0.00212	0.01541	0.01739
ki,10	0.00077	-0.00015	0.00027	0.00086	0.00023	0.00230	0.00229	0.00007	0.00171	-0.01153	0.00118	0.00200
ki,11	0.00578	0.00166	0.00359	0.00607	0.00267	0.01324	0.01289	0.00075	0.01541	0.00118	-0.07306	0.00982
ki,12	0.00657	0.00229	0.00429	0.00724	0.00329	0.01577	0.01596	0.00108	0.01733	0.00164	0.00954	-0.08499

Table 4.41 Characteristic Roots for the Restricted and Unrestricted Models.

Unrestricted Model			Restricted Model		
1984	1986	1990	1984	1986	1990
-0.00441	-0.00513	0.12514	-0.00423	-0.00550	-0.00576
-0.01152	-0.00932	-0.00716	-0.01150	-0.00926	-0.00870
-0.02193	-0.01958	-0.01141	-0.02190	-0.01965	-0.01263
-0.03254	-0.02697	-0.01502	-0.03229	-0.02681	-0.01801
-0.03891	-0.33354	-0.02166	-0.03876	-0.03319	-0.02964
-0.52990	-0.04674	-0.03714	-0.05219	-0.04619	-0.04041
-0.76510	-0.07006	-0.06830	-0.07581	-0.06993	-0.06155
-0.95584	-0.83593	-0.89582	-0.96257	-0.08363	-0.07302
-0.10590	-0.10130	-0.13686	-0.10583	-0.10029	-0.10083
-0.11577	-0.12310	-0.14610	-0.11320	-0.12097	-0.13550
-0.00324	-0.14844	-0.35880	-0.13474	-0.14781	-0.14414

As with most empirical results, caution in drawing conclusions is warranted. First, conclusions regarding the extent to which we are able to reject or accept a concavity hypothesis should consider the fact that most flexible functional forms cannot guarantee concavity for all **[p,m]** combinations. Because the ALIDS (like the Translog and LES) cannot maintain curvature over the whole **[p,m]** space, they are at best only local approximations. An alternative would be to impose global regularity as a constraint on estimation as done by Chalfant [1987] using a Fourier form. Second, we can only draw statistical inferences about our negativity conditions in 5 of 6 cases reported in Table 4.41: if all eigenvalues are less than zero, then we certainly would not reject the null hypothesis of concavity. The only question is whether one should accept or reject the null hypothesis in the sixth case. Nevertheless, our result is important from a policy vantage point because it allows us to make welfare applications of the model, although the presence of one positive root in the 1990 unrestricted model is of some concern. There have been other approaches to investigating issues of curvature. Chalfant, Gray, and White [1991] have used a Bayesian approach, via Monte Carlo integration and importance sampling, to assess curvature, monotonicity, and substitution relationships. Whether or not adopting this approach would lead to different estimates in the context of the present study is an empirical matter that exceeds the scope of this study and holds potential for future econometric work.

4.9 Goodness of Fit

Hitherto, we have presented a discussion of parameter estimates and associated elasticities. It is, however, appropriate to consider a further issue of model validation by assessing the statistical properties of our estimated model. In Tables 4.1 - 4.6, we presented the system weighted R^2 and the F-statistics for each budget share equation. The F-statistics correspond to the second stage of the 3SLS and must be interpreted as such. The weighted R^2 is a statistical measure of goodness of fit, i.e. it measures the proportion of variation in the household budget shares explained by our set of explanatory variables. Notice that we are interested in the system weighted R^2 here as opposed to a single-equation R^2 whose significance and interpretation is limited in this context. A system weighted R^2 provides a goodness of fit measure based on joint performance of all equations in the system rather than a measure obtained from a single objective function especially since all our equations were estimated using 3SLS by stacking all our equations and performing a single regression with the stacked observations weighted by the inverse of the model error covariance matrix. The system weighted R^2 is a goodness of fit measure of the entire system and is given by:

$$R^2 = \frac{1 - \hat{e}^T(\Sigma^{-1} \otimes I)\hat{e}}{W^T(\Sigma^{-1} \otimes D_T)W}$$

where DT=IT-jj/T is an idempotent matrix, e is a vector of GLS residuals, and (∑-1⊗I) is the weight. (see McElroy 1977 for details).

It should be emphasized that the R^2 values only provide information that complements our theoretical and statistical evaluation of our estimated parameters. In particular, R^2 values are particularly sensitive to the range taken by the endogenous variables. For instance, the values tend to be higher for quantity or expenditure dependent models and much lower for share equations. Furthermore, explained variation increases as more regressors are added to the model even when such increase in explained variation may not be significant by some other criteria such as likelihood ratio or F tests. In general, one needs to evaluate other measures like estimated parameters and elasticities in terms of their plausibility with the theory. .

The results show that system weighted R^2 values range from 0.35 to 0.53 for both the restricted and unrestricted models. Although these values suggest that only about 50 percent of the total variation in respective household budget shares is explained by our present ALIDS, this result nevertheless represents a reasonable fit considering that cross-section data are employed in this study. Typically, we would expect R^2 values from budget share estimates based on cross-section data to be much smaller than ones derived from time series data where variables are highly correlated overtime. Reasons for such low values may be varied and may include, *inter alia*, measurement errors from data reporting or coding, extreme values in cross-sectional data series, model misspecification, and randomness in the behaviour of households. All 2SLS F-statistics produce p values less than .0001, indicating that the model variables taken together are statistically significant in explaining observed variations in budget share allocation for the respective food categories around their respective means.

4.10 Validating the Household ALIDS

So far, our validation has been confined to investigating the precision and plausibility of parameter estimates, elasticities, theoretical restrictions, and goodness of fit. In this section, we evaluate the predictive performance of our ALIDS since validating a model via forecasting is equivalent to testing a model's stability and hence enables us to evaluate the model's goodness of fit to data. We employ Theil's [1971] forecast error statistics, U and $U1$, in which we basically wish to determine the proximity of predicted budget shares to the observed budget shares of all food commodities over all cross-sections. To achieve this, we took the combined PUMDT data and divided it into two parts: Eastern Canada (Atlantic, Quebec, and Ontario provinces) and Western Canada (Prairies and Pacific region) using appropriate data handling statements in SAS. We then proceeded to estimate the model for Eastern Canada. This estimated sub-model (Model 1) was subsequently employed to forecast budget shares for Western Canada (Model II). Finally, a comparison of the goodness of fit statistics generated from Model 1 and Model 2 provided us with a basis for validation: if there is no discernible difference in the goodness of fit statistics between the two models, then we can conclude that the model is validated, so that additional cross-sectional units enable us to forecast just as well as those employed for estimation.

The results are presented in Table 4.42. Looking at Theil's U and $U1$ statistics, we see that these statistics are close to the ideal value of zero, implying that the simulation is quite good.

Table 4.42 Theil's U1 and U Statistics: 1984, 1986, and 1990.

	1984		1986		1990	
Share	U1	U	U1	U	U1	U
W1	0.0095	0.0047	0.0017	0.0012	0.0059	0.0032
W2	0.0046	0.0023	0.0045	0.0027	0.0045	0.0023
W3	0.0053	0.0026	0.0029	0.0021	0.0043	0.0034
W4	0.0063	0.0031	0.0035	0.0027	0.0084	0.0065
W5	0.0052	0.0021	0.0049	0.0039	0.0091	0.0057
W6	0.0073	0.0036	0.0041	0.0022	0.0028	0.0013
W7	0.0086	0.0043	0.0068	0.0032	0.0045	0.0036
W8	0.0026	0.0013	0.0050	0.0042	0.0071	0.0054
W9	0.0099	0.0049	0.0029	0.0021	0.0062	0.0042
W10	0.0030	0.0015	0.0037	0.0030	0.0063	0.0029
W11	0.0080	0.0040	0.0028	0.0021	0.0042	0.0037

This is also apparent from the mean percentage error which shows that on average, the amount by which our model overestimates the actual budget shares is quite small. As an alternative to Theil's approach, one can also adopt a dummy variable approach suggested by Judge *et. al.* [1988] to test the validity of our fitted ALIDS model. Using the two datasets pertaining to Model 1 and Model 2 described in the preceding paragraph, it is possible to define an intercept-shifting binary variable representing Western Canada and estimate the model (Model 2) subject to the intercept-shifter for this region. A standard Chow F- test can be employed to evaluate the hypothesis.

4.10.1 Model Validation and Assumptions of the Classical Linear Regression Model.

Before concluding this section, it is instructive to consider several problems that can arise in the context of the classical linear regression model, namely, serial correlation, heteroscedasticity, multicollinearity. and simultaneous equation bias. First, this study assumes that all errors are serially independent in view of the fact that we are employing cross-sectional data. Second, the use of such data suggests that the error term may not be homoscedastic given that PUMDTs involve heterogeneous household units. Compared to time series data, heteroscedasticity may be the rule rather than the exception in cross-sectional data. If indeed the errors were not homoscedastic, our OLS estimates of the parameter variances would be biased. In order to establish whether or not heteroscedasticity was a problem, we used a quick intuitive approach of examining the constance of the error variance, $\hat{e}^T\hat{e}$. Simple visual inspection suggests that the squared residuals exhibit no systematic pattern. This is obviously a simple test. One could employ the more sophisticated White-*test* or the Breusch-Pagan-*test* and evaluate the χ^2 values for the presence or absence of heteroscedasticity. However, we did not venture into this because it will complicate our analysis. Nevertheless, as pointed out in Section 4.3, one advantage of estimating share equations is precisely the fact they involve less heteroscedasticity than quantity-dependent specifications since total variability of shares is less than that associated with quantity. This may allow us to proceed with estimation with slight confidence in the precision of our estimates. In any case, as Judge *et. al.* [1988] point out, significance tests suggesting the presence of heteroscedasticity can also indicate other types of misspecification errors (e.g. omitted variables or simply inappropriate functional form). Further more, if one were to proceed with correcting for heteroscedasticity, one needs strong *a priori* knowledge of which variables to use as a weight to transform the variance. Needless to say, when dichotomous relationships are present, such remedial measures can become quite complicated.

4.11 Summary

This Chapter has demonstrated the importance of incorporating economic and demographic variables in the analysis of household food-at-home expenditures, as evidenced by our *F*-test values for the null hypothesis that demographic variables do not play a significant role in explaining household FAH expenditure patterns. With regard to demographic variables, it was interesting to observe how household size, and age of head of household affected the sensitivity of food-at-home expenditures by a typical household through out its life-cycle. The estimated parameters are highly significant in most cases and both their signs and orders of magnitude are plausible and in keeping with *a priori* expectations. In addition, all theoretical restrictions of neoclassical theory were tested. Based on *F*-tests, homogeneity was not rejected. However, symmetry was rejected while concavity of the expenditure function was established as indicated by the nonpositive eigenvalues, thus enabling some welfare applications to be made.

We also validated our model by not only examining goodness-of-fit statistics (all of which were reasonably high given cross-sectional data), but also computing Theil's U and U1 statistics. These statistics were quite favourable.

Chapter 5

Accounting for Zero Food at Home Consumption in Microdata: A Tobit Model using the Heckman Procedure

5.1 Introduction

In the preceding analysis, our assumption in deriving the ALIDS is that the dependent variable, w_i, takes only nonzero positive values. We eschewed this problem by excluding those observations from the above analysis. Hence, an aspect of our SAS dataset management (described in Chapter 3) involved the deletion from the PUMDTs all those observations for which reported household expenditures on food-at-home was zero over the observation period. This was done because zero values of the dependent variable (i.e. zero budget shares) imply a censored dependent variable and hence a violation of the multivariate normality assumption leading to biased parameter estimates. Given the small proportion of households reporting zero expenditures, we believed that excluding such households did not lead to serious sample selection bias. In the absence of any statistical test of hypothesis, this is a bold assumption. Our rejection of the theoretical restriction of symmetry persuades us to investigate further whether we have introduced some bias in our sample by such deletion.

The objective of this section is to simply demonstrate whether or not the elimination of zero consumption households does in fact yield parameter estimates that are dramatically different from ones that would be obtained if an alternative method incorporating zero observations were employed. In this regard, we can treat this exercise as an aspect of model validation, albeit unorthodox. This is especially important in that it may just be the case that differences between households are systematic, in which case excluding even a few observations from the sample may result in loss of information. Thus, although reports of zero expenditures are due to misreporting by households, it is also true that because budget surveys record diaries over short durations (two weeks in our PUMDTs), these records may present an inaccurate picture of the underlying consumption preference structure of a given household. In fact, zero expenditures may be observed for infrequently purchased foods even though a given household did in fact consume the item. On the other hand, non consumption of a commodity by a household may be purely due to the fact that such a household does not derive any utility from a particular commodity for a variety of economic and cultural reasons. Hence, the basic question is, How can we account for these zero purchases in order to calculate elasticities conditional on both those households already in the market and those not in the market for a given commodity? This is the issue that we now consider in the next section. It is emphasized that because this exercise is purely investigatory, the subsequent analysis does not go beyond evaluating the statistical significance of the censored model parameters.

5.2 A Tobit Analysis of Zero Expenditures

In order to address the above problem, we shall use a censored regression technique based on work by Gronau [1974], Cragg [1971], Amemiya [1978, 1984], Nelson and Olson [1978], Lee [1978], and Heckman [1978, 1979, 1990]. All these works are generalizations of Tobin's [1958] original work and have lead to a group of models called Tobit models. Applications to food demand analysis include work Heien and Wessells [1990], and Burton, Tomlinson, Young [1994]. We will not present any discussion of alternative methods of dealing with the censored variable. These are addressed by Deaton and Irish [1984], Kay, Keen, and Morris [1984], Gould [1992], and Heien and Durham [1991].

Formally, a variable is considered censored if it cannot take on certain values. In the case of our ALIDS, we are saying the budget shares, w_i, cannot assume negative values. Tobin [1958] was the first to identify this problem in his pioneering work and showed that the application of OLS yielded biased and inconsistent estimates. Tobin termed his model 'limited dependent variable model' where the assumption is that a number of its values are clustered at some limiting values, typically zero. Tobin's work is related to literature on Probit analysis, and for this reason, Golberger [1964], referred to Tobin's model as a *Tobit* since the actual estimation procedure employs the Probit analysis model where the Probit basically defines a continuous variable such that we can make standard assumptions about the dependent variable and the error term. The theory behind the Probit has been well treated by Maddala [1983]. The essence is that there exists an underlying response or unobservable variable y^* defined by the regression

$$y^* = \beta^T x + e \tag{5.1}$$

Since y^* is unobservable in practice, a binary variable y is defined in the usual way as:

$$y = 1 \text{ if } y^* > 0$$

$$y = 0 \text{ if } y^* \leq 0 \tag{5.2}$$

and the Probit is employed to determine the probability that a household will purchase a given commodity. Hence, the censored variable is analyzed in the general Probit framework of the form:

$$prob\,[y=1] = prob[y^*>0] = prob\,(e_i > -\beta^T x) \tag{5.3}$$

where x is a vector of explanatory variables (in our ALIDS case, it corresponds to the set of prices, food-at-home expenditure, household size, age of head, and region as defined by equation (4.13); β is a k-dimensional vector of unknown parameters that delineate the effect of a proportional change in x on the probability; e is a vector of stochastic errors assumed to be $n.i.d.(0, \sigma^2)$; F is the cumulative distribution function of e and its functional form is given by

$$F\left(\frac{-\beta^T x}{\sigma}\right) = \int_{-\infty}^{\frac{-\beta^T x}{\sigma}} \frac{1}{\sqrt{2\Pi}} \exp(-\frac{t^2}{2})\,dt \tag{5.4}$$

Note that in this formulation, $\beta^T x$ is $E(y^*|x)$ and not $E(y|x)$ as in the linear probability model. The probability in (4.35) imply that the observed values y are simply realizations of a binomial process with probabilities varying from one draw to another depending on x.

The likelihood function corresponding to this model is:

$$\mathcal{L}(\beta,\sigma_e^2;y) = \prod_{[\forall y]} prob(y) = \prod_{[\forall y=0]} F\frac{(-\beta^T x)}{\sigma_e} \prod_{[\forall y=1]} [1 - F\frac{(-\beta^T x)}{\sigma_e} \qquad 5.5$$

In terms of the Tobit, we are saying that our observations on expenditure shares, wi, can only be zero or positive: the household can buy something or nothing and no negative expenditures are allowed. The data is therefore partly discrete and partly continuous. In our case, the continuous response is censored at zero. In general, Tobit models belong to a class of models sometimes called censored or truncated regressions. According to Amemiya [1984], a model is censored if one can at least observe the exogenous variables, in which case the only information missing pertains to values of the dependent variables in the observable range. In contrast, a model is truncated if one observes neither the value of the dependent variable nor the exogenous variable outside a specified range, for instance, if no observations are available on households who do not make a purchase.

To formalize the essence of the Tobit, let

$$Y = X^T\beta + e^* \qquad 5.6$$

represent as regression model for the utility maximizing amount of expenditure on a given food commodity, where as before, X is a vector of explanatory variables and e_i~$N(0, \sigma^2)$ and it is independent of other errors. If the household purchased the ith food commodity during the survey period, then Y is the actual expenditure and it is positive. On the other hand, if the household is listed as not having purchased the commodity, then Y is not observed and is therefore recorded as zero. Hence, what we actually observe is a variable y defined as

$$y = \max(0, X^T\beta + e) \qquad 5.7$$

or more explicitly

$$y = X^T\beta + e \qquad \text{if } Y = X^T\beta + e > 0$$

$$y = 0 \qquad \text{otherwise} \tag{5.8}$$

Hence, equation 5.6 becomes

$$y = X^T\beta + e \tag{5.9}$$

where $X^T\beta + e$ is a latent variable observed when zero or positive but censored at zero (when it would otherwise be negative); e is censored at $-X^T\beta$. Notice that censoring y at zero and e at $-X^T\beta$ amounts to truncating the lower tail of the y distribution. Hence, the probabilities are accumulated at the cut-off point such that the means of y and e will differ from the corresponding Y and e^* respectively. Therefore, restricting the range of values that the dependent variable can take results in nonzero means of the error and hence in biased and inconsistent OLS estimators. A maximum likelihood procedure is thus applied to obtain consistent estimates of β and σ^2.

The likelihood function comprises two parts: a component for those observations on y that are positive and another for those observations that are zero. Thus, as in the Probit, the sample of H observations is divided into the first H_0 observations for which Y=0 and the remainder H_1 into observations for which $Y > 0$. Explicitly, we have the following:

i). If $Y = 0$, than all that is known is that

$$y = X^T\beta + e < 0 \quad \text{or } e < -X^T\beta, \text{ so}$$

$$\text{prob}(Y{=}0) = \text{prob}[e < -X^T\beta]$$

$$= \int_{-\infty}^{X^T\beta} f(e)\,de = 1 - F(X^T\beta) = 1 - F \tag{5.10}$$

and follows from the fact that e has a symmetric distribution, where F is the cumulative distributive density function defined in (5.4), hence the relationship with the Probit.

ii). If $Y > 0$, we have

$$y = X^T\beta + e > 0$$

Therefore, the probability o a purchase is given by

$$\text{prob}(Y{>}0)\ \text{f}(y|Y>0) = F\,\frac{f(y - X^T\beta,\ \sigma^2)}{F}$$

$$= \frac{1}{\sqrt{2\pi\sigma^2}}\ \exp(-\frac{1}{2}\sigma^2)\,(y - X^T\beta)^T(y - X^T\beta) \qquad 5.11$$

where $f(.)$ and $F(.)$ are normal and cumulative density functions evaluated at $X^T\beta$. Since we observe y and X, we can find β and σ^2.

The likelihood function corresponding to the Tobit is then derived by taking the product over the zero observations and the product over the positive observations. Doing this for all H observations, the function can be expressed as

$$L(\beta, \sigma^2, Y) = \text{prob}(Y)$$

$$= \prod_{(\forall\, Y=0)} 1 - F\left(\frac{-X^T\beta}{\sigma}\right) \prod_{(\forall\, Y>0)} \frac{1}{\sqrt{2\pi\sigma^2}}\ \exp(-\frac{1}{2}\sigma^2)\,(y - X^T\beta)^T(y - X^T\beta) \qquad 5.12$$

and the corresponding log likelihood function is:

$$ln\ L = \sum_{(\forall Y=0)} \ln(1 - F) - \left(\frac{H_1}{2}\right)\ln 2\pi - \left(\frac{H_1}{2}\right)\ln 2\sigma^2 - \sum_{(\forall Y>0)} \frac{(y - X^T\beta)^T(y - X^T\beta)}{2\sigma^2} \qquad 5.13$$

Although the log likelihood function can be maximized using the Newton-Raphson method which uses a matrix of second order derivatives, Amemiya [1973] has shown that the expressions for the second order partials are quite cumbersome. Fair [1977] proposed a simpler method of scoring which uses the information matrix in place of the negative of the Hessian. An even simpler and ingenious method was suggested by Heckman [1979]. His method characterizes sample selection as a specification error due to an omitted variable. The omitted variable is first estimated and subsequently incorporated as a probability dependent instrument in a second step using OLS.

To illustrate the Heckman procedure, we begin by defining an equation

$$y = X^T\beta + e \qquad 5.14$$

for the H_1 observations for which $Y > 0$ and both y and e are truncated normal variables. The conditional expectation of y given $Y > 0$ is

$$E(y|Y>0) = X^T\beta + E(e|Y>0)$$

$$= X^T\beta + E(e|e^*>-X^T\beta) \qquad 5.15$$

Since $e_i^* \sim N(0,\sigma^2)$, the mean associated with the corresponding truncated variable e can be shown to be given by

$$E(y|Y>0) = E(e/e^*>-X^T\beta) = \frac{\sigma^2}{\sqrt{\sigma^2}}\lambda_i \qquad 5.16$$

where

$$\lambda_i = \frac{\phi(-X^T\beta/\sqrt{\sigma^2})}{\Phi(-X^T\beta/\sqrt{\sigma^2})} \qquad 5.17$$

and ϕ and Φ are density and cumulative probability functions of a standard normal random variable evaluated at the argument. λ_i is the inverse of Mill's ratio and in reliability theory it is called the hazard rate or mortality rate.[17] Note two interesting properties of λ_i: first, its denominator represents the probability that the i^{th} observation has data for y; second, it value is inversely related to the probability, i.e. the lower the probability that an observation has data on y, the larger the value of λ_i associated with that observation. In other words,

$$\partial\frac{\lambda_i}{\partial\phi_i} > 0$$

and

$$\lim_{\phi_i\to\infty} \lambda_i = \infty \qquad \lim_{\phi_i\to-\infty} \lambda_i = 0 \qquad 5.18$$

Hence, according to Heckman, samples in which the selectivity problem is trivial (such that the sample selection rule guarantees that all potential population observations are sampled), λ_i becomes insignificantly small, thus allowing least squares estimates to have optimal properties.

Based on this result, the conditional expectation of y given $Y > 0$ can be written as

$$E(y|Y>0) = X^T\beta + \frac{\sigma^2}{\sqrt{\sigma^2}}\lambda_i \qquad 5.19$$

[17] See for instance Johnson and Kotz [1970]; and Barlow and Proschan [1975].

and allowing for the nonzero mean of e, we can write the regression for the H_1 observations for which $Y > 0$ as

$$y = X^T\beta + \frac{\sigma^2}{\sqrt{\sigma^2}}\lambda_i + e \qquad 5.20$$

where $E(e) = 0$ since $e = Y - E(y|Y>0)$. The problem with OLS is that it omits the second term on the right hand side of 5.20. If λ_i were known, we would estimate β and σ consistently using OLS. Since λ_i is unobservable, Heckman proposes a two-step consistent estimation procedure which reflects the importance of having a censored rather than a truncated sample. A likelihood function is formed for some binary variable as follows:

$$Z_i = 1 \quad \text{if } Y > 0$$

$$Z_i = 0 \quad \text{if } Y \leq 0 \qquad 5.21$$

The log likelihood function corresponding to this variable is given by

$$lnL = \sum_{i=}^{H} \ln F\left((1 - Z_i)\left[\frac{-X^T\beta}{\sigma}\right] + Z_i\left[-\frac{1}{2}\ln(2\pi\sigma^2) - \frac{1}{2}\frac{(y - X^T\beta)^T(y - X^T\beta)}{\sigma^2}\right]\right) \qquad 5.22$$

which is the likelihood function for the Probit defined above, the difference of course being that for the Probit, the error variance is unity while for the Tobit, it is σ^2 . It is the maximization of this function that is the basis for Heckman's two-step procedure for computing consistent estimates of the relevant parameters. Specifically, the two steps can be summarized as follows:

Step 1: Use the Probit MLE to estimate the inverse Mill's ratio λ (call it $\hat{\lambda}$). This is a Probit in that the dependent variable is 1 or 0 depending on whether or not y is observable.

Step 2: Using H_1 observations for which $Y > 0$, replace λ by $\hat{\lambda}$ in the likelihood function (5.22) and regress y on X and $\hat{\lambda}$ via OLS to obtain estimated values of β and σ^2.

This additional regressor is a function of the probability of a household purchasing the commodity.

The estimates of β are consistent and asymptotically normally distributed. However, because e^* is truncated, we have heteroscedasticity. Hence, our calculated standard errors are biased and inconsistent. This result has been demonstrated by Amemiya [1984] and it can easily be shown that the variance of e reduces to

$$E(ee^T) = \sigma^2 - \sigma^2 (X^T\beta/\sigma)\lambda - \sigma^2\lambda^2 \qquad 5.23$$

implying that X does indeed contain nontrivial regressors. The Heckman procedure yields an immediate test for the efficiency of OLS, i.e. if the coefficient on the Inverse Mills Ratio variable is statistically insignificant. This issue is carefully addressed in our actual estimation. See discussion below.

In terms of our ALIDS model, the decision to purchase or not to purchase is indicated by the 12 budget shares (corresponding to the 12 food commodities) which are indicated as binary (dependent) variables censored by a subset of unobservable latent variables. Each budget share, w_i, is either zero or some positive amount for each household. Thus, in stage one, the consumption decision is specified as a dichotomous choice problem

$$w_i^h = f(p_1^h, p_2^h, ..., p_{12}, m^h, D_1^h, D_2^h, ..., D_{17}^h) \qquad 5.24$$

where all variables are as defined in equation (4.13).

In the second step, the inverse Mills ratio is computed for each household. This ratio serves as an instrument that incorporates the censoring variables in the second stage of the estimation of the ALIDS demand system. The inverse Mills ratio for the i^{th} commodity in the h^{th} household is given by

$$R_i^h = \frac{\varphi(p^h, D^h, m^h)}{\Phi(p^h, D^h, m^h)} \qquad 5.25$$

where p^h is a vector of prices for the h^{th} household, D^h is a vector of demographic variables for the h^{th} household, and φ and Φ represent the density and cumulative probability functions, respectively. The inverse Mills ratio for households not consuming the i^{th} commodity is computed as:

$$R_i^h = \frac{\varphi(p^h, D^h, m^h)}{[1 - \Phi(p^h, D^h, m^h)]} \qquad 5.26$$

With these modifications, our ALIDS in 4.13 can now be respecified as:

$$w_i^h = \alpha_{io}^h + \sum_j \ln p_j^h + \beta_i \ln(\frac{m}{P}) + \sum_j \delta_{ij} D_j^h + r_i R_i^h \qquad 5.27$$

All the theoretical restrictions of economic theory remain the same except that now the summability restriction further requires that $\sum_i r_i R_i^h = 0$. However, as noted by Heien and Wessells, this restriction is not generally possible since if all n equations are specified as above, summability would not be preserved since R_i could assume any value. Hence, summability is preserved by respecifying the equation corresponding to the 'OTHER' category (the omitted equation in 4.13) as:

$$w_i^h = \alpha_{io}^h + \sum_j \ln p_j^h + \beta_i \ln(\frac{m}{P}) + \sum_j \delta_{ij} D_j^h - \sum_j^{n-1} r_j R_i^h \qquad 5.28$$

Thus, in the second step, the entire system is re-estimated using iterative 3SLS conditional on homogeneity and symmetry. Recall again that the endogeneity problem associated with expenditure carries over to this equation. Hence, 3SLS is appropriate to correct for this endogeneity, and means that we must modify step two of the Heckit model to run 3SLS instead of OLS. Note that for households not consuming a given commodity, we have the problem of missing prices. As a proxy, we adopted the *ad hoc* procedure of using sample means prices for all household units reporting zero expenditure. Various approaches to dealing with missing prices are considered by Gourieroux and Montfort [1981], Heien and Pompelli

[1988], and Cox and Wohlgenant [1986]. A final point related to estimation concerns the heterscedasticity problem arising from the fact that e^* is truncated, and leads to biased and inconsistent calculated standard errors. In actual estimation, we have taken this problem into accounted and calculated correct standard errors for the second stage of the Heckit models.

For this section only, all data processing was handled by SAS which has superb data programming capabilities. Using relevant SAS statements, we transferred the reconstituted data to SHAZAM and estimated the Heckit model accordingly. SHAZAM has a matrix routine that enables one to not only compute the inverse Mill's ratio, but also to calculate a heteroscedastic-consistent variance covariance matrix in step two. All SAS and SHAZAM routines were performed using Sunsparc UNIX workstations.

5.3 Estimated Results

Tables 5.1 - 5.6 present estimated parameters along with goodness of fit statistics and Marshallian elasticities. All the results are conditional on homogeneity and symmetry restrictions. Once again, since the objective of this exercise is verification, we do not present a full range of elasticities and other regularity tests since these can be reasonably inferred from the estimates. These results are quite encouraging for several reasons. First, all parameter estimates are statistically significant and both their signs and orders of magnitude are not quantitatively different from the uncensored ALIDS. Second, and probably the key variable, is the parameter estimate for the instrument R_i delineated by r_i. The significance levels for r_i in all 11 equations are below 2 in absolute value. This leads us to assert that the addition of the inverse Mills ratio to the ALIDS model as a variable incorporating censoring latent variables does not significantly alter the qualitative or quantitative implications of our results. In this case, we can conclude that deleting zero observations as we did, yields reliable estimates. *A posteriori*, this result should not come as a surprise since sample selection bias is proportional to the probability of zero observations,

Table 5.1 Homogeneity and Symmetry Restricted Heckit Model: Parameter Estimates and Mean Budget Shares: 1984

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
Wi	0.11427	0.03915	0.05585	0.07957	0.04136	0.13160	0.17090	0.01171	0.15288	0.02501	0.11139	0.09885
αi	0.13229	0.05467	0.07792	0.05620	0.01909	0.13140	0.12036	0.01773	0.13868	0.03658	0.12152	0.09356
	8.51[a]	*7.14*	*9.13*	*5.53*	*2.27*	*10.64*	*8.59*	*4.28*	*8.48*	*7.43*	*9.30*	
$\gamma i1$	0.01360											
	45.49											
$\gamma i2$	-0.00052	0.00765										
	-3.96	*64.45*										
$\gamma i3$	-0.00086	-0.00074	0.00909									
	-6.29	*-8.52*	*70.34*									
$\gamma i4$	-0.00094	-0.00046	-0.00088	0.00955								
	-5.66	*-4.26*	*-7.74*	*48.58*								
$\gamma i5$	-0.00042	-0.00055	-0.00057	-0.00088	0.00609							
	-3.21	*-6.65*	*-6.53*	*-8.20*	*52.08*							
$\gamma i6$	-0.00182	-0.00092	-0.00135	-0.00057	-0.00068	0.01815						
	-8.30	*-5.92*	*-8.48*	*-2.89*	*-4.61*	*42.26*						
$\gamma i7$	-0.00227	-0.00121	-0.00069	-0.00148	-0.00017	-0.00434	0.02263					
	-9.22	*-7.13*	*-4.03*	*-6.80*	*-1.05*	*-13.16*	*45.84*					
$\gamma i8$	-0.00017	-0.00019	-0.00014	-0.00028	-0.00016	0.00000	-0.00001	0.00139				
	-2.22	*-3.38*	*-2.52*	*-3.96*	*-3.01*	*-0.04*	*-0.12*	*22.17*				
$\gamma i9$	-0.00293	-0.00164	-0.00240	-0.00231	-0.00109	-0.00545	-0.00761	-0.00039	0.03024			
	-10.67	*-8.82*	*-12.53*	*-9.70*	*-6.09*	*-14.78*	*-19.24*	*-3.02*	*51.95*			
$\gamma i,10$	-0.00042	-0.00028	-0.00045	-0.00045	-0.00033	-0.00044	-0.00064	0.00005	-0.00847	0.00453		
	-4.73	*-4.42*	*-7.03*	*-5.56*	*-5.44*	*-3.43*	*-4.77*	*1.08*	*-5.75*	*59.52*		
$\gamma i,11$	-0.00179	-0.00080	-0.00046	-0.00093	-0.00074	-0.00211	-0.00031	-0.00010	-0.00359	-0.00505	0.01517	
	-8.49	*-5.83*	*-3.21*	*-5.25*	*-5.47*	*-8.46*	*-11.36*	*-1.11*	*-11.90*	*-4.92*	*48.15*	
$\gamma i,12$	-0.00148	-0.00035	-0.00057	-0.00039	-0.00052	-0.00050	-0.00109	0.00002	-0.00198	-0.00205	-0.00103	0.00992
	-8.54	*-2.95*	*-4.74*	*-2.55*	*-4.43*	*-2.26*	*-4.50*	*0.16*	*-7.62*	*-2.25*	*-5.41*	
βi	-0.01134	0.01069	0.00857	0.00951	0.02000	-0.01804	0.00999	0.00058	-0.01310	0.00414	-0.00830	-0.01272
	-1.72	*3.31*	*2.38*	*2.22*	*5.64*	*-3.47*	*1.68*	*-0.03*	*-1.90*	*2.00*	*-1.50*	

Table 5.1 (continued)

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
δiH2	-0.01483	0.00620	0.00403	0.01132	0.02319	-0.04132	0.03628	0.00274	-0.02469	0.01723	0.00601	-0.02616
	-1.24	*1.06*	*0.62*	*1.46*	*3.63*	*-4.42*	*3.41*	*0.87*	*-2.00*	*4.63*	*0.60*	
δiH3	-0.03533	0.01024	0.00652	0.00629	-0.02042	0.00952	0.03951	-0.00055	0.00725	0.00665	0.00095	-0.03061
	-2.26	*1.34*	*0.76*	*0.62*	*-2.43*	*0.77*	*2.82*	*-0.13*	*0.44*	*1.36*	*0.72*	
δiH4	-0.00885	-0.00011	-0.00292	0.01457	-0.00296	0.01472	0.05777	0.00299	-0.04267	0.00302	-0.01933	-0.01624
	-0.48	*-0.02*	*-0.29*	*1.22*	*-0.30*	*1.02*	*3.52*	*0.62*	*-2.23*	*0.52*	*-1.26*	
δiH5	-0.03742	0.03029	0.01978	0.00136	0.01822	0.00190	0.05673	-0.00620	-0.10018	0.01010	0.05779	-0.05237
	-1.23	*2.04*	*1.19*	*0.07*	*1.12*	*0.08*	*2.08*	*-0.77*	*-3.17*	*1.06*	*2.27*	
δiH6	0.00996	0.03553	-0.00981	0.03923	0.04912	-0.04385	0.03922	-0.00152	-0.09419	0.00053	0.02935	-0.05356
	0.17	*1.26*	*-0.31*	*1.04*	*1.58*	*-0.96*	*0.72*	*-0.10*	*-1.57*	*0.02*	*0.61*	
δiH7	0.05674	0.05574	0.01670	0.12466	-0.01213	0.04453	-0.04220	-0.04246	-0.09517	0.03130	-0.09626	-0.04145
	0.66	*1.33*	*0.35*	*2.23*	*-0.26*	*0.66*	*-0.55*	*-1.88*	*-1.06*	*1.16*	*-1.34*	
δiA35	0.02281	-0.00091	-0.00292	-0.01300	0.00633	0.00202	0.00898	0.00123	-0.03581	-0.00533	0.03057	-0.01397
	1.62	*-0.13*	*-0.38*	*-1.42*	*0.83*	*0.18*	*0.72*	*0.33*	*-2.45*	*1.21*	*2.60*	
δiA45	0.00745	0.00356	0.00518	-0.01455	0.00133	0.00465	0.00674	0.00841	-0.05776	0.01374	0.04944	-0.02818
	0.41	*0.40*	*0.52*	*-1.23*	*0.13*	*0.32*	*0.41*	*1.75*	*-3.05*	*2.41*	*3.24*	
δiA55	0.00800	0.00106	-0.00521	-0.00836	-0.00610	-0.03842	0.02205	0.00148	-0.00687	-0.00320	0.03117	0.00442
	0.05	*0.12*	*-0.54*	*-0.73*	*-0.64*	*-2.78*	*1.40*	*0.32*	*-0.38*	*-0.58*	*2.15*	
δiA65	-0.01125	0.01166	0.00633	0.01158	-0.00813	-0.01954	0.00776	0.00489	0.00557	0.00045	0.00997	-0.01930
	-0.83	*1.76*	*0.85*	*1.31*	*-1.17*	*-1.83*	*0.64*	*1.34*	*0.69*	*0.10*	*0.88*	
δiR2	0.01532	-0.00188	-0.00797	0.01447	-0.00947	-0.00179	0.03507	-0.01407	-0.03828	0.00563	0.00594	-0.00297
	0.96	*-0.24*	*-0.92*	*1.41*	*-1.11*	*-0.14*	*2.48*	*-3.38*	*-2.33*	*1.13*	*0.44*	
δiR3	-0.02449	-0.00409	-0.01346	0.03108	0.00059	0.01443	0.02076	-0.00684	0.01157	-0.00882	-0.03853	0.01780
	-1.65	*-0.56*	*-1.67*	*3.24*	*0.07*	*1.24*	*1.57*	*-1.77*	*0.75*	*-1.91*	*-3.12*	
δiR4	-0.03373	-0.00262	-0.01272	0.01803	0.01746	0.00728	0.03179	-0.01114	-0.03609	-0.00064	0.01194	0.01044
	-2.52	*-0.40*	*-1.74*	*2.08*	*2.43*	*0.69*	*2.66*	*-3.17*	*-2.60*	*-0.15*	*1.07*	
δiR5	-0.00415	0.01065	-0.01175	0.00612	0.02930	-0.00191	0.00826	-0.00863	-0.03327	0.00166	0.00028	0.00346
	-0.24	*1.28*	*-1.27*	*0.55*	*3.21*	*-0.14*	*0.55*	*-1.94*	*-1.89*	*0.31*	*0.02*	
δiQ2	0.00986	0.00159	-0.00177	-0.00710	0.01435	0.01841	-0.00878	-0.00209	-0.00882	0.00245	-0.01109	-0.00703
	0.74	*0.24*	*0.03*	*-0.88*	*2.02*	*1.78*	*-0.74*	*-1.60*	*-0.64*	*0.59*	*-1.00*	
δiQ3	-0.00039	0.00191	0.00024	0.00159	0.02083	-0.01972	-0.01705	-0.00566	-0.00582	0.00416	0.01756	0.00234
	-0.03	*0.31*	*-0.56*	*0.19*	*3.05*	*-1.98*	*-1.50*	*-1.69*	*-0.44*	*1.05*	*1.66*	
δiQ4	-0.00813	-0.00405	-0.00397	0.01366	0.01459	0.01979	-0.02878	-0.00111	-0.01782	0.00839	0.01098	-0.00357
	-0.62	*-0.63*	*-1.24*	*1.62*	*2.09*	*1.94*	*-2.48*	*-0.32*	*-1.32*	*0.15*	*1.02*	
IMR	0.00100	0.00591	0.00816	0.00547	0.00222	0.00142	0.00112	0.00212	0.00155	0.00387	0.00126	-0.0341
	1.06	*1.64*	*1.43*	*1.00*	*0.99*	*0.89*	*1.23*	*1.31*	*1.75*	*1.02*	*0.98*	

a. Figures in italics are ratios of parameter estimates to standard errors.

Table 5.2 Homogeneity and Symmetry Restricted Heckit Model: Parameters Estimates and mean Budget Shares. 1986.

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
W_i	0.09212	0.03287	0.04896	0.07547	0.03507	0.18909	0.15589	0.00890	0.14478	0.02233	0.10268	0.09182
α_i	0.09040	0.05482	0.06540	0.06880	0.03668	0.10415	0.14162	0.00683	0.06600	0.03277	0.19210	0.14042
	9.44'	*11.17*	*10.80*	*9.67*	*6.53*	*11.41*	*14.25*	*2.52*	*5.86*	*10.33*	*20.53*	
γ_{i1}	0.01084											
	63.02											
γ_{i2}	-0.00040	0.00693										
	-5.18	*91.95*										
γ_{i3}	-0.00083	-0.00062	0.00832									
	-9.37	*-10.54*	*89.70*									
γ_{i4}	-0.00110	-0.00038	-0.00081	0.00940								
	-10.35	*-5.24*	*-10.14*	*67.90*								
γ_{i5}	-0.00056	-0.00046	-0.00041	-0.00085	0.00547							
	-6.88	*-8.52*	*-6.75*	*-11.53*	*69.32*							
γ_{i6}	-0.00147	-0.00118	-0.00105	-0.00141	-0.00071	0.02286						
	-10.45	*-12.06*	*-9.78*	*-10.62*	*-7.15*	*91.16*						
γ_{i7}	-0.00142	-0.00093	-0.00075	-0.00172	-0.00011	-0.00564	0.02142					
	-8.90	*-8.08*	*-6.06*	*-11.21*	*-0.99*	*-26.69*	*61.63*					
γ_{i8}	-0.00013	-0.00012	-0.00008	-0.00016	-0.00009	-0.00009	-0.00001	0.00119				
	-2.80	*-3.18*	*-2.12*	*-3.26*	*-2.70*	*-1.38*	*-0.11*	*27.86*				
γ_{i9}	-0.00195	-0.00179	-0.00194	-0.00136	-0.00093	-0.00606	-0.00608	-0.00040	0.02820			
	-11.09	*-14.38*	*-14.27*	*-8.15*	*-7.44*	*-26.23*	*-21.84*	*-4.62*	*69.48*			
$\gamma_{i,10}$	-0.00033	-0.00030	-0.00047	-0.00027	-0.00036	-0.00028	-0.00043	0.00005	-0.00114	0.00032		
	-6.15	*-7.37*	*-10.94*	*-5.11*	*-9.16*	*-3.70*	*-4.76*	*1.67*	*-11.77*	*80.64*		
$\gamma_{i,11}$	-0.00144	-0.00035	-0.00070	-0.00078	-0.00067	-0.00303	-0.00259	-0.00010	-0.00335	-0.00008	0.01433	
	-10.61	*-3.87*	*-6.89*	*-6.34*	*-7.14*	*-18.22*	*-13.48*	*-1.63*	*-15.93*	*-4.91*	*65.08*	
$\gamma_{i,12}$	-0.00121	-0.00044	-0.00067	-0.00056	-0.00033	-0.00196	-0.00174	-0.00066	-0.00320	0.00378	-0.00100	0.00800
	-9.85	*-5.23*	*-7.21*	*-4.88*	*-3.78*	*-12.69*	*-9.64*	*-1.17*	*-16.37*	*-1.26*	*-6.94*	
β_i	0.00337	0.00803	0.00969	0.00569	0.01168	-0.00930	0.00201	0.00244	0.01329	0.00378	-0.03787	-0.01280
	0.87	*4.09*	*4.00*	*2.00*	*5.18*	*-2.56*	*0.50*	*2.27*	*2.96*	*2.99*	*-10.09*	

Table 5.2 (continued)

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
δiH2	0.00134	0.00786	0.00045	-0.00455	-0.00306	0.02995	0.00421	-0.00038	0.00967	0.00757	-0.04191	-0.01114
	0.19	*2.28*	*0.11*	*-0.91*	*-0.77*	*4.65*	*0.60*	*-0.19*	*1.23*	*3.42*	*-6.37*	
δiH3	-0.00779	0.00420	-0.00029	-0.01155	-0.00586	0.03947	0.00978	0.00135	0.01884	0.00728	-0.04751	-0.00792
	-1.07	*1.14*	*-0.07*	*-2.15*	*-1.38*	*5.68*	*1.30*	*0.66*	*2.22*	*3.05*	*-6.72*	
δiH4	-0.00948	0.00125	-0.00433	-0.01511	-0.00802	0.05382	0.01033	-0.00113	0.02618	0.00389	-0.04810	-0.00930
	-1.32	*0.34*	*-0.96*	*-2.84*	*-1.90*	*7.80*	*1.38*	*-0.55*	*3.11*	*1.64*	*-6.86*	
δiH5	-0.01302	0.0028	-0.00094	-0.01370	-0.01211	0.07242	0.00701	-0.00148	0.02086	0.00253	-0.05187	-0.01254
	-1.58	*0.67*	*-0.87*	*-2.24*	*-2.50*	*9.12*	*0.81*	*-0.63*	*2.15*	*0.93*	*-6.44*	
δiH6	-0.02301	0.00337	0.00761	-0.00940	-0.00631	0.08911	0.00187	-0.00041	0.02320	0.00113	-0.06069	-0.02646
	-1.79	*0.51*	*0.93*	*-0.97*	*-0.82*	*7.18*	*0.14*	*-0.11*	*1.53*	*0.26*	*-4.78*	
δiH7	-0.00966	0.00335	0.00998	-0.02070	-0.00533	0.08614	0.00798	-0.00171	0.01071	0.00120	-0.06262	-0.01932
	-0.69	*0.42*	*1.01*	*-1.80*	*-0.85*	*5.80*	*0.49*	*-0.39*	*0.59*	*0.23*	*-4.12*	
δiA35	0.00551	0.00025	0.00401	0.00294	0.00107	-0.00066	-0.00041	0.00015	0.00597	-0.00075	-0.01254	-0.00553
	-1.13	*0.10*	*1.31*	*0.82*	*0.37*	*-0.14*	*-0.08*	*0.11*	*1.05*	*-0.47*	*-2.64*	
δiA45	-0.00167	-0.00139	0.00205	0.00342	-0.00035	0.01386	0.00284	0.00239	-0.00043	0.00053	-0.00952	-0.01173
	-0.29	*-0.47*	*1.32*	*0.81*	*-0.10*	*2.56*	*0.48*	*1.52*	*-0.06*	*0.29*	*-1.71*	
δiA55	0.00590	-0.00745	0.00274	0.00262	0.00217	0.01563	-0.00238	0.00296	-0.00421	-0.00258	-0.01050	-0.00491
	0.87	*-2.17*	*0.64*	*0.53*	*0.55*	*2.45*	*0.34*	*1.57*	*-0.53*	*-1.17*	*-1.60*	
δiA65	0.00149	-0.00296	-0.00360	-0.00304	0.00109	0.00912	0.00972	0.00175	-0.00916	0.00552	0.00018	-0.01009
	0.19	*-0.77*	*-0.75*	*-0.54*	*0.24*	*1.27*	*1.25*	*0.83*	*-1.04*	*2.24*	*0.02*	
δiR2	0.00356	0.00046	0.00177	0.01087	-0.01121	0.00029	0.00097	0.00449	0.00221	0.00238	0.00247	-0.01826
	0.96	*0.08*	*0.27*	*1.42*	*-1.85*	*0.03*	*0.09*	*1.55*	*0.18*	*0.70*	*0.24*	
δiR3	-0.00895	0.00946	0.00380	-0.00764	0.01135	0.06417	-0.01075	-0.00106	0.06492	-0.00594	-0.05540	-0.06397
	-1.65	*2.19*	*1.68*	*-1.22*	*2.30*	*7.71*	*-1.22*	*-0.43*	*6.51*	*-2.10*	*-6.73*	
δiR4	-0.03939	-0.01746	-0.01366	0.02370	-0.00470	0.01796	0.01502	-0.00463	0.05513	-0.00266	-0.01723	-0.01207
	-3.84	*-3.34*	*-2.12*	*3.12*	*-2.34*	*1.84*	*1.42*	*-1.62*	*4.62*	*-0.79*	*-1.72*	
δiR5	-0.00594	0.00879	0.00444	0.02906	-0.00747	0.00448	-0.02585	-0.00126	0.00577	0.00222	-0.01039	-0.00384
	-0.53	*1.55*	*1.24*	*3.52*	*-3.21*	*0.42*	*-2.25*	*-0.41*	*0.45*	*0.61*	*-0.96*	
δiQ2	0.00410	0.00467	-0.00662	0.00131	0.00058	-0.00385	-0.00059	0.00091	-0.00209	-0.00122	0.00307	-0.00028
	0.86	*1.81*	*-2.08*	*0.35*	*2.02*	*-0.80*	*-0.11*	*0.65*	*-0.35*	*-0.73*	*0.62*	
δiQ3	0.00529	-0.00020	-0.00253	0.00076	0.00061	-0.01156	0.00850	0.00043	-0.00172	-0.00206	0.00016	0.00233
	1.04	*-0.07*	*-0.79*	*0.20*	*3.05*	*-2.39*	*1.62*	*0.29*	*-0.29*	*-1.23*	*0.03*	
δiQ4	0.00287	0.00410	-0.00539	0.00524	-0.00009	-0.00804	-0.01099	0.00173	0.00073	-0.00050	0.00074	0.00960
	0.56	*1.58*	*-0.16*	*1.39*	*-0.03*	*-1.66*	*-2.09*	*1.21*	*0.12*	*-0.30*	*0.14*	
IMR	0.00306	0.00126	0.00140	0.00236	0.00178	0.00140	0.00273	0.00185	0.00120	0.00064	0.00139	
	1.15	*0.82*	*1.15*	*1.02*	*1.28*	*0.82*	*1.37*	*1.75*	*1.52*	*1.02*	*0.74*	

a. Figures in italics are ratios of parameter estimates to standard errors.

Table 5.3 Homogeneity and Symmetry Restricted Heckit Model: Parameter Estimates and Mean Budget Shares: 1990

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
Wi	0.07313	0.02325	0.04530	0.07556	0.03603	0.16076	0.16723	0.00848	0.19021	0.01639	0.09624	0.10742
αi	0.07342	0.03673	0.04790	0.06807	0.04732	0.13096	0.16468	0.00728	0.17069	0.01759	0.11220	0.12316
	7.44[a]	*7.01*	*6.24*	*7.39*	*6.43*	*9.68*	*11.64*	*2.97*	*10.31*	*4.76*	*9.00*	
$\gamma i1$	0.01220											
	87.40											
$\gamma i2$	-0.00065	-0.00789										
	-9.63	*98.13*										
$\gamma i3$	-0.00133	-0.00092	0.01026									
	-15.39	*-14.44*	*92.64*									
$\gamma i4$	-0.00133	-0.00037	-0.00095	0.01085								
	-11.24	*-5.46*	*-10.95*	*78.51*								
$\gamma i5$	-0.00110	-0.00059	-0.00080	-0.00077	0.00729							
	-11.35	*-9.81*	*-10.72*	*-9.34*	*79.05*							
$\gamma i6$	-0.00094	-0.00108	-0.00130	-0.00080	-0.00084	0.02171						
	-9.81	*-10.16*	*-9.79*	*-5.35*	*-6.60*	*68.08*						
$\gamma i7$	-0.00146	-0.00051	-0.00075	-0.00181	-0.00031	-0.00480	0.02263					
	-11.24	*-4.69*	*-5.48*	*-11.77*	*-2.37*	*-20.23*	*66.97*					
$\gamma i8$	-0.00173	-0.00016	-0.00024	-0.00015	-0.00018	-0.00016	-0.00014	0.00141				
	-3.74	*-3.58*	*-4.94*	*-3.00*	*-3.95*	*-0.20*	*-1.74*	*27.72*				
$\gamma i9$	-0.00018	-0.00211	-0.00186	-0.00227	-0.00165	-0.00704	-0.00683	-0.00029	0.03201			
	-11.30	*-18.10*	*-12.34*	*-13.46*	*-11.57*	*-27.25*	*-25.58*	*-3.41*	*78.83*			
$\gamma i,10$	-0.00193	-0.00050	-0.00044	-0.00037	-0.00034	-0.00036	-0.00042	-0.00008	-0.00099	0.00454		
	-9.06	*-10.76*	*-9.08*	*-7.21*	*-7.39*	*-4.46*	*-5.18*	*-2.06*	*-11.65*	*80.67*		
$\gamma i,11$	-0.00045	-0.00059	-0.00077	-0.00117	-0.00081	-0.00219	-0.00295	-0.00005	-0.00294	-0.00039	0.01471	
	-9.29	*-7.00*	*-7.00*	*-9.43*	*-7.72*	*-11.59*	*-15.18*	*-0.76*	*-13.65*	*-6.29*	*63.39*	
$\gamma i,12$	-0.00117	-0.00042	-0.00089	-0.00107	-0.00070	-0.00183	-0.00238	0.00077	-0.00412	-0.00020	-0.00115	0.01315
	-10.59	*-5.29*	*-8.63*	*-9.03*	*-7.02*	*-10.24*	*-12.81*	*1.31*	*-20.16*	*-3.45*	*-7.59*	
βi	-0.00126	0.01491	0.01896	0.00583	0.00934	-0.01918	0.01153	0.00149	-0.02328	0.00949	-0.00654	-0.02128
	2.00	*6.67*	*5.77*	*1.47*	*2.96*	*-3.31*	*-1.89*	*0.94*	*-3.29*	*6.03*	*-1.22*	

Table 5.3 (continued)

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
δiH2	0.00845	0.01157	0.01312	-0.00737	0.01076	0.01344	-0.01041	-0.00392	-0.03528	0.00707	-0.00339	-0.00404
	0.46	*3.36*	*2.59*	*-1.21*	*2.21*	*1.50*	*-1.11*	*-1.61*	*-3.07*	*2.91*	*-0.41*	
δiH3	0.00305	-0.00063	0.01250	-0.00430	-0.00555	0.03099	-0.02868	-0.00132	0.00096	0.00647	-0.00088	-0.01261
	0.33	*-0.13*	*1.87*	*-0.53*	*-0.86*	*2.63*	*-2.32*	*-0.41*	*0.07*	*2.03*	*-0.08*	
δiH4	0.00287	0.00958	0.00694	-0.00440	0.00129	0.04565	-0.01772	-0.00684	-0.01038	0.01093	0.00707	-0.04498
	-1.20	*1.89*	*0.93*	*-2.98*	*0.18*	*3.47*	*-1.28*	*-1.91*	*-0.64*	*3.06*	*0.58*	
δiH5	-0.01158	0.01491	0.02141	-0.01938	0.00188	-0.02548	-0.00429	-0.00274	0.01044	0.00893	0.01744	-0.01153
	-1.70	*1.73*	*1.69*	*-2.24*	*0.15*	*-1.14*	*-0.18*	*-0.45*	*0.38*	*1.47*	*0.84*	
δiH6	-0.02772	0.01850	0.04578	-0.05201	0.03610	0.03601	-0.01702	-0.00792	-0.04880	0.00694	0.02390	-0.01375
	-1.86	*1.21*	*2.04*	*-3.21*	*1.68*	*0.91*	*-0.41*	*-0.73*	*-1.01*	*0.64*	*0.65*	
δiH7	-0.05351	-0.00900	-0.00263	0.02100	0.03340	0.05458	-0.01939	-0.00206	-0.09739	0.02331	-0.10290	0.15458
	-1.58	*-0.36*	*-0.07*	*3.46*	*0.97*	*0.86*	*-0.29*	*-0.11*	*-1.26*	*1.35*	*-1.75*	
δiA35	0.07324	-0.00116	-0.01001	0.00578	0.00470	-0.00212	-0.01864	-0.00341	-0.00518	-0.00100	0.01138	-0.05358
	-1.79	*-0.31*	*-1.79*	*2.82*	*0.88*	*-0.21*	*-1.81*	*-1.27*	*-0.43*	*-0.37*	*1.25*	
δiA45	0.01264	0.00256	-0.00085	0.01054	-0.00229	-0.01679	0.00856	-0.00584	0.01206	-0.00358	-0.00011	-0.01691
	-1.43	*0.54*	*-0.12*	*2.81*	*-0.34*	*-3.17*	*-0.67*	*-0.18*	*0.84*	*-1.07*	*-0.01*	
δiA55	-0.01282	-0.00017	-0.01472	0.02857	0.00157	0.00763	0.00444	-0.00510	-0.00506	0.00567	-0.00846	-0.00155
	0.31	*-0.03*	*-1.90*	*4.53*	*0.21*	*0.56*	*0.31*	*-1.37*	*-0.30*	*1.53*	*-0.67*	
δiA65	0.00315	0.00391	-0.00074	0.00338	0.01277	0.03740	-0.01385	-0.00236	-0.02240	0.00230	-0.02541	0.00187
	-0.21	*0.96*	*-0.12*	*0.98*	*2.23*	*3.30*	*-1.25*	*-0.82*	*-1.74*	*0.80*	*-2.61*	
δiR2	0.00165	-0.00895	0.00609	0.02290	-0.01221	0.04377	-0.01650	-0.00294	-0.03056	0.00230	-0.00418	-0.00135
	-0.33	*-1.81*	*0.83*	*2.62*	*-1.75*	*3.42*	*-1.23*	*-0.84*	*-1.95*	*2.33*	*-0.35*	
δiR3	-0.00311	-0.00251	0.00886	0.00882	-0.00780	-0.00803	0.02549	-0.00051	-0.00922	0.00811	-0.02746	0.00735
	-0.18	*-0.54*	*1.31*	*1.08*	*-1.20*	*-0.67*	*2.04*	*-0.15*	*-0.63*	*-1.07*	*-2.49*	
δiR4	0.00158	-0.01083	-0.01076	0.02005	-0.00478	0.01441	-0.00804	-0.00635	-0.02675	-0.00347	0.02462	0.01032
	-0.12	*-2.48*	*-1.68*	*3.12*	*-0.77*	*1.28*	*-0.67*	*-2.06*	*-1.93*	*0.16*	*2.35*	
δiR5	-0.01003	0.00123	-0.00097	0.00699	-0.00706	0.03880	-0.03103	-0.00786	-0.02841	0.00048	0.01998	0.01789
	1.71	*0.25*	*-0.13*	*3.52*	*-1.01*	*3.03*	*-2.31*	*-2.25*	*-1.81*	*-0.31*	*1.69*	
δiQ2	0.01601	-0.00067	-0.00202	0.00585	0.00845	-0.00819	-0.00617	0.00502	-0.03903	-0.00107	0.01825	0.00358
	0.71	*-0.02*	*-0.35*	*0.35*	*1.55*	*-0.81*	*-0.58*	*1.85*	*-3.16*	*2.88*	*1.96*	
δiQ3	0.00522	0.00753	-0.00143	-0.00199	0.00366	0.01689	-0.01359	0.00083	-0.00532	0.00788	-0.01871	-0.00097
	0.37	*2.02*	*-1.96*	*-3.02*	*0.96*	*1.74*	*-1.33*	*-0.31*	*-0.44*	*2.44*	*-2.08*	
δiQ4	0.00265	0.01226	-0.00962	0.01335	0.00616	0.00094	-0.02497	0.00867	-0.00909	0.00642	-0.00197	-0.00479
	-0.79	*3.38*	*-2.98*	*4.39*	*1.20*	*0.10*	*-2.99*	*3.37*	*-0.79*	*0.89*	*-0.23*	
IMR	0.00534	0.00126	0.00076	0.00211	0.00109	0.00140	0.00173	0.00125	0.00143	0.00112	0.11109	
	0.91	*0.82*	*0.78*	*1.09*	*1.10*	*0.82*	*1.23*	*1.27*	*1.18*	*0.99*	*0.81*	

a. Figures in italics are ratios of parameter estimates to standard errors.

Table 5.4 Uncompensated Elasticities: Homogeneity and Symmetry Restricted Heckit Model: 1984

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
Wi	0.114	0.039	0.056	0.080	0.041	0.132	0.171	0.012	0.153	0.025	0.111	0.099
ε1i	-0.870	-0.164	-0.033	-0.025	-0.065	0.002	-0.020	0.009	-0.009	-0.036	-0.007	0.044
ε2i	-0.001	-0.815	-0.019	-0.010	-0.032	-0.002	-0.009	-0.018	-0.007	-0.018	-0.004	0.002
ε3i	-0.002	-0.034	-0.846	-0.018	-0.041	-0.002	-0.007	-0.015	-0.011	-0.027	0.000	0.001
ε4i	0.000	-0.033	-0.028	-0.889	-0.060	0.007	-0.013	-0.028	-0.008	-0.031	-0.002	0.006
ε5i	0.000	-0.025	-0.017	-0.016	-0.873	0.001	-0.003	-0.016	-0.004	-0.020	-0.004	0.000
ε6i	-0.003	-0.059	-0.044	-0.023	-0.080	-0.844	-0.033	-0.007	-0.024	-0.039	-0.009	0.012
ε7i	-0.003	-0.077	-0.039	-0.039	-0.087	-0.010	-0.878	-0.011	-0.035	-0.054	-0.015	0.011
ε8i	0.000	-0.008	-0.004	-0.005	-0.009	0.002	-0.001	-0.882	-0.002	0.000	0.000	0.002
ε9i	-0.010	-0.084	-0.066	-0.047	-0.100	-0.020	-0.053	-0.041	-0.789	-0.059	-0.021	0.000
ε10,i	-0.001	-0.014	-0.012	-0.009	-0.020	0.000	-0.005	0.003	-0.053	-0.823	-0.003	0.078
ε11,i	-0.005	-0.051	-0.025	-0.025	-0.072	-0.001	-0.008	-0.014	-0.014	-0.220	-0.856	0.021
ε12,i	-0.003	-0.036	-0.025	-0.017	-0.060	0.010	-0.012	-0.003	-0.004	-0.098	-0.002	-0.887
εi,M	0.901	1.273	1.153	1.120	1.484	0.863	1.058	1.050	0.914	1.166	0.926	0.871
εiH2	-0.039	0.048	0.022	0.043	0.168	-0.094	0.064	0.070	-0.049	0.207	0.016	-0.079
εiH3	-0.053	0.045	0.020	0.014	-0.085	0.012	0.040	-0.008	0.008	0.046	0.001	-0.053
εiH4	-0.014	-0.001	-0.009	0.033	-0.013	0.020	0.061	0.046	-0.051	0.022	-0.031	-0.030
εiH5	-0.026	0.060	0.028	0.001	0.034	0.001	0.026	-0.041	-0.051	0.032	0.041	-0.041
εiH6	0.002	0.017	-0.003	0.009	0.023	-0.006	0.004	-0.002	-0.012	0.000	0.005	-0.010
εiH7	0.006	0.016	0.003	0.018	-0.003	0.004	-0.003	-0.041	-0.007	0.014	-0.010	-0.005
εiA35	0.034	-0.004	-0.009	-0.027	0.026	0.003	0.009	0.018	-0.039	-0.036	0.046	-0.024
εiA45	0.008	0.011	0.011	-0.022	0.004	0.004	0.005	0.085	-0.045	0.065	0.053	-0.034
εiA55	0.008	0.003	-0.010	-0.012	-0.016	-0.032	0.014	0.014	-0.005	-0.014	0.031	0.005
εiA65	-0.015	0.046	0.017	0.022	-0.030	-0.023	0.007	0.064	0.006	0.003	0.014	-0.030
εiR2	0.022	-0.008	-0.023	0.030	-0.037	-0.002	0.034	-0.197	-0.041	0.037	0.009	-0.005
εiR3	-0.050	-0.024	-0.056	0.090	0.003	0.025	0.028	-0.135	0.018	-0.082	-0.080	0.042
εiR4	-0.092	-0.021	-0.071	0.070	0.131	0.017	0.058	-0.296	-0.073	-0.008	0.033	0.033
εiR5	-0.005	0.034	-0.027	0.010	0.089	-0.002	0.006	-0.093	-0.027	0.008	0.000	0.004
εiQ2	0.022	0.010	-0.008	-0.022	0.087	0.035	-0.013	-0.045	-0.015	0.025	-0.025	-0.018
εiQ3	-0.001	0.012	0.001	0.005	0.124	-0.037	-0.025	-0.119	-0.009	0.041	0.039	0.006
εiQ4	-0.018	-0.026	-0.018	0.043	0.088	0.037	-0.042	-0.024	-0.029	0.083	0.024	-0.009

Table 5.5 Uncompensated Elasticities: Homogeneity and Symmetry Restricted Heckit Model; 1986

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
W_i	0.09212	0.03287	0.04896	0.07547	0.03507	0.18909	0.15589	0.00890	0.14478	0.02233	0.10268	0.09182
ε_{1i}	-0.886	-0.035	-0.035	-0.022	-0.047	-0.003	-0.010	-0.040	-0.022	-0.030	0.020	0.000
ε_{2i}	-0.006	-0.797	-0.019	-0.007	-0.024	-0.005	-0.006	-0.022	-0.015	-0.027	0.009	0.002
ε_{3i}	-0.011	-0.031	-0.840	-0.014	-0.028	-0.003	-0.005	-0.022	-0.018	-0.020	0.011	-0.003
ε_{4i}	-0.015	-0.030	-0.032	-0.881	-0.049	-0.004	-0.012	-0.038	-0.016	-0.029	0.020	0.005
ε_{5i}	-0.007	-0.023	-0.015	-0.014	-0.856	-0.002	-0.001	-0.020	-0.010	-0.018	0.006	0.000
ε_{6i}	-0.023	-0.082	-0.059	-0.033	-0.083	-0.870	-0.039	-0.062	-0.059	-0.051	0.040	0.007
ε_{7i}	-0.021	-0.066	-0.046	-0.035	-0.055	-0.022	-0.865	-0.044	-0.056	-0.024	0.032	-0.003
ε_{8i}	-0.002	-0.006	-0.003	-0.003	-0.006	0.000	0.000	-0.869	-0.004	-0.053	-0.006	0.023
ε_{9i}	-0.026	-0.090	-0.068	-0.029	-0.075	-0.025	-0.041	-0.085	-0.818	0.152	0.021	-0.070
$\varepsilon_{10,i}$	-0.004	-0.015	-0.014	-0.005	-0.018	0.000	-0.003	0.000	-0.010	-1.018	0.005	0.049
$\varepsilon_{11,i}$	-0.019	-0.036	-0.035	-0.018	-0.053	-0.011	-0.018	-0.039	-0.033	-0.021	-0.823	0.001
$\varepsilon_{12,i}$	-0.017	-0.036	-0.032	-0.014	-0.040	-0.006	-0.012	-0.099	-0.031	0.154	0.024	-0.900
$\varepsilon_{i,M}$	1.037	1.244	1.198	1.075	1.333	0.951	1.013	1.274	1.092	1.169	0.631	0.861
ε_{iH2}	0.005	0.074	0.003	-0.019	-0.027	0.049	0.008	-0.013	0.021	0.105	-0.126	-0.038
ε_{iH3}	-0.016	0.023	-0.001	-0.028	-0.031	0.038	0.012	0.028	0.024	0.060	-0.085	-0.016
ε_{iH4}	-0.019	0.007	-0.017	-0.038	-0.043	0.054	0.013	-0.024	0.034	0.033	-0.088	-0.019
ε_{iH5}	-0.012	0.007	-0.002	-0.015	-0.029	0.032	0.004	-0.014	0.012	0.009	-0.042	-0.011
ε_{iH6}	-0.005	0.002	0.003	-0.002	-0.003	0.009	0.000	-0.001	0.003	0.001	-0.011	-0.006
ε_{iH7}	-0.001	0.001	0.002	-0.002	-0.001	0.004	0.000	-0.002	0.001	0.000	-0.005	-0.002
ε_{iA35}	0.010	0.001	0.014	0.007	0.005	-0.001	0.000	0.003	0.007	-0.006	-0.021	-0.011
ε_{iA45}	-0.002	-0.005	0.005	0.005	-0.001	0.009	0.002	0.032	0.000	0.003	-0.011	-0.015
ε_{iA55}	0.007	-0.025	0.006	0.004	0.007	0.009	-0.002	0.037	-0.003	-0.013	-0.011	-0.006
ε_{iA65}	0.003	-0.014	-0.012	-0.006	0.005	0.008	0.010	0.031	-0.010	0.039	0.000	-0.018
ε_{iR2}	0.007	0.003	0.007	0.028	-0.061	0.000	0.001	0.096	0.003	0.020	0.005	-0.038
ε_{iR3}	-0.023	0.069	0.019	-0.024	0.078	0.082	-0.017	-0.029	0.108	-0.064	-0.130	-0.168
ε_{iR4}	-0.101	-0.126	-0.066	0.075	-0.032	0.023	0.023	-0.124	0.090	-0.028	-0.040	-0.031
ε_{iR5}	-0.008	0.035	0.012	0.050	-0.028	0.003	-0.021	-0.018	0.005	0.013	-0.013	-0.005
ε_{iQ2}	0.011	0.035	-0.034	0.004	0.004	-0.005	-0.001	0.025	-0.004	-0.014	0.007	-0.001
ε_{iQ3}	0.014	-0.001	-0.013	0.002	0.004	-0.015	0.013	0.012	-0.003	-0.023	0.000	0.006
ε_{iQ4}	0.008	0.031	-0.027	0.017	-0.001	-0.011	-0.018	0.048	0.001	-0.006	0.002	0.026

Table 5.6 Uncompensated Elasticities: Homogeneity and Symmetry Restricted Heckit Model: 1990

Equation	BEEF 1	PORK 2	CHICK 3	OMEAT 4	FISH 5	CEREAL 6	VEGE 7	SUGAR 8	DAIRY 9	FATS 10	NALCO 11	OTHER 12
Wi	0.07313	0.02325	0.04530	0.07556	0.03603	0.16076	0.16723	0.00848	0.19021	0.01639	0.09624	0.10742
ε1i	-0.832	-0.075	-0.060	-0.020	-0.045	0.000	-0.015	-0.035	-0.001	-0.070	-0.007	0.003
ε2i	-0.008	-1.354	-0.030	-0.007	-0.022	-0.004	-0.005	-0.023	-0.008	-0.044	-0.005	0.148
ε3i	-0.017	-0.069	-0.792	-0.016	-0.034	-0.003	-0.008	-0.036	-0.004	-0.053	-0.005	0.001
ε4i	-0.017	-0.064	-0.053	-0.862	-0.041	0.004	-0.016	-0.031	-0.003	-0.066	-0.007	0.007
ε5i	-0.014	-0.049	-0.033	-0.013	-0.807	-0.001	-0.004	-0.027	-0.004	-0.042	-0.006	0.008
ε6i	-0.010	-0.149	-0.096	-0.023	-0.065	-0.846	-0.040	-0.030	-0.017	-0.115	-0.012	0.010
ε7i	-0.017	-0.129	-0.087	-0.037	-0.052	-0.010	-0.876	-0.046	-0.015	-0.122	-0.019	0.009
ε8i	-0.024	-0.012	-0.009	-0.003	-0.007	0.000	-0.001	-0.835	0.000	-0.052	0.000	0.025
ε9i	0.001	-0.213	-0.121	-0.045	-0.095	-0.021	-0.054	-0.068	-0.808	-0.170	-0.018	-0.017
ε10,i	-0.026	-0.032	-0.017	-0.006	-0.014	0.000	-0.004	-0.012	-0.003	-0.732	-0.003	0.015
ε11,i	-0.005	-0.087	-0.057	-0.023	-0.047	-0.002	-0.024	-0.023	-0.004	-0.080	-0.841	-0.003
ε12,i	-0.014	-0.087	-0.065	-0.022	-0.047	0.001	-0.022	0.072	-0.008	-0.075	-0.005	-0.856
εi,M	0.983	1.641	1.418	1.077	1.259	0.881	1.069	1.176	0.878	1.579	0.932	0.802
εiH2	0.038	0.162	0.094	-0.032	0.097	0.027	-0.020	-0.151	-0.060	0.141	-0.011	-0.012
εiH3	0.008	-0.005	0.053	-0.011	-0.030	0.037	-0.033	-0.030	0.001	0.076	-0.002	-0.023
εiH4	0.007	0.075	0.028	-0.011	0.006	0.051	-0.019	-0.146	-0.010	0.121	0.013	-0.076
εiH5	-0.010	0.042	0.031	-0.017	0.003	-0.010	-0.002	-0.021	0.004	0.036	0.012	-0.007
εiH6	-0.007	0.015	0.020	-0.013	0.019	0.004	-0.002	-0.018	-0.005	0.008	0.005	-0.002
εiH7	-0.006	-0.003	-0.001	0.002	0.008	0.003	-0.001	-0.002	-0.004	0.012	-0.009	0.012
εiA35	0.195	-0.010	-0.043	0.015	0.025	-0.003	-0.022	-0.078	-0.005	-0.012	0.023	-0.097
εiA45	0.021	0.013	-0.002	0.017	-0.008	-0.013	0.006	-0.083	0.008	-0.026	0.000	-0.019
εiA55	-0.017	-0.001	-0.032	0.038	0.004	0.005	0.003	-0.060	-0.003	0.035	-0.009	-0.001
εiA65	0.007	0.026	-0.003	0.007	0.055	0.036	-0.013	-0.043	-0.018	0.022	-0.041	0.003
εiR2	0.004	-0.060	0.021	0.047	-0.053	0.042	-0.015	-0.054	-0.025	0.022	-0.007	-0.002
εiR3	-0.010	-0.024	0.044	0.026	-0.049	-0.011	0.034	-0.013	-0.011	0.111	-0.064	0.015
εiR4	0.006	-0.136	-0.069	0.078	-0.039	0.026	-0.014	-0.219	-0.041	-0.062	0.075	0.028
εiR5	-0.021	0.008	-0.003	0.014	-0.030	0.037	-0.028	-0.140	-0.023	0.004	0.031	0.025
εiQ2	0.052	-0.007	-0.011	0.018	0.056	-0.012	-0.009	0.140	-0.049	-0.016	0.045	0.008
εiQ3	0.018	0.082	-0.008	-0.007	0.026	0.027	-0.021	0.025	-0.007	0.121	-0.049	-0.002
εiQ4	0.009	0.132	-0.053	0.044	0.043	0.001	-0.037	0.255	-0.012	0.098	-0.005	-0.011

and we have already observed that zero observations in our reconstructed PUMDTS were a small proportion of the total sample.The extent to which these estimates are totally free of sampling bias is an empirical matter whose investigation holds potential for future econometric work. Overall, it is fair to say that micro data sets such as the PUMDTs, inherit large sample properties that allow us the flexibility of managing our data without severely imparting sampling error. By their vary nature, PUMDTs are restrictively large, and managing data via deletions may be warranted to serve resources and time. This does not imply a diminished role for censored regressions. Quite to the contrary. Our expenditure data are average weekly expenditures, which necessarily means that fewer zero expenditure will be observed relative to daily diary records since the zero expenditure problem does tend to be less of a problem as the degree of commodity aggregation increases, as in our case (See Tables 3.3, Chapter 3).

5.4 Summary

This Chapter dealt with the critical problem of sample selectivity bias. This issue is often ignored in cross-sectional demand studies. Although our results indicated the absence of such bias, we believe that at lower levels of aggregations, the results would be different, hence censored regression analysis would play a greater role in explaining the sensitivity of food-at-home expenditure to various economic and demographic factors. Nevertheless, our finding that the IMR is insignificant in all cases that we have estimated for our level of agregation should serve to inform future research in this area.

Chapter 6

Analyzing Food At Home Expenditure Using a Nested ALIDS and Translog Demand System.

6.1 Introduction

In Chapter 5, we estimated an Almost Ideal Demand System (ALIDS) modified to account for demographic factors. Our choice of functional form was subjective to the extent that it was not based on a statistical comparison of various models. Nevertheless, we estimated the ALIDS because in most previous empirical studies, the ALIDS has retained some amenable properties that make it an 'almost ideal' choice for most demand studies.

A study such as this one would probably be incomplete if it did not also evaluate alternative demand systems so as to ascertain whether or not the data used in this study are insensitive to different flexible functional form specifications. However, statistical interpretations based on comparison of alternative empirical specifications using goodness of fit criteria may be inadequate since, in general, most of these models are not nested within each other in the sense that one demand system is not a special case of others even if such models possessed identical properties. Two such popular demand systems are the ALIDS and the exactly aggregable Translog of Christensen, Yorgenson, and Lau [1975]. As Lewbel [1989] points out, it is not easy to choose between these two systems based on their consistency with economic theory in that both systems are second order flexible in prices and total expenditure; their budget share Engel curves are linear in the logarithms of total expenditures (implying similar aggregation properties); and they have indirect utility functions that are built up of polynomials in logarithms of prices.

In view of these considerations, the objective of this Chapter is to use the PUMDT to evaluate the relative performance of these two popular PIGLOG models within a nested framework proposed by Lewbel [1989]. The Lewbel framework is adopted for this evaluation because it avoids a number of problems associated with non-nested test procedures and presents a parsimonious joint system which reduces either to the exactly aggregable Translog or the ALIDS model with appropriate linear parametric restrictions involving only a subset of the joint model parameters.

The rest of this Chapter is organized as follows. In section 6.2, we present a specification of the composite Lewbel system (henceforth Transalids). The Transalids is appropriately extended to account for demographic variables already defined in Chapters 3 and 4. In section 6.3, we present estimation methods while results, including a comparison of relevant goodness of fit tests and tests of linear hypothesis are presented in section 6.4. Section 6.5 concludes the Chapter. It is emphasized that since the objective of this Chapter is the evaluation of relative performance of the nested models, we will not present a detailed discussion of parameter estimates and elasticities. Rather, this exercise is best interpreted as yet another model validation endeavour.

6.2 Specification of Nested ALIDS/Translog (Transalids) Demand System

Lewbel' s composite model is based on the following well-behaved indirect utility function:

$$\log[\nu(\mathrm{P},\mathrm{Z})] = b^{T}\mathrm{P} + \log[d + a^{T}\mathrm{P} + \frac{1}{2}\mathrm{P}^{T}c\mathrm{P} - (a^{T} + \mathrm{P}^{T}c1)\mathrm{Z}] \qquad 6.1$$

which we have represented conveniently using matrix notation for ease of exposition. ν is the indirect utility function, P is a price vector of dimension N with component ρ_i and $\rho_i = log(p_i)$; $Z = log\ (m)$ where m is total food-at-home expenditure; 1 is the n-vector of ones; a and b are vectors; d is a scalar; and c is a symmetric matrix with the parametric restrictions of summability, homogeneity, and symmetry stated as $a^T=1$, $b^T1=0$, and $1^Tc1=0$ $\forall$ i,j.

Applying the logarithmic form of Roy's identity to (6.2) yields the Transalids budget share equations for the h^{th} household written as:[18]

$$w_i = \frac{a_i + c_i^T P + b_i(d + a^T P + \frac{1}{2} P^T c P) - [c_i 1 + b_i(1 + P^T c 1)]Z}{1 + P^T c 1} \qquad 6.2$$

For Slutsky symmetry, we require c to be symmetric. This system nests the ALIDS and the Translog as two special cases via the following linear restrictions: $c_i^T1=0$ $\forall$ i yields the ALIDS model while $b_i=0$ $\forall$ i yields the exactly aggregable Translog of Christensen *et. al.* Both restrictions can be empirically tested to evaluate the adequacy and relative explanatory power of the ALIDS and the Translog for a given data set.

In order to account for demographic variables, we extend the Transalids by translating the intercept term a_i and writing it as a linear function of a vector D which contains binary variables representing household size, age, region, and season as defined in Chapter 3. The modified Transalids can now be written as:

$$w_i = \frac{a_{io} + a_i^T D + b_i P + c_i^T P - [c_i 1 + b_i(1 + P^T c 1)]Z}{[i + P^T c 1]} \qquad 6.3$$

where again summability is given by $a_i^T=0$. The vector D contains elements that are unity or zero by construction, and hence imply that different constants given by a_{io} + a_i^TD will appear in the numerator of the above equation based on the (0,1) condition. There are a total of 17 categories for dummy variables. We do not know the extent to which greater parsimony

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[18] The logarithmic form of Roy's identity is defined as $-\frac{\partial \log v^h / \partial \log p_i}{\partial \log v^h / \partial \log m} = w_i^h$. The subscript h in (6.2) is dropped for convenience only.

would be achieved by conditioning h^{th} household's indirect utility function $ln\ v^h(p,m)$ on say household size, and modelling only a subset of demographic variables by intercept shifting binary variables.

6.3 Data and Estimation

The Transalids is estimated using the PUMDT described in Chapter 3. The variables and model parameters are exactly identical to the ones employed in the preceding analysis (Chapter 4). For estimation, we again append a stochastic component e_i to each full model equation to capture random errors in the household's utility maximising plans and any heterogeneity across households. We also adopt the common practice of deleting one equation (the 'OTHER' category) since as noted earlier, the covariance matrix has rank N-1, implying singularity of the matrix. The implied parameters of the deleted equation are derived using the summability restriction. Similarly, we also assign zero values to the first row in the D matrix of binary variables to avoid perfect multicollinearity. The entire sytem is estimated using nonlinear 3SLS available in SAS SYSNLIN and MODEL. As pointed out in Chapter 4, this is done to account for expenditure endogeneity. In implementing the Transalids, we experienced serious SAS convergence problems owing to the nonlinearity introduced by the price index $d + a^T P + 0.5P^TcP$. This was compounded by the fact that in order for us to test the two nested versions of the Transalids, we had to run separate regressions for each model which clearly involves many more nonlinear relationships than either the ALIDS or the Translog.[19] To overcome this, we used a simplifying approximation and used the mechanical Stone price index. This may induce some specification error since strictly speaking, the geometric index of Stone is by definition not nested within the composite model of Lewbel. However, a number of studies, including Lewbel, have shown that

[19] Notwithstanding the high cost of parsimony in parameters, it must however be qualified that the Transalids has only a few more free parameters than does the ALIDS (which it embodies). This is an attractive feature, especially in the homogeneous and symmetric Transalids which has $[½(N^2 + 5N) - 2]$ parameters compared to $[½(N^2 + 3N) - 1]$ for the ALIDS and $[½(N^2 + 3N) - 2]$ for the Translog.

this replacement does not seriously undermine the confidence to be placed on goodness of fit measures that ensue from this approximation. At any rate, we also need to weigh this against the very high computational costs of estimating the full specified model.

Thus, when we impose the restriction $c^T 1 = 0 \ \forall \ i$ and replace the price index P with Stone's index P*, we have the following ALIDS (which in the terminology of Blanciforti and Green is Linear Approximate):

$$w_i^h = a_{io} + a_{i2}D_1 + ... + a_{in}D_n + c_i^T P + b_i(Z - P^*) + e_i \qquad 6.4$$

Similarly, the following is our exactly aggregable Translog from the restriction $b_i = 0 \ \forall \ i$:

$$w_i = \frac{a + c_i^T P - c_i^T 1Z + e_i}{1 + P^T c1} + e_i \qquad 6.5$$

with all variables, parameters , and restrictions defined as above.[20] Since the budget share equations are homogeneous of degree zero in prices, one can impose the normalization $a_m = -1$ suggested by Christensen and Manser [1977] in order to identify the parameters.

6.4 Estimation Results

We started with the full Transalids model and estimated it in its unrestricted form using SAS SYSNLIN routine which supports nonlinear estimation. We then saved the covariance matrix Σ. In the second regression, the homogeneity and symmetry restrictions were imposed on the composite model and the reduced model was estimated subject to the covariance matrix from

[20] Notice how (6.5) is equivalent to the application of Roy's identity to the indirect utility function of the form

$$\ln v(p,m) = \sum_i \alpha_i \ln \frac{p}{m} + \frac{1}{2}\sum_i \sum_j \beta_{ij} \ln \frac{p_i}{m} \ln \frac{p_j}{m}.$$

the first regression. This process was repeated for the ALIDS and the Translog. Based on the parameters and the covariance matrix of each unrestricted and restricted model, we used the objective function values to compute likelihood ratio test (LR). Formally, the LR test has a χ^2 distribution with q degrees of freedom as follows:

$$LR = -2[L(\beta_r, \sigma_r^2) - L(\beta_u, \sigma_u^2)] \sim \chi_q^2 \qquad 6.6$$

where $L(\beta_r,\sigma_r^2)$ is the value of the restricted maximum likelihood function and $L(\beta_u,\sigma_u^2)$ is the value of the unrestricted maximum likelihood function, and q is the number of restrictions or degrees of freedom and is equal to the difference between the number of unrestricted parameters and the number of restricted parameters which is simply the difference in the number of restrictions between the unrestricted and the restricted model. [For details see the Kmenta 1986, and Judge *et. al.* 1985]. [21]

In addition to the LR test statistic, we also present the Akaike information criteria (AIC) [Akaike 1981] which is based on an extension of the maximum likelihood principle and seeks to incorporate in model selection a measure of the precision of the estimate and a measure of the rule of parsimony in the parameterization of a statistical model. The AIC is derived by minimizing -2 log(ML) + 2(K) where K is the number of parameters. In our present context, the AIC is necessitated by a need to avoid any bias that may arise from substituting Stones' price index for the 'true' price index $d + a^T P + 0.5P^T cP$. The former is only approximate to the Transalids.

Table 6.1 presents the LR test for each of the specification for the three years estimated separately. Looking first at the unrestricted model (reading across the first row corresponding to this specification) we note immediately that there is no significant difference in the values of the

[21] A numerically equivalent way of implementing the LR test statistic is given by $LR = -T\log_e\left(\frac{|\Sigma_r|}{|\Sigma|}\right)$ where $|\Sigma_r|$ is the determinant of the residual covariance matrix of the maximum likelihood restricted model and $|\Sigma|$ is the determinant of the covariance matrix based on the unrestricted model and applies to normally distributed disturbances.

Table 6.1 Tests of Restrictions using the Likelihood Ratio Test and the Akaike Information Criterion: 1990

Model Restriction	Transalids	ALIDS	Translog
1. Unrestricted Model			
Objective function value	90,782	90,771	90,773
Number of parameters (K)	341	329	330
AIC = (-2ln(ML)+2(K)	-180,883	-180,885	-180,887
2. Homogeneity Restricted Model			
Objective function value	90,781	90,769.	90,772.
Number of Parameters (K)	330	318	319
Number of Restrictions (q)	11	11	11
χ^2 value[a]	1.26	3.52	3.54
2. Symmetry Restricted Model			
Objective function value	90,688	90,664.	90,661.
Number of parameters (K)	242	241	243
Number of restrictions (q)	99	88	87
χ^2 value[b]	188.90	213.46	223.84
AIC	-180,852.26	-180,847.82	-180,837.74

[a] Critical values: $\chi^{2\,(0.05)}$ = 6.64, $\chi^{2\,(0.01)}$ = 3.84
[b] Critical values: $\chi^{2\,(0.05)}$ = 124.34, $\chi^{2\,(0.01)}$ = 135.81

objective functions of each of the three models. In fact, by the AIC criterion, we see that neither model is really preferred.

Next, we imposed homogeneity on each system and re-estimated the systems subject to the residuals covariance matrix from the unrestricted model. Our results once again show no significant difference between the homogeneous systems and the full model, as suggested by the nearly identical log likelihood functions and the fact that all χ^2 values are less than their critical values at the upper tail probalities of 0.10, 0.05, and 0.01. Furthermore, the AIC are all similar. When we evaluate each unrestricted model with respect to its symmetry restricted form, we notice a very substantial drop in the value of the log likelihood function. Based on the LR test and the AIC, we may conclude that cross-equation restrictions of symmetry cannot be accepted. Given our earlier results reported in Chapter 4, we are inclined to assert that this new evidence supports our *F*-tests in which we failed to reject homogeneity but strongly rejected symmetry. Notice that we are comparing test statistics from equation-by-equation estimates (based on the F test) with system-wide tests requiring an asymptotic statistics such as the LR. In this vein, the above results are only asymptotically valid, which implies that given our large sample size and a 12-equation system, we would expect our asymptotic system-wide statistical tests to bias these results toward rejection our a given hypothesis. This point has been illustrated by Laitinen [1978] and Meisner [1979].

A comparison of elasticity estimates from the different systems would provide yet another way of evaluating the relative performance of these models. This exercise would obviously be academic since our parameter estimates show no significant differentiation. Nevertheless, elasticities for the composite model can be derived using the following formulae which are a result of straight forward partial differentiation of w_i with respect to p:

a). Price Elasticity:

$$\epsilon_{ij} = \frac{1}{w_i}\left(\frac{1}{1 + P^T 1)^2}\right)[(1 + P^T c1)(c_{ij} + \beta_i(w_i - c1)] \quad - c1[a_{i0} + a_{i1}D_1 + \ldots + c_i^T P + \beta_i P^* \quad - (c_i + \beta_i(1 + P^T c1))Z] - \delta_{ij}$$

6.7

where δ_{ij} is Kronecker delta.

b). Expenditure Elasticity:

$$\epsilon_{in} = 1 - \frac{1}{w_i}\left(\frac{c_i^T 1}{1 + P^T c1} + \beta_i\right) \qquad 6.8$$

Notice how for the Translog, the elasticities are easily derived by simply imposing the restriction b_i=0. Furthermore, it can be shown that the elasticities of substitution from the Translog are identical to those derived from the ALIDS. See for instance Chalfant [1987].

6.5 Summary and Conclusions

The objective of this Chapter was to employ the PUMDT to evaluate the relative performance of two popular PIGLOG models (ALIDS and Translog) within a nested framework proposed by Lewbel. In this sense, one can say that this is another dimension of model validation. This exercise is particularly pertinent in the light of the fact that the relative merits and demerits of the ALIDS and the Translog have been a perennial source of major controversy among economists of various persuasions. Our results are in keeping with Lewbel's own conclusions when he observed that the ALIDS and the Translog are more or less identical in terms of both explanatory power and estimated parameters. In fact, Lewbel has shown that although his joint model was slightly superior statistically, its elasticity estimates were close to those of other models. The statistical superiority of the joint model has also been reported by Yen and Chern [1992]. It is interesting to observe that in a subsequent piece of work, Lewbel [1991] shows that most household demands are reasonably modelled as PIGLOG, in particular ALIDS. Hence, we can conclude *ex post* that our original choice of the ALIDS model, with all its amenable features (e.g. ease of estimation) was 'almost ideal'.

Chapter 7

Summary and Conclusions

In this Chapter, we summarize the major findings of this study. Limitations of the study are identified and suggestions for future research are provided.

7.1 Major Findings

This study employs the concept of weak separability and two-stage budgeting to generate a matrix of demand elasticity estimates for Canadian food-at-home consumption as well as to assess the theoretical restrictions of utility theory. The first stage involved Canadian households allocating expenditures to food-at-home, food-away-from-home, and nonfood. In the second stage, households allocate the FAH expenditures to 12 disaggregated food commodities, namely: beef, pork, poultry, other meat, fish, cereals, vegetables, sugars, dairy, fats and oils, non alcoholic beverages, and 'other' processed foods. The second stage was estimated using the Almost Ideal Demand System (ALIDS) which was modified to incorporate household size, age of household head, region of residence, and season. These demographic variables were represented by dichotomous categorical variables and incorporated by allowing the intercept to be a function of these binary variables. The model was estimated using Public Use Microdata Tapes for the years 1984, 1986, and 1990. PUMDTS provide a rich source of information on demographic variables that enables the incorporation of a wide range of these variables in a complete demand system of disaggregated food commodities. Data for each year was employed separately to estimate model parameters. The ALIDS was selected *a priori* for its amenable features.

The complete matrix of elasticities shows that our results are quite plausible and household size, age, region, and season have relatively significant effects on Canadian household food consumption patterns. Both the Marshallian and Hicksian elasticities have negative signs. For the

Marshallian elasticities, this sign is expected *a priori* while for the Hicksian, the negative own price elasticities indicate compliance with the concavity or negativity condition of the Slutsky substitution matrix. These elasticities are quite plausible and their magnitudes fall within ranges reported by other studies. In general, after examining Hicksian compensation, it was established that the degree of substitutability outweighs the degree of complementarity among these food commodities in Canada, as suggested by the preponderance of positive Hicksian cross-price elasticities. Expenditure elasticities are generally very high for meats and indicate that further increases in meat consumption should be expected provided there is an accompanying increase in household income.

This study also considered the critical issue of functional form. Two popular flexible functional forms, (the ALIDS and the Translog), were compared employing a nested framework suggested by Lewbel [1989]. The parameter estimates of all the models did not show any major differentiation, as judged by the likelihood ratio test (LR) and the Akaike Information Criteria (AIC). In addition, the issue of sample selection bias which is often ignored in cross section studies was addressed by comparing results from a Tobit (Heckit) model incorporating the Inverse Mills Ratio. Selection bias was found not to be a significant problem for the level of aggregation employed.

Model specification issues related to endogeneity of expenditure were also addressed. Unlike most complete demand system studies that assume expenditure exogeneity, this study used a complete information estimation procedure (3SLS) to correct for possible specification error introduced by endogenous regressors.

Finally, the study tested homogeneity and symmetry, as well as computed eigenvalues for evaluating the concavity of the expenditure function. Homogeneity was not rejected but symmetry was strongly rejected. Nonpositive characteristic roots suggested that concavity appears to hold.

7.2 Significance of Study

This study has produced a matrix of elasticities for a moderately disaggregated food commodity model within a micro-economic framework consistent with an individual household's optimization behaviour. These elasticities can be employed by policy makers and industry analysts in forecasting and sensitivity analysis. In particular, this information can be used to appraise the structure of food expenditure patterns among Canadian households. Our disaggregated model is especially useful for industry managers who operate in rather more narrowly defined markets in which decisions pertaining to pricing, new product development, and merchandising are made. This information may prove useful for these managers although much lower levels of disaggregation may prove even more useful for these managers who might be specifically interested in merchandizing related, say to t-bone steak, sirloin, lean ground beef, etc. The incorporation of demographic variables was particularly relevant because it provided a set of demographic elasticities which can be used to analyze changes in the demand for foods that are consistent with changes in socioeconomic factors. Moreover, these estimates can be extended to the evaluation of government welfare programs. For instance, using the expenditure function, one can construct economic indices which would measure the relative costs of reaching a given standard of living under two different price scenarios using the well known compensating and equivalent variation concepts. Analyzing regional policies is also fairly straight forward: once population characteristics and price information for a specific region are known, our demographically translated model can be employed to provide household demand parameters for these spatially delineated markets. Suffice it to say that our use of such complex PUMDTs and the successful incorporation of demographic variables in a theoretically plausible demand system marks a significant point of departure from other Canadian studies that have primarily been based on aggregate time series analysis.

Finally, policy makers can also use this information by considering the fact that the presence of highly significant price effects on food budgets in all 12 shares equations suggest that price policy will continue to be an important agricultural policy instrument in Canada, especially within the context of Canada's supply managed products such as poultry and dairy. To see this, observe that all Marshallian own-price elasticities are negative and less than unity, implying that increasing prices of a supply managed product such as chicken (via say production quotas or import measures) would result in increased revenue to Canadian poultry producers and processors.

Earlier, we stated that much lower levels of aggregation may prove even more useful for managers in the food industry. Nevertheless, our elasticities still have important implications for producers and processors in Canada, especially with respect to the red meat industry. In particular, the observed salient position taken by chicken, pork, and fish in the Canadian diet poses a specific challenge for the red meat industry and calls for greater emphasis on breeding for leaner beef products coupled with better product branding, marketing, and promotion. Such apparent structural change implies that food processors will need to make significant cost adjustments to its production technology. This may ultimately be reflected either through higher costs of marketing services or improvements in efficiency. In this view, managers need a lucid understanding of the linkages between retail and farm prices in order to ascertain the full effects of changes in household demand, farm output supplies, and the cost of marketing services on retail and farm-level prices. The elasticity information provided by this study is a step toward addressing these issues. Future research in this vein might combine our elasticity estimates to study demand interrelationships for meat products at the farm level and their links with consumer demand and marketing group behaviour.

7.3 Limitations and Suggestions for Future Research

This study has made several contributions. First, a complex and comprehensive PUMDT was successfully managed to retrieve data pertaining to a variety of variables and weights employed in this study. Second, neoclassical micro-econometric models incorporating socioeconomic variables were successfully specified and operationalized to generate demographically translated parameter estimates and elasticities for disaggregated foods in Canada. This contrasts very sharply with previous Canadian demand studies which do not incorporate demographic variables in spite of the recognized importance of these factors in explaining changes in the pattern of household food preferences. We contend that serious misspecification may result since in most industrialized countries, it is generally recognized that individual food commodities account for a small proportion of a household's total budget. In this case, the weight placed on traditional variables (price and income) as determinants of food expenditure patterns should not be exaggerated. Needless to say, most of this also hinges on whether or not our weak separability assumptions are reasonable. Third, functional from specification and model validation, including sample selection bias were modelled within an econometrically sound framework. Fourth, this study provided comprehensive tests of neoclassical restrictions of homogeneity, symmetry, and negativity. These tests are often never performed in most studies, as was clear from Table 4.34 in Chapter 4.

However, there are many demand-related issues that cannot possibly be covered due to resource and time constraints. Below, we propose a few areas in which research efforts may be directed.

First, our study did not consider pooling the Microdata across the three years due to the extremely high computational costs from using the TSCSREG procedure in SAS. Pooling would have enabled more systematic treatment of structural change issues as well as aggregation over agents. It can be argued the inability to pool the three sets of cross-sections removes a time dimension from the data which could eliminate an important source of market price variation. In particular, we have showed that considerable interhousehold unit price variation exists in the data. Hence, to what extent does this price variation across households at a single point in time reflect changes in market prices? Although we believe that we have to an appreciable degree addressed this issue by incorporating seasonal dummies corresponding to the quarter in which the household was surveyed, it would be useful to ascertain the degree to which the use of artificial price variables affect the estimation results and the interpretation of price parameters and elasticities. It is interesting to note that Statistics Canada surveys households over a twelve month period. In a way, this is a virtue and one could claim that the PUMDTs have intertemporal elements built into them.

Second, in this study, we have adopted the conventional approach of using Stone's price index as a proxy variable to avoid the convergence problems associated with nonlinear estimation.

However, this approach is often well justified for studies based on time series or pooled cross sectional data in which market prices are highly collinear. Since we have not pooled the data, it may be argued that it is difficult to anticipate a systematic pattern of movement in unit prices derived from cross-sectional data which are to a large extent driven by qualitative and preference differences. If unit prices were not closely collinear, would Stone's index still provide a good approximation to the original nonlinear ALIDS model? This is clearly an empirical issue and future research might explore the effect of the use of the price proxy on the estimated results o the ALIDS model. However, we are still encouraged by the fact that our Divisia prices provide a good fit to our model based both on the F statistics and Theil's results from model validation.

Third, an issue that has gained importance in cross-sectional studies is the question of quality effects. Recall that our prices are unit values obtained by dividing the expenditure values by the quantity values of each commodity. However, as indicated in Chapter 3, quality choice may reflect the effect of prices as households respond to price changes by adjusting both the quantity and quality. For instance, Deaton [1988, 1990] has suggested that in order to employ these unit prices in place of real market prices, one must assume that commodities are homogeneous. This is an area needing more work.

Fourth, the limited dependent variable problem is often more real than is assumed. Our levels of aggregation may implicitly distort the data structure and artificially eliminate the occurrence of zero expenditures. It would be interesting to reconstruct the Microdata sets with even much lower levels of disaggregation than attempted in this study. For instance, we could define a third stage in which meat expenditure is allocated among meat products. This is particularly relevant because sample selection bias is proportional to the probability of limit observations, and hence influenced by the level of aggregation.

Fifth, issues regarding simultaneity in prices and quantity are generally overlooked in most empirical work. Eales and Unnevehr [1993] have developed a useful analytical framework (the

Inverse Almost Ideal Demand System) which can be employed to investigate these important issues. An appropriate time series of cross sectional observations could facilitate this aspect.

Sixth, the nonparametric approach [Afriat, Varian] provides an alternative procedure for determining whether a finite price-quantity vector is consistent with the Generalized Axiom of Revealed Preference (GARP). This approach, which has been applied to Canadian data by Kohzadi and Mupondwa [1993] has its own strengths and weaknesses. Future research might explore the extent to which incorporating this approach would facilitate a better assessment of the consistency of data with utility maximization and a consumer's preference structure.

Seventh, given the strong rejection of our symmetry tests, it would be useful to try dynamic specifications to include factors other than current price and expenditure. These may include habit and wealth effects. In addition, since PUMDTS provide a rich source of information on a variety of socioeconomic variables, one may consider variables such as number of children, employment status, education, marital status, *et cetera*, while a break-down of the Microdata by income class would enable the estimation of Engel curves for different socio-economic groups.

Finally, there is a renewed interest in the use of input-output models for analyzing economic impacts at national and provincial levels. It has generally been observed that the household sector is one of the primary factors that affects the precision of input-output models. The integration of a plausible micro demand system such as ours into an appropriately specified input-output model would greatly improve precision in characterizing the economy. This is another area of potential future research.

The researcher is advised that management of PUMDTs to achieve these research goals is a thankless task requiring patience, time, high speed computing and data retrieval facilities, and some basic knowledge about programming.

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